PAPERS PRESENTED TO THE

LATIN AMERICAN PANEL

ON POST GRADUATE EDUCATION IN

AGRICULTURAL ENGINEERING

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NATIONAL AGRARIAN UNIVERSITY OF PERU

PAPERS PRESENTED

IN THE

Panel

ON

POST GRADUATE AGRICULTURAL ENGINEERING EDUCATION AND RESEARCH IN LATIN AMERICA

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[redacted]

FOREWORD

At the threshold of the 1970's education in all its branches has advanced to include science and knowledge unknown only a few years ago. Agriculture and engineering science serving agriculture has shared in this application of new knowledge with the resulting influence of change. Latin America, with its vast human, material and physical resources, faces many problems in its development towards increased food production and improved living standards. Agricultural engineers, alone and in co-operation with others, seek solutions to the involved problems which demand vigorous application of knowledge, initiative and imagination. Adequacy in preparation of professional personnel demands modern high quality educational systems in which incomplete or obsolete education cannot be afforded.

As a contribution to the definition of educational requirements for agricultural engineers in Latin America a Panel on Post Graduate Agricultural Engineering Education and Associated Research in Latin America was organized and held in Lima, Peru, August 4-8, 1969.

The sponsors of the Graduate Programme in Agricultural Engineering at La Molina are satisfied that their objectives have been met. The interest and objectives of people engaged in agricultural engineering in the region have been united. A Latin American Society of Agricultural Engineering (SLAIA) was formed in the Panel and this society is certain to play a major role in establishing technical and scientific education and applications needed in Latin America.

The report of the panel was published and circulated to the participants and others following the meeting. The report contained the recommendations and suggestions of the panel and information related to planning participants and execution of the meetings. Only a list of the titles of papers with authors as presented to the panel was included. These papers formed the background for discussion in the meetings and the basis for the approved body of recommendations.

This volume contains the papers presented to the meeting classified according to their themes and sequence of delivery to the panel. Some annexes and appendixes have been omitted to reduce the size of the volume. These omissions have been identified by an asterisk. The deletions do not affect the central theme of the concerned papers. A limited number of these annexes or of the individual papers may be obtained upon request from the Interamerican Institute of Agricultural Sciences, Apartado 11185, Lima, Peru or directly from the respective author or institution.

The papers contained deal with the philosophy, objectives, requirements for undergraduate and graduate education, research, accreditation, financing and administration of Agricultural Engineering Programmes in Latin America. Sponsors of the panel are pleased to make the information contained available for use by those interested, associated or involved in Agricultural Engineering Education Programmes in Latin America and elsewhere.

The panel sponsors gratefully acknowledge the work of all authors whose papers appear in this volume. The co-operation and assistance offered by staff members of the National Agrarian University, participants from Latin America, consultants, students, and technical officers of International Organizations all of whom contributed to the success of the meeting is much appreciated.

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1. PHILOSOPHY OF AGRICULTURAL ENGINEERING & EDUCATION REQUIRED FOR THE PROFESSION by Carl W. Hall, Michigan State University, East Lansing, Michigan, U.S.A.

INTRODUCTION

Agricultural Engineering is widely recognized as a profession which can contribute to the development of a country. These developments might be economic, social, technological, or educational, or a combination thereof. The development of a country depends primarily on utilization of its resources. These resources include human as well as physical. We are principally concerned, as agricultural engineers, with the industrialization of agriculture as a means of increasing the agricultural potential of the land and the productibity of the land and labor.

The experiences of other countries provide at least a partial model and guide for development. In very few cases are successful models of development directly transferable to other countries. There are various parameters which must be considered in the application of a model of development, altering its make-up and use for another country.

AGRICULTURE AND INDUSTRY DEVELOPMENT

In general, schemes to improve the economy of a country based only on industrial and urban areas have failed. Likewise schemes designed to help primarily the farm sector have not been successful. There is a direct relationship between the development of farm and industry. As farming becomes mechanized, there is often a movement of people from farms to the city. Obviously, many social and economic problems can develop if the industrial sector is not developed simultaneously to utilize the number of people and kinds of skills available. People living on the land provide at least 50% of the gross national product in many countries. To initiate major changes in the productivity of a country which receives at least 50% of its income from farming, necessitates as one of the first steps making farming more efficient. In the early stages of development farming and agriculture are nearly synonymous. As a country develops farming requires a smaller percentage, but often much higher levels of training of manpower involved in the agriculture sector. Because of the mobility of trained or educated manpower, the abilities needed will be available and will be used throughout the economy whether farm, rural, urban or industrial.

As industrial development proceeds, the terms farm, agriculture, and rural take on very different meanings. Farm refers to land. Rural refers to nonurban. Agriculture includes the production and processing of food, feed, and natural fibers of which the farm is but one segment. Much of the agriculture segment of the economy may include nonfarm pursuits. Thus agriculture, as an industry, must become more efficient in the farming sector by increasing land productivity and labor productivity.

LAND PRODUCTIVITY

The fact that every underdeveloped country is still principally engaged in farming should offer a clue to potential development. The first step is to increase the productivity of the land being farmed. The productivity of the land can be increased by:

1. Using proper fertilization, soil management, and cultural procedures and practices.
2. Using proper weed control
3. Adopting soil and water conservation practices, including irrigation, drainage, and erosion control
4. Reducing losses from insects, diseases, rodents, and birds
5. Utilizing meaningful mechanization
6. Using correct plant populations of improved, adapted crop varieties

These requirements all sound rather easy to attain. However, we know too little about transferring these recommended practices to other areas of the world, particularly to tropical areas, where many of the underdeveloped countries are located.

Meaningful mechanization has a permanent place in increasing productivity. Meaningful mechanization can be considered as land saving. That is, more productivity per acre in developing areas. A major advantage of meaningful mechanization is that the timeliness the accuracy of doing the job are increased--two crops of corn per year instead of one, three crops of rice instead of two. The job to be accomplished may be seeding or planting, placement of fertilizer, application of chemicals for insect or weed control, harvesting, handling, or threshing of the crop.

LABOR PRODUCTIVITY

Labor productivity refers to the output per yield of time input, generally expressed as output per man hour of work. Meaningful mechanization can also be considered as labor serving and labor saving, which provides greater productivity. Mechanization permits replacing or supplementing human and animal with mechanical power, thus increasing the dignity of workers, improving the environment in which the work is carried out, doing the job more efficiently, and increasing the capacity for work.

With mechanization there is a trend to substitute human or animal power with engine power and to utilize energy produced external to agriculture, such as fuels and electricity. About 85% of the draft power in farming throughout the world is provided by animals. The production energy for farm power in the USA has shifted very rapidly from internal to external sources--that is, from the farm to industry. Fuel for energy has shifted from forage and grain fields for animals to oil or coal fields for engine fuel and electricity. In the USA each worker now has available 25 to 35 horsepower, as compared to only 2 horsepower 50 years ago. Likewise, the labor productivity in the past 50 years has increased approximately ten times.

Labor productivity is increased through:

1. Meaningful mechanization
2. Improved work techniques
3. Healthier and safer working conditions
4. Increased land productivity
5. Improved worker management
6. More training and education of the worker

It is often stated that labor in agricultural production is not the limiting factor for areas of high population in relation to land area. Such a general statement does not recognize the importance of quality of labor. This labor force is often not trained nor educated to work in an advanced agricultural technology and in an industrial society. This concept as a basis of policy has been a deterrent to the proper development of some countries.

Mechanization refers to the proper and economic utilization of mechanical methods related to farming and agriculture. Mechanization is one technical aspect of increasing the productivity of workers. The thought held by many that mechanization means large power equipment units and tractors is misleading. Mechanization is defined as the use of tools to extend the hand and energy of man. This might include an improved hoe, substitution of animal with engine power, utilization of energy such as fuel and electricity, application of control devices, improved methods or developments of highways to improve the utilization of mechanical items. The movement of water from source to application, etc.

EDUCATION

It is generally agreed that the level and extent of education must continually be advanced to provide a base for development. This philosophy is true regardless of the stage of development of the country. Even highly developed countries continue to train or educate more people and at a higher level to provide for dynamic development. A wide range of training and education is needed to provide for a broad spectrum of manpower. Vocational training is a necessity. Skills need to be upgraded to meet the needs of the new technologies which come to fruition in a developing country. Technicians relate their skills to the problem. Engineers are needed for design and research. Other sciences are necessary. Agricultural Engineer programs of various institutes, colleges, universities, and governments should be designed to serve this broad spectrum of manpower-mechanization needs. The training and/or educational programs extend from hour-long discussions and meetings,one-day meetings, weekly, monthly, or specialized conferences to two-year, four-year, and advanced degree programs.

Any educational program of a country must be designed to meet both the short-term and long-term of the country or region. The educational programs in Agricultural Engineering are no exception. Often short term needs have to be met first so that support for long-term needs may be obtained simultaneously or later. Short-term needs have a tendency to be more of a "training" than "education" in nature. Agricultural Engineering by its definition and objective should incorporate both aspects--training and education.

AGRICULTURAL ENGINEERING PROGRAM DESIGN

Agricultural Engineering programs should be designed to:

1. Obtain information for properly mechanizing agriculture, considering human and physical resources.
2. Disseminate information to industry and those working with industries to apply the new knowledge.
3. Train and educate students at various levels to serve the engineering and mechanization aspects of agriculture--production and processing.
4. Train people to extend information through extension programs and conduct extension programs in engineering applied to agriculture.

Graduates of Agricultural Engineering programs will serve the above design. Thus, the development of training and educational programs must be based on and carried out with those who will benefit, including employers, unions, government, education, workers, and industry. Some of our graduates will go into research, others into adult education and extension activities. A comparison of various countries throughout the world shows that the number of researchers and extensioners is related to the development of a country. Vocational training must not be overlooked. An important dimension of educational programs of a country must be vocational training. Agricultural Engineering can make a contribution by teaching those who will be doing the teaching, the mechanical skills needed in the mechanization and engineering of agriculture. There is a reluctance even in some advanced countries to recognize the importance of developing skills required to properly carry out work in agriculture. In effect, this training serves not only farming and agriculture but prepares people to move into industrial pursuits so that the industrial economy benefits.

CURRICULUM

Educators are continually confronted with the vexing question regarding the breadth and depth of an engineering curriculum. In general most of us will agree that an undergraduate engineering program leading to a Bachelor of Science should include humanities, basic science and mathematics, basic engineering, basic agriculture, and courses in engineering design. However, we would find less agreement concerning the specific courses included and time devoted to the various subjects within these categories. Again, we must put considerable weight on the objectives of the curriculum and the economic environment in which we are working. I doubt whether we could unanimously agree on the basic core of knowledge which all students who receive a degree in Agricultural Engineering should have. We have not been able to resolve this among many of our faculties, so I doubt if we could agree on a countrywide basis. Thus, programme represent compromises. I would hope we could agree, however, that the near ultimate of our programs should be to provide the parameters, knowledge, and methods for engineering design. We must be able to design equipment, or structures, or processes to meet an objective or to solve a problem. I believe that we should emphasize as our major objective in our undergraduate curricula focusing on engineering design. This does not mean that everyone will be a designer upon graduation. It means, however, that everyone will be educated in this direction so that they might teach, design, analyze, and apply their knowledge and procedures to engineering problems related to agriculture.

It would be desirable to have a common set or group of courses which all students take who get a B.S. in Agricultural Engineering. We should try to keep this at a minimum, so the students will have sufficient electives in their programs to explore other areas, provide breadth, or to take advanced courses in the same areas, to provide depth to their program.

The technical needs of a country or countries vary greatly. An Agricultural Engineering curriculum in one country would very unlikely be the same as a curriculum in another country. If we were fairly certain that a majority of students would go into one occupational area, such as soil and water engineering, the program could be slanted to meet these particular needs through course and curriculum design.

The curriculum should consider the first job and, at the same time, the other opportunities for service which might develop by time of graduation or shortly thereafter in another area. These areas of concern change rapidly. As countries set up specific objectives and devote money to carrying out these objectives, the expertise needed changes. A person who thought he was going to be in soil and water engineering might, within five years, be working in an area related to preservation of grain or mechanization systems, depending upon national programs and industrial development. This happens quite often in developing countries where changes in internal administration and external support may quickly shift goals and areas of emphasis. At the undergraduate level a minimum of one course in each area might be sufficient with an additional course or two in the student's expressed area of interest. This student would then be qualified to enter occupations of secondary interest should such financial support be greater at a later date. One of the important aspects of Agricultural Engineering is the ability to define the problem, analyze the problem, and set up procedures for solving the problem. These approaches will be incorporated in several of the courses the students take regardless of the area of concentration.

The breadth of an undergraduate program must be given considerable weight. Perhaps this breadth is even more important in a developing country where much work must be done with people in developing new and changing old attitudes. There will undoubtely be much mobility of students after graduation. In developing countries college graduates often move quite rapidly into administrative jobs. Here a broader background and particularly an acquaintance with all areas of Agricultural Engineering is needed. It is quite acceptable to me that we talk about areas of concentration within Agricultural Engineering at the undergraduate level, but I would do this only if we get a breadth whereby the student receives education in all areas important to the particular country.

The cost of developing and teaching the courses in the undergraduate curriculum, if not now, will in the very near future, come under close scrutiny. Better student enrollment in the courses will result under the breadth depth ratio as mentioned above. As engineers we would like to be more quantitative in our approach to the solution of the design of curriculum. So far the equations have eluded us.

GRADUATE PROGRAM

As the country develops, more advanced training and education are required to meet the needs of the various segments or the sectors of the economy. One method of meeting these needs is through a graduate program, commonly one to two years beyond the Bachelor of Science degree. Longer time is required if the equivalent of an undergraduate degree has not been obtained previously. Options must provide as many paths as possible to reach the advanced level of training. Thus, we should include the potential for people with non engineering degees and engineering degrees other than agriculture, and for Agricultural Engineers to take advanced work leading to a Master of Science. In order to meet the advanced educational needs of a country, we can provide a Master of Science in Agricultural Engineering or a more limited Master of Science in an area of specialty. In our planning we have attempted to provide this flexibility here at the Universidad Agraria. In general, the advanced degrees provide the opportunity for gaining additional depth in engineering subjects. Many of these subjects can be taken outside of the engineering faculties, including mathematics, physics, biological sciences, etc. The Master of Science degree should terminate with the presentation and defense of a thesis based on design and/or research work. As design remains a major need and objective in developing countries, I believe design option should be available in engineering programs in developing countries. Thus, graduate programs in Agricultural Engineering should integrate advanced science and engineering, research, and design. Thesis subjects should be based upon real and expressed needs.

Some individuals have a tendency to minimize the importance of research in developing countries. The following points illustrate the importance of research in developing countries:

1. Some problems are prevalent which have not been solved elsewhere.
2. Solutions to problems offered by a more advanced economy might not be applicable because of differences in religious, economical, or sociological environments.

3. Solutions to problems must be evaluated, using local conditions, considering crops, varieties, soil, climate, and other natural resources.
4. A spirit of improvement and progress will be made by local people if they are involved in the improvement of their economy.
5. The interrelationship of workers in various fields of endeavor and the interdependence of the various areas of knowledge are demonstrated and practiced in a research environment.

In general, research carried on by the student in his home country to solve a visible and expressed problem, and carried out under proper supervision, will be much more valuable to the student and to his country than one carried out 10,000 miles away. Thus, our program located here can help serve the countries concerned and involved.

SUMMARY

Usually one summarizes a paper by selecting points presented previously and emphasizing these in the final minute or two. Generally it is not acceptable to present new ideas in this summary. I am going to take exception to this approach.

There are no quick or easy answers to provide for economic development. We must all be prepared to exert our utmost of efforts and energy to a long-time program of development. In the proper social, political, and economic environment, three basic physical networks are needed. These three networks are communication networks, transportation network, and a power network. Agricultural Engineers around the world for the past 50 years have worked in strengthening and building these networks. Agricultural Engineers have worked on segments of these networks--no one professional group handles the entire network. And if, in your country, one of these networks is lacking or not being developed, it may provide the focus for developing new programs of service in Agricultural Engineering such as, telephone systems, rural power lines, rural road development, etc. The need might be, of course, a curriculum, a research project, or a public education campaign.

Inauguration Day:

2. ROLE OF AGRICULTURAL ENGINEERING IN MEETING THE NEEDS OF IMPROVED RURAL LIVING & AGRICULTURAL PRODUCTION.by C.G.E. Downing, Director, Agricultural Engineering Research Branch, Canada Department of Agriculture- Ottawa, Canada.

The title of this paper limits somewhat the role of the agricultural engineer in our modern thinking that technology in general can affect all of society. Although agricultural engineering is concerned primarily with agricultural production and rural living, its benefits or shortcomings can affect other segments of the community or society. The water that flows from or through agricultural land is utilized by many others for various purposes; likewise the air that blows across agricultural land is used by other people, and certainly the products which are the result of agricultural people's work are used by all of society. The very definition of engineering implies a broad involvement and responsibility when related to production from the materials and resources of nature. Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgement to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.

It is not difficult to philosophize, make general statements and state platitudes in regard to such basic principles and responsibilities, but it is much more difficult to implement them effectively. It is important that the young engineer of today and tomorrow be more fully aware, than engineers of the past, of the sociological implications of his research, developments and other works, not only on the people with whom he works in agriculture, but on service industries and society as a whole. However, agricultural engineering must first begin at the grass roots operation and have its impact on agricultural production before there is likely to be any appreciable benefits or improvements in rural living or for that matter, in the living standards or conditions of the rest of the nation.

Agricultural engineering research, development and application in the real sense of the word, is of fairly recent origin and has been carried out in most areas in rather piecemeal fashion without any great degree of organization or direction. Despite this apparent lack of direction great progress has been made in many areas. Some significant accomplishments have developed through a trend from the elementary to the complicated while others have come about due to expediency and priority of emergency problems that have developed.

A major example of achievement from an emergency was the development of the mulch tillage system and equipment for dry-land grain farming in Western Canada and Midwestern U.S.A. which resulted from the serious drought and wind erosion catastrophe of the 1930-40 era. Although there was some evidence prior to the time of this emergency that the agricultural practices being carried out were not particularly satisfactory for production in this areas, no planned research and development was carried out until the emergency developed. Then through the initiative and innovative capacity of a number of engineers and others faced with the problem, an entirely new system of agricultural production with new machines and equipment evolved in a very short period of time and saved that part of two nations from almost oblivion.

History will probably record another spectacular development in the tomato harvester program in California in which a law of the State was passed which very seriously limited the human resources available for harvesting such a crop. The ingenuity and the initiative of engineers in government, university and industry were called upon to save this crop for the State and for the benefit of the nation.

We are now fast moving towards three serious emergencies being created by short term research and development activities. These are air pollution, water pollution, and product contamination from the use of pesticides and the disposal of agricultural wastes.

Despite these shortcomings, lack of organization, and direction, many other phases of agricultural production have occurred and rural living and working conditions have improved tremendously. The statement made some twenty years ago that in North America it would be necessary in the foreseeable future to have "two blades of grass grow where one grew before" has indeed come to pass. Present production levels have been accomplished through a great deal of research, development and application in the broad agricultural science are including agricultural engineering. Evidence of the agricultural engineering contributions and role is exemplified in the great diversity of po wer units and machines being used in all aspects of production, in the irrigation, drainage and water supply systems, in the farm buildings and other structures that dot the landscape, in the application of electric power to labour saving and automation equipment, in the processing of food and in the improvement of the environment , working and living conditions, and the aesthetics of rural living.

Although much progress has been made, there is evidence that there is potential for much greater increases to be accomplished. The research and development that has been carried out in many instances in the past has been associated with the more elementary and obvious aspects of problems related to various types of agricultural production. While there are still broad areas requiring this same approach, in many areas the research and development will have to be done in greater depth and with greater integration of resources in order to achieve the further potential in production that exists. It is important for countries who are just beginning to mechanize agriculture and to introduce other agricultural engineering developments to understand that there is a broad spectrum of activities that must be considered from the very elementary in field equipment and land drainage to the very sophisticated approaches to total automation.

Automation appears to be the direction in which all technology is moving. Regardless of the industry or the resource area that is being developed it tends to follow four logical steps which are important in the planning and assessment as growth and development occurs. These are:

The provision of:
1. Animal power to augment human muscle
2. Automatic machines to augment human skills
3. Instrumentation to augment human senses
4. Decision-making machines to augment human thinking

Most countries in the western world with developed agricultural programs have pretty well passed through step 1 and are in various aspects of step 2, depending on their progress in grain production, horticultural crop production or livestock production. In recent years there has been considerable development and activity in step 3, and some experimental work is being carried out in step 4.

There are certainly many specific challenges which face the agricultural engineer within this broad potential of increased production and rural living. There is the ever present challenge of taking the drudgery out of work and the load from the back of man. This is the most significant one in improving working conditions of the agricultural worker and which can contribute real benefit in rural living. In most of the developed agricultural areas of the world activity in this aspect has shifted from grain production practices to forage production or to fruit and vegetable production or to livestock production systems.

The agricultural engineer as an efficiency expert, must ever be prepared to analyze "patterns of progress" to ensure that what appears to be progress is in fact so. It is quite evident that increased sources of power are being utilized to produce greater crops. Aggregate average crop yields in Canada have increased from 0.6 tons per acre in 1951 to 0.9 tons in 1966. During this period of time available horsepower on the farm for the production of these crops increased from 18 horsepower per 100 acres to 42 horsepower. A quick analysis shows that the horsepower available per ton of production has increased from 0.3 to 0.46. A number of questions might well be asked. Are farms overpowered? Is power less efficiently used? Are the present total production systems the most efficient or is increased power an essential of more sophisticated mechanized and automated machines.

By definition, utilizing the materials and forces of nature for the benefit of mankind is one of the responsibilities of the engineer. With the great developments in materials science there is real challenge and opportunity for utilizing new types of materials. With the accelerated use of energy going into agricultural production, there is reason to consider whether there is unlimited sources of energy available in present form, or should new types be exploited for agricultural applications.

As an applied scientist, the agricultural engineer should ever be searching the frontiers of scientific breakthroughs in all fields of endeavour to study and assess their potential for utilization in agricultural production practices. What type of spin-off can be expected from the space programs under way , or from the nuclear energy developments in the country , or what type of feedback is there from the developments in the Armed Services?

The agricultural engineer must be a synthesizer of ideas, concepts and practices and should look at the total involvement of men, machines and materials in the various agricultural production programs. Systems engineering encompasses such a total involvement. It is an area in which the agricultural engineer must play a leading role in our modern concept of mechanized and automated agricultural production and in the control of environments associated with production practices or resource conservation and development.

As mentioned previously, most agricultural engineering research and development in the past was done in a piecemeal fashion without any long term planning or was carried out because of emergencies that developed. The old adage "necessity is the mother of invention" produced great results and the agricultural engineering role was one of action and expediting. However, in this day and age, with costs rising so rapidly and with the sophistication that is coming into research and development, it is essential that better long term planning and co-ordination be fundamental factors in research and development for the future. This is particularly true for new countries or new agencies in which agricultural engineering is being introduced.

While it is advisable to capitalize on the progress made by other countries and agencies and to assess their failures and shortcomings, it is most important to plan and organize programs such that meaningful results will accrue that are pertinent to the real problems that do exist or which are foreseeable in the future. The modern concept of management by objectives is a very practical way in focusing attention on these requirements for agricultural engineering.

It is necessary that the programming in agricultural engineering be related to the broad aims for improving agricultural production and it must also be related to the broad objectives of the organization or agency of which agricultural engineering is a part. The total aspects of the role of agricultural engineering in agricultural production or improving rural living, cannot be properly carried out in isolation but must be associated with the whole system.

It is important to first define the specific aspects of the programming concept so that all factors can be kept in perspective as the process of establishing and conducting research and development and its application takes place such that real and meaningful results might be achieved. The main factors involved are aims, objectives, goals, and activities or projects. Although they all seem to be headed in the same direction, each has a separate function which is defined as follows:

1. AIMS- Aims are statements of the basic purposes or missions related to the total picture of production or of an organization engaged in a part of the process. They are intended to give general direction and broad perspective and have quite a long life span.

2. OBJECTIVES- Objectives are broad statements about what an organization engaged in a segment of the process wishes to achieve. They are less broad than aims, have a narrower focus and often have a shorter duration.

3. GOALS- Goals are statements of specific results to be achieved , often with a definite time interval. They serve as targets to be shot at and hit.

4. ACTIVITIES or PROJECTS- Activities or projects are actions, operations, processes, etc., through which results are achieved to satisfy the goal.

On the basis of these concepts, the general goals of agricultural engineering research, development and application are put in focus with the broad aims and objectives of increasing agricultural production and improving rural living. Although in some instances the agricultural engineering goal may be a major factor in the organization's objective, in others it may only be a minor activity, but must be satisfied in order that the objective can be completely realized. This highlights the need for co-operative projects in agricultural production and interdisciplinary approaches to many of the problems. It is also necessary to appreciate that there will be a diversity of agencies involved in research and development in agricultural engineering in any country and therefore it should not be expected that any one agency would do all that is required. Thus there is need to be aware of other activities being carried out elsewhere in agricultural engineering and to encourage co-ordination among the various agencies. These agencies might include federal research stations, universities, provincial governments, industry, farm organizations, co-operatives, and individual farms.

A. Broad AIMS for Agencies Involved in Research, Development and Application in Agricultural Production and Rural Living.

1. To improve production of agricultural products and food.
2. To safeguard quality of agricultural resources and to improve working and living conditions for agricultural people.
3. To contribute to the universal pool of scientific knowledge and to support the development of agricultural science and technology.
4. To make available to farmers the results of advances in research.

These broad AIMS pretty well cover the requirements of a country in regard to agricultural production. They do not however touch on the aspect of marketing or distribution that helps to make them available for human consumption. It is unlikely that any one agency would carry the complete responsibility to satisfy all of these aims. Also, any one agency might be involved in more than one of the aims but not carry the complete responsibility or coverage of activities related to it. It is therefore essential in the planning to outline less broad aspects of the program into more finite objectives for various types of agencies that might be involved. The following generally outlines these objectives in regard to agricultural engineering.

B. Broad OBJECTIVES for Agencies Involved in Agricultural Engineering Research, Development and Application in Agricultural Production.

1. To improve the economic efficiency of agricultural and horticultural production units.
2. To improve the efficiency and quality of agricultural and horticultural crop production.
3. To improve the efficiency and quality of livestock production.
4. To control insects, diseases and other pests that affect agricultural production and storage.
5. To process and manufacture feed for livestock and food for human consumption.
6. To attain better utilization, conservation and pollution control of water, soils and air for agricultural production.
7. To create improved environments and conditions of work and living for agricultural people.
8. To aid in the development and conduct of biological and other research involved in improved agricultural production through the investigation of new engineering concepts, development of systems, instruments, apparatus, controls and devices to increase the scope, accuracy and efficiency of such research.
9. To utilize efficiently and economically the materials and forces of nature through the production of food and fibre for the benefit of mankind.
10. To contribute to the universal pool of scientific and technical engineering knowledge and to support the development of agricultural engineering.
11. To make available to farmers the results of advances in engineering research and development applicable to agricultural and horticultural production and to improving rural living.

These OBJECTIVES are fairly broad but they bring into focus the areas and types of responsibilities in which agricultural engineering must be involved and around which goals and projects or activities might be planned and conducted which could have some effect on agricultural production or in rural living.

Although some large agencies might be involved in all of these objectives at one time or another, smaller agencies would be wise to be selective. They should choose those which pertain to present or foreseeable needs in agricultural production in the region in which the agency has responsibility. Those selected need to be assessed and related to present or potential resources both in regard to individual goals and projects as well as interdisciplinary programs. Unless GOALS, PROJECTS and ACTIVITIES are specific and get down to the real assessment, decision making, planning and operations, AIMS and OBJECTIVES simply remain as paper operations.

General GOALS which cover the main fields of agricultural engineering will be outlined first. Out of these more definite goals, or projects could be developed for any specific agency.

C. GOALS for Agricultural Engineering Research, Development and Application for Agricultural Production and Improving Rural Living.

1. To improve the utilization of existing energy sources and to exploit new energy sources for power, heating, lighting and other applications in agricultural production, processing and transportation.
2. To develop, evaluate, or improve man-machine systems to prepare a seedbed, plant seed, apply fertilizer and other materials to permit optimum growth conditions with effective and efficient weed, pest and disease control to ensure the economic production of quality agricultural and horticultural crops.
3. To develop, evaluate, or improve man-machine systems for the efficient and economic harvesting and handling of agricultural and horticultural crops.
4. To develop, evaluate, or improve equipment, methods or systems for control of optimum soil-air-water relationships for agricultural and horticultural crop production.
5. To develop agricultural building construction systems combining structural elements, cladding, thermal insulation and other components in order to provide economical and functional farm buildings for processing and storing farm crops, for the housing of farm livestock and farm people.
6. To develop and evaluate systems for mechanized and automated feeding, confining, sorting and handling of farm livestock for collecting livestock products and for removal of animal wastes.
7. To develop, design and evaluate air-moving systems, humidity and temperature control, heating , cooling, lighting and other items to provide optimum plant, animal or human environments in farm buildings and farm homes.
8. To conceive, develop and evaluate safe and economical storage, treatment, handling and disposal methods especially suitable for agricultural wastes to ensure against air, water or soil pollution.
9. To conduct experimental or developmental studies on new engineering concepts, systems and equipment in support of biological research related to agricultural production.
10. To develop and maintain a technical and scientific information resource in agricultural engineering integrated with other information resources for the use of research engineers and others.
11. To publish scientific and technical papers and farmer-oriented publications on research and development being conducted and new information obtained from other sources.
12. To give consultant, advisory or instructional information at workshops, seminars, committee meetings , farm groups, etc., on new developments in agricultural engineering and to assist in the development of agricultural engineering standards, codes and recommendations.

To be specific in regard to an individual agency, assume that the agricultural engineering operation is part of a research station or agency concerned with horticultural crop production and that this agency is part of a broader national or international operation concerned with total production in a region.

Looking at the broad AIMS as outlined above agricultural engineering would definitely have major responsibility to AIM A-1 with lesser concern to the other AIMS. It would also be concerned with OBJECTIVES B-1, B-2, B-4 and B-6 with lesser interest in some of the other OBJECTIVES. In regard to the general GOALS, it would need to be concerned with GOALS C-2, C-3 and C-4 with lesser interest in a number of other GOALS.

Further assuming that an economic crop for the area was apples, specific sub-roles or projects might well take the following form:

(1) By 1971, to develop a spraying system and satisfactory equipment to economically control insects and blight on apple trees (related to GOAL C-2).
(2) By 1972, to develop an apple picker to remove apples suitable for the fresh fruit market (related to GOAL C-3).
(3) By 1974, to develop and evaluate a drainage system for apple orchards to give optimum soil-water relationships (related to GOAL C-4).

It is now possible to effectively plan the activities, evaluate resources and prepare estimates with some assurance that the work will assist in fulfilling the AIMS and OBJECTIVES of the whole organization and it pinpoints the specific role of agricultural engineering in this aspect of production.

A second case might be considered that fits within the broad AIMS and OBJECTIVES of the larger organization, but at another research station or agency which has different responsibility than the previous one in the total production program of the region. Assume that this research station or agency has responsibility in livestock production. Here again it would appear that it had major responsibility in regard to AIM A-1. In the broad OBJECTIVES area it would appear that its main responsibility was related to OBJECTIVE B-3 with its specific interest in general GOALS C-5 , C-6, and C-7.

Now assume further that a major priority of the agency of which agricultural engineering is a part is in the area of beef cattle and the decision to develop a confined feeder operation on slotted floors has been made. Immediately it appears that three sub-GOALS or projects must be developed.

(1) By 1972, develop and construct a suitable structure for the confined housing of 200 head of beef feeders using a slotted floor design (related to GOAL C-5).
(2) By 1972, design and develop and automated feeding, watering and livestock handling system for 200 head of beef feeders confined in a slotted floor housing structure (related to GOAL C-6).
(3) By 1972, develop and design and air-moving system, humidity, temperature and lighting control system for the optimum environment for 200 head of beef feeders in a confined slotted floor housing structure. (related to GOAL C-7).

Now, if an overview is made in the overall planning it will be realized that only part of the responsibility has been met and that attention should be directed to OBJECTIVE B-6 which tends to support AIM A-2. Thus, an additional specific GOAL or PROJECT must be developed such as (4).

(4) By 1972, conceive and develop a safe and economical storage, treatment, handling and disposal system for livestock wastes from a 200 head beef feeder slotted floor confined structure (related to general GOAL C-8).

Here again, planning, resource assessment, financial requirements, etc. can be developed with assurance that the projects will satisfy the broad AIMS and OBJECTIVES of the total organization as well as those of the individual research station or agency. It will indicate the role of agricultural engineering in this phase of agricultural production.

One of the major factors in the complete planning and production process which has been inferred in a number of instances is that of coordination within agencies as well as among agencies involved in the agricultural production and rural living environment.

The cost of research and development and the availability of resources in agricultural engineering emphasize the fact that duplication of effort should be avoided except perhaps for a limited amount that might be justifiable in the academic field of post-graduate education.

Co-ordination of agricultural engineering activities can only really be well carried out if these is co-ordination in the total production areas and at the higher levels of agency administration. However, the agricultural engineer, by virtue of his basic role in the handling of men, machines and materials, should take leadership in co-ordination activities.

In summary, it might well be said that the role of the agricultural engineer in agricultural production and rural living is to take the load from the back of man and the drudgery out of agricultural work and to improve the environment and living conditions for agricultural people.

As an efficiency expert, he must also see that waste is eliminated in all phases of production and that all operations function efficiently and effectively.

He must be ever searching the frontiers of all research and development for new materials, sources of energy, concepts and systems that could be utilized to improve various phases of agricultural production.

He must give leadership as a co-ordinator and be an expediter of all activities in which he becomes involved.

Theme 1: THE STATUS OF AGRICULTURAL ENGINEERING EDUCATION IN LATIN AMERICA

3. THE STATUS OF AGRICULTURAL ENGINEERING EDUCATION IN LATIN AMERICA: ARGENTINA by Teófilo V. Barañao, Faculty of Agriculture and Veterinary Medicine, University of Buenos Aires.

AGRICULTURAL ENGINEERING EDUCATION AND THE AGRICULTURE IN ARGENTINA

Teaching of Agricultural Engineering, at a level similar to that of La Molina, that is, a university education level, as yet does not take place in Argentina.

We feel that, in essence, Agricultural Engineering is that profession which applies exact sciences, Mathematics, Physics, Graphical and Analytical Sciences, to agriculture, while taking into account the biological and social factors of the rural environment. It can be included within the general context of Engineering because it is based on a strong foundation of the aforementioned sciences; and within that of Agronomy because of its relationships with the agrarian environment.

Engineering has been defined as the science and the art of organizing the work and using the materials and sources of energy provided by nature to the benefit of mankind. This is the basic concept associated to the handling of inert elements; but scientific progress has made it possible to broaden the field of Engineering to cover part of the biological sphere. There lies the origin of Agricultural Engineering which, according to the concepts now in force in Argentina, is substantially based on the natural sciences, especially the biological, with the indispensable complement of Chemistry, Economics and Sociology as applied to Agriculture.

The eight national faculties of Agronomy have a certain agreement as to curriculae as regards to a proportional distribution of basic and applied sciences. In these curriculae there is a marked preponderance of natural sciences over physics, mathematics and engineering. Of an average of 37 subjects in a curriculum for a degree only 16-18% correspond to physics and mathematics and their applications to rural Engineering.

The Faculty of Agronomy and Veterinary Medicine of Buenos Aires and the faculty of Agronomy of La Plata have a Department of Rural Engineering within their educational structure. The department includes Surveying, Applied Mechanics, Agricultural Machinery, Agricultural Hydrology and Rural Construction; the latter being an elective at Buenos Aires. This is in fact a nominal grouping; there is no administrative organization or agency in charge of coordinating teaching and research activities in these disciplines. Meetings are rather infrequent and are called mainly to discuss general affairs related to the administrative function of the Faculty. Usually the head professors of these disciplines act independently as regards to the teaching problems and, as regards to administrative affairs they handle these directly with the authorities of the universities. It must be pointed out that the Rural Engineering Department excludes basic subjects such as Mathematics, Physics, and Statistical Calculus; thus the lack of educational coordination becomes even more marked.

Other Faculties have also tried to apply the same system, but only nominally and with similar results.

At the National University of the South, at Bahía Blanca, due to its departamental structure, Agronomy participates to a greater extent that in other Universities in a joint and coordinated action; there is better communication between the disciplines included under each Department.

Specializations in Agricultural Engineering

It is difficult to establish an order of priorities for specializations in Agricultural Machinery, Irrigation and Drainage, Agricultural Structures and Rural Planning, Processing of Agricultural Products, etc., due to the many problems of a technical nature to be found in Engineering and which arise in Argentina's vast territory.

Argentina has a surface area of 280 million hectares, broad-ranging climatic conditions which go from the subtropical to the glacial; regions of frequent and plentiful rains alternating with others of scarce rainfall in which, fortunately, 1.25 million hectares have been placed under irrigation; with 30 million hectares under cultivation, equivalent to only 10% of its total territory and of which 22 million hectares involve annual crops, which implies plowing and planting all year round; with a vast and growing agricultural machinery pool though not in pace with the progress of the world of today; with 500 plants turning out agricultural machinery and implements, giving employment to 25 thousand blue and 8 thousand white collar workers; with plants producing about 13 thousand tractors a year; with rural electrification plants based on thermal plants for the pampa plains and channeling the power produced by the hydroelectric plants now under construction into industries manufacturing milk, oleaginous , wine, textile and sugar products, complemented with the use of secondary products and the preparation of balanced feed rations; with the urgent problem of rural housing and agricultural construction adapted to the climate and social characteristics of the environment, based on the use of regional elements and raw materials, where prefabricated materials for cattle and poultry installations built according to modern standards can be successfully used; with the growing demand for perishable products classification and conservation plants; with countless problems in need of immediate or mediate solution, as can arise in a country in the process of development such as ours; with all the above in mind it can be stated that Argentine offers the Agricultural Engineering profession broad and actual perspectives with no order of priorities.

Employment

For the Engineer, including all specialties within this term, Argentina at present offers full employment. However, at present there is great concern because of the migration of university professionals, among which engineers predominate, which poses a serious social and economic problem. Agricultural Engineers are not involved in this phenomenon. It is probable that INTA - Instituto Nacional de Tecnología Agropecuaria (National Institute of Agricultural and Cattle Technology) whose specific activities absorb a great number of graduates for experimental and research work, towards which activities present education prepares or even leads them, creates the stability and balance between the number of graduates and the number of positions open. We could even affirm that there are not enough Agricultural professionals to satisfy the demand.

One explanation given for the exodus of non-agronomical engineering professionals is their solid physicomathematical scientific foundation. This being the reason for the demand for their services in industrialized countries which have technical problems whose solutions can be found mainly in advanced theoretical knowledge. Not only the pragmatic perspectives, but also the possibility of working in top level foreign scientific centers contribute to this attraction.

Full employment is not an obstacle but rather a confirmation of this statement: there are not sufficient graduates to satisfy the needs. National universities do not turn out the numbers required by progressive development; possibly because of the lack of material resources such as classrooms, laboratories, experimental fields and, what I feel is most important, the scarcity of top level teachers.

This, I suppose, is the reason for the establishment of private universities, born from the need of providing education to large numbers of candidates who could not enter the National Universities. The lack of a true university spirit, due to improvisation; and their limited resources to equip laboratories, libraries and teaching aids and, even more serious still, the lack of teaching capabilities in many cases, prevent these Universities from carrying out an acceptable job in the field of agronomy and, in particular, of Agricultural Engineering.

Post Graduate Level Agricultural Engineering Curriculum

A graduate course has been given since April 1968. A school for this purpose was created by an agreement of June 27, 1967 among the University of Buenos Aires, University of La Plata, the National Institute of Agricultural and Cattle Technology of Argentina and the Inter-American Insitute of Agricultural Sciences of the OAS. The course started on that date was entitled "Use of Agricultural Machinery". Its purpose was to "strengthen among the participants the basic knowledge which will permit them to make a better interpretation of the complex problems posed by agricultural mechanization and, specially, to complement their professional level know-how with a good physico-mathematical basis which is of the utmost importance to face the possible applications in the field of agricultural and cattle technology within the scope of this specialty.

For more than a decade we have been struggling for the creation of a specific career in Agricultural Engineering. Taking advantage of the opportunity created by the approval of a recommendation of the First Pan American Congress on the Teaching of Engineering Associations of September 12 to 17, 1960, we submitted a project which proposed the study of the feasibility of such work, at the University of Buenos Aires. With the approval of the university authorities the idea was accepted and a joint Commission, formed by Agriculture and Engineering professors was set up. I was honored to represent the former. After its discussions the initiative was approved and a curriculum, which I can discuss with you in detail was drawn up.

For different reasons the plan has not been implemented to date, only attempts at working out professional equivalences and the relationship between careers in Agronomy, Land Surveying, Industrial or Civil Engineering. Thus we would achieve a technical graduate integration within the framework of Agricultural Engineering adapted to Argentina. The first professionals in this specialty could be graduated in two years. I feel that a University such as that of Buenos Aires, with Faculties of Agriculture and Engineering by means of joint action could provide Agricultural Engineering Education just by coordinating a curriculum which would be integrated to the disciplines at present taught in each School. For example, all exact, theoretical and applied sciences could be taught in the Faculty of Engineering and all the biological, chemical and natural sciences at the Faculty of Agriculture.

Furthermore, the following basic postulates would apply: a) their establishment would not affect the University budget; b) it would result from the joint educational efforts of the two Faculties from the same University.

This is not an utopian concept; many professors of Engineering and Land Surveying frequently consult us and show their interest in such integration of knowledge when they contemplate the opportunities offered by the technological outlook stated at the beginning of this paper. This is so much so that, looking at it from a single angle, that of Agricultural Machinery and Mechanization, we can appreciate the satisfactory results which can be obtained from the participation of professionals trained in this field. The reason I am using this example is my experience gained in handling the coordination of the present course at the Graduate School, to which I have referred previously. I feel that the small number of participants is due to the handicap posed to these professionals- Agricultural Engineers- in facing, at some time in their lives, the acquiring of theoretical knowledge in the physico-mathematical sciences and their applications to Mechanisms, Thermodynamics, Soil Mechanics, Electrotechnology, etc., whose intensity and depth was limited to 50 quarterly hours, for each of them.

On the other hand, those that have passed the curriculum will have the degree of Magister Scientiae, but this shall be an academic degree whose worth shall only be appreciated by teaching and research institutions and shall have no legal value for private industrial and agricultural enterprises.

This would not apply if a similar experience at a higher level were attempted with Agricultural and Engineering graduates of the different specialties. The conquest of knowledge in Chemistry, Biology and Agronomical subjects would be more accessible to the graduates of these professions because of their sound foundation in the formative disciplines of the exact sciences.

I must report that in the Agricultural Machinery industry, in grain elevators, in the transformation and fermentation agricultural industries, in the irrigation and drainage works, in sistematization tasks, in cattle raising constructions, in land subdivision and colonization planning and in other activities of an agricultural nature, there is a large measure of participation of Engineers and Land Surveyors but very little of Agricultural Engineers. However, the former have found serious difficulties because of their lack of knowledge of the typical factors of the rural environment, its multiple aspects fully within the field of Agronomy; a phenomenon which implies a dispersion and poor use of capabilities which is detrimental to the State and the community.

This is why the legal aspects and professional competence must be borne in mind. Present legislation provides for the exercise of the so called liberal professions. The philosophy applicable to these cases is based on the need of establishing measures to protect the health and the property of the community.

The so called Professional Councils have been established for purposes of compliance of the different laws and regulations; these are bodies which unite the graduates, registered in the different Registers, with the guarantee of the degree granted by the Universities. Thus they assure their elegibility to carry out their tasks, based on the scientific and technical knowledge of their respective specialties.

This concept is brought to light with the idea of dispelling any doubt which could arise as regards to the competence of the future Agricultural Engineers in tasks which, at present, are carried out by other professionals. It is not a question of granting unfair advantages or privileges; unfair competition and the encroachment on other jurisdictions are censured by professional Ethics. We have taken very much into account that scientific and technical preparation can make it feasible for the Agricultural Engineer to concurrently carry out the tasks which at present are handled by other professionals.

What is important in these cases is to provide the graduate with sufficient and necessary science to meet the demand posed by present circumstances with their different problems and whose solution can probably be found in "teamwork", which has proven so fruitful in those human societies having a heightened sense of cooperation.

With the above I believe I have given you an objective idea of the status of Agricultural Engineering Education at present in Argentina.

Theme 1:

4. THE STATUS OF AGRICULTURAL ENGINEERING EDUCATION IN LATIN AMERICA: BOLIVIA by Oscar Torrico , Faculty of Agricultural Sciences, Universidad Mayor de San Simón.

AGRICULTURE ENGINEERING EDUCATION AND THE AGRICULTURE IN BOLIVIA

I. Agriculture Engineering Education.

The year of 1963, marks the beginning of Agriculture Engineering Education in Bolivia with the establishment of the Department of Agriculture Engineering at the Agricultural Science Faculty of the Universidad Mayor de San Simón, in Cochabamba. This Department was considered within the organization of the Faculty in a project between the government and the Special Fund of the United Nations.

Although the Faculty of Agricultural Sciences considers some courses on agriculture engineering in the 'ingeniero agrónomo' curriculum, the establishment of the Department of Agriculture Engineering started a semi-specialization in irrigation.

In 1967, the Faculty of Agricultural Sciences presented to the University Council a reorganization programme based on two aims: 1) organization by departments, and 2) semi-specialization. A new program of studies was approved based on the courses offered by seven Departments:

1. Department of Agriculture Engineering
2. Department of Soils
3. Department of Technology
4. Department of Plant Breeding
5. Department of Animal Husbandry
6. Department of Forestry
7. Department of Agricultural Economy and Sociology

The new program of studies includes for the last year or fifth grade, four elective courses of semi-specialization for each one of the seven Departments, so that the future Ingeniero Agronomo may register on the Department at his free election, under a flexible curriculum.

The elective courses under the present organization by department of a Faculty of Agriculture Engineering are as follows:

Department of Agriculture Engineering:

1. Irrigation and Drainage
2. Underground Water
3. Rural Electricity
4. Rural Housing and Planning

Department of Soils:

1. Soil Conservation
2. Derivation, Morphology and Classification of soils
3. Soil Surveying
4. Soil Salinity

Department of Technology:

1. Dairy Industry

2. Meat Industry
3. Fruits and Vegetable Industry
4. Vegetable Oils
5. Wine Industry

These courses are part of a new Program of studies now under way, supported by a loan agreement between the Universidad Mayor de San Simón and the BID to guarantee the economical aspects of its operation, including the construction of physical facilities.

This effective impact on the development of the rural areas on behalf of the Agrarian Reform now in full enforcement in the country, determined the establishment of a second centre of Agriculture Engineering in Bolivia, in the Ministry of Agriculture under the Division of Development for Rural Communities. This department now keeps a section of Agriculture Engineering with its own budget and in charge of all the small irrigation projects at a national level, coordinating the applications for loans on this line. At present, this Division works in coordination with the Agriculture Extension Division and the Division of Cooperatives.

Before the development of these centres of Agricultural Engineering, all the irrigation projects, big and small, were centralized in the General Direction of Irrigation, under whose administration two important irrigation systems were built in the country:

1. The irrigation system N° 1 of La Angostura, for the irrigation of 10,000 Ha. in the zone of Valle Bajo (Low Valley) of Cochabamba.

2. The irrigation system N° 2 of Tacagua for the irrigation of 5,000 Ha. in the zone of the Altiplano.

The technical personnel of the above mentioned centers are Civil Engineers and Ingenieros Agronomos with a semi-specialization in Agriculture Engineering, as they are both in Mexico as well as in La Molina, Lima, Peru. Including graduate courses in Irrigation offered by Zona Andina of IICA and the Interamerican Center for Integral Development of Land and Water Resources (CIDIAT) in Mérida, Venezuela, sponsored by Utah State University and Project 213 of the Technical Cooperative Program of the OEA.

The Ingenieros Agrónomos who graduate from the Faculty of Agricultural Sciences of the Universidad Mayor de San Simón under the programs of studies prior the reorganization, are capable of receiving the semi-specialization courses offered in the above mentioned countries because the following engineering courses were included in their curricula:

- Mathematics
- Topography (Surveying)
- General Hydraulics
- Rural Construction
- Basic Technology
- Agriculture Machinery
- Agriculture Hydraulics

Because of the needs imposed by the Agrarian Reform in Bolivia, there has been a special aim for the development of only two branches of Agriculture Engineering: a) Irrigation and Drainage, and b) Rural Structure and Rural Planning.

As there is in the country a Center of Agricultural Education with a program of study that aims to prepare Ingenieros Agrónomos with a semi-specialization in seven fields, one of which is agriculture engineering and on the other part there is an organism of the same name at government level, the opportunities for work of such specialists are:

First: Teaching the elective courses under the new programme of studies; research, as now the Faculty of Agricultural Sciences has the Experimental Station of Tamborada which has been definitely transfered by the government to the University. It is important to remark here the intention of the new program of studies to integrate the Research Sections of the Experimental Station of La Tamborada to the corresponding Departments of the Faculty.

Second: Opportunities to work in this field, as the Central Division for Rural Communities Development, plans to extend its services to each of the States of the Republic keeping separate offices. In this second point, we must also mention the working opportunities dealing with the management of the irrigation systems, in accordance with the economical possibilities of each institution, there is the great interest to put into action the experiences of the agricultural engineer in the technical control of water management.

In the above analysis shows the present status of Education in Agriculture Engineering in Bolivia as due to the action of the Faculty of Agricultural Sciences with the definite objectives of getting a better use of water and land resources for the agriculture development, we hope that the Faculty under the new program will complete its work in the field of agriculture engineering, with the same responsibility towards the agricultural industries, pushing other fields of specialization such as Food Technology and Machinery, but always in accordance with the particular needs of the country.

II. The Agriculture Problem.

To be able to give a general idea of the problem of agriculture in Bolivia, it is necessary to consider three completely different zones: The Altiplano (high lands) the Valles Andinos (andean valleys) and the Llanos (the plains) that represent 16%, 14% and 70% respectively, of the total surface of Bolivia.

The population of Bolivia is of 4 336.900 inhabitants, of which 66% belongs to the rural area. If we distribute this rural population in the three zones of the country we will have the following percentage; 32% in the Altiplano, 53% in the valleys and 15% in the Llanos Orientales.

The above information was used as the social-demographic base for planning in the Agrarian Reform in the country, this fact cannot be forgotten, if one is to follow the development of Agriculture in Bolivia. The greatest impact of the Agrarian Reform, with respect to fragmentation and establishment of "minifundio" (sub economic holdings" was produced in the Andes valleys and the Altiplano, that is, in the rural zones of heavier population and smaller area. The Agrarian Reform in the Llanos Orientales, could not have the same characteristics, as the lands there exceeded the working possibilities of the rural population, never the less in these areas a new plan was developed : Colonization.

If it is true that the Agrarian Reform with the above mentioned peculiarities has had some handicaps, never the less the biggest error (taking into consideration the important social and economic transformation of the nation) has been that from the very beginning it has not included an agricultural plan for the affected properties. The work of the Department of Agricultural Engineering of the Faculty of Agricultural Sciences of Cochabamba was initiated after the functioning of the National Service of Agrarian Reform.

An schematical representation of the present agricultural production will show for the different zones, in accordance to the predominant climatic and soil conditions, the following:

In the Altiplano, there are two regions: 1) the high part to the north with a semi-arid climate, (dry spring, autumn and winter) and the section to the south with arid climate (low precipitation in all the seasons). The soils, considering its predominance, can be classified as shallow soils, mostly sandy, deep and saline. There are some clay loam and clay soils. The main crop of the high lands is potato, next in importance are oca, cañahua, quinoa, barley, etc. If it is true that in the highlands animals with importance of wool production such as vicuñas, llamas, alpacas are raised, at present there is under way a project for sheep raising, together with one in forrage utilizing ground water irrigation, sponsored by the Special Fund of the United Nations.

The zone of the valleys has a semi-arid climate (with dry spring, autumn and winter) soils are deep, medium deep and shallow with different textures: silty-clay loams; silty loams, loams and clays. It is a fertile zone for the production of cereals, potatoes, vegetables and specially for alfalfa, to increase milk production. In Cochabamba there is a plant for dairy products with a daily capacity of 40,000 liters. At present it is working with

25,000 liters a day. This zone is characterized for having the highest rural population of the country.

The zone of Los Llanos Orientales has the largest surface of Bolivia, and is represented by three regions, from the stand point of climate: The Llanos del norte, with humid climate with no definite dry seasons, with a predominance of jungle forest, 2) the Llanos del centro with a semi-dry climate without a well defined dry season, and with a predominance of forest and pastures, and 3) the Llanos del sur with a semi-dry to dry climate, with predominance of zeprophitics. Soils in order of importance are: deep, medium deep, silty-loam; clay-silty loam; and sandy loam. The main crops are: sugar cane, rice, cotton, tobacco, citrus fruits, rubber, woods, etc. At present there is under way an important project in the Beni zone, for cattle raising. In the region of Santa Cruz there are four sugar cane plantations with a yearly refining capacity of 95,000 tons of sugar.

The most important statistics on agriculture products can be summarized as follows:

Sugar cane	1 049,000 tons per year
Rice	43,000 tons per year
Potato	635,000 tons per year
Corn	224,000 tons per year
Wheat	40,000 tons per year
Barley	60,000 tons per year

As the country aims to be self sufficient for agriculture products, some projects in depth have been outlined such as the wheat program by the National Institute for Wheat, and there is no doubt of the important role that agricultural engineering with its branches: agriculture machinery, irrigation and drainage, food technology, and Agriculture planning and structures, has in this programme.

Theme 1.

5. STATUS OF THE EDUCATION IN AGRICULTURAL ENGINEERING IN LATIN AMERICA: BRASIL by Anivaldo Pedro Cobra, Professor of the Superior School of Agriculture "Luiz de Queiroz" Universidad de Sao Paulo, Piracicaba, Brasil.

1. GENERAL CONSIDERATIONS.
   1. 1. Geo-Agricultural informations
   1. 2. Climate and precipitation
   1. 3. Economy
   1. 4. Farm machinery industry
   1. 5. Transport

2. SOILS AND AGRICULTURE
   2. 1. Soils
   2. 2. Main crops
   2. 3. Irrigation

3. AGRICULTURAL COLLEGE EDUCATION
   3. 1. Colleges, enrollment and courses
   3. 2. Tendencies of Agricultural Engineering Education at the University of Sao Paulo
   3. 3. Closure

1. General considerations.

1. 1. Geo-agricultural informations

The Federal Republic of Brasil is divided into 22 states and 5 territories encompassing an area of 8,512,000 km^2. Table 1 shows some of the social and agricultural aspects presented by the 5 physiographic regions characterizing the country in 1960.

Region	Lands Cultivated 1,000 ha.	Farms 1,000 ha.	No. of farms 1,000 ha.	Population Rural 1,000	Urban 1,000	% Total Area
North	32341	458	138	1618	938	42. 0
Northeast	45999	6838	965	10377	5301	11. 4
East	65587	7792	954	12799	12034	14. 8
Middlewest	61445	1417	159	1953	1053	22. 0
South	60077	13253	1131	12229	12619	9. 7
Total	265449	29758	2247	38975	31990	99. 9

Table 1. - Lands of farms, cultivated lands, number of farms and rural and urban population of Brasil in the different regions totalized a population of 70,697,000 in 1960. (Brasil's position in World Agricultural Trade ERS - Foreign 190 U. S. Department of Agriculture, October 1967.)

Brazilian population is presently estimated as 92,282,000 inhabitants, based on a 3% annual rate of increasing. However, the population density is one of the lowest in the world, i. e. about 10 people per square kilometer. In 1960, 90% of the population and 93% of the cropland were located in less than half of the country's area and within a litoral band of about 500 km.

1. 2. Climate and precipitation.

As to climate, the North region presents a predominantly ecuatorial and sub-ecuatorial climate; tropical climate predominates in the Eastern, Central West and on the coast of the Northeastern region, with zonal variations; in the center of the Northeastern region it is semi-arid and in the Southeastern zone of the East region it is tropical of altitude. A sub-tropical climate predominates in the major part of the South region.

In certain zones of the Amazon basin, which encompasses the North and part of the South region, annual precipitation of over 2,500 mm occurs. In the Southern zone of the Central West and on the coast of the East region, annual precipitation of over 1,500 mm prevails. In most of the South region, rainfall of over 1,000 mm per annum occurs. Annual precipitation in the Northeast region is irregular: on the costal zone it reaches above 1,000 mm per annum, whereas in the center it varies around 500 mm. The area considered as the "Drought Polygon" encompasses part of the Northeast and of the East region, and measures 1,803,547 km2. In this area annual precipitation is quite irregular and often it does not reach 500 mm.

In December of 1967, there were 900 meteorological stations operating in Brazil, of which 106 were located in the South region.

Brasil's hydraulic potential is estimated at 54,060.8 MW, of which about 6,000 MW are being utilized; hydroelectric plants with generating capacity of 6,000 MW are under construction and in various stages of completion. There are projects which view to utilize 15,000 MW.

However, the country has been short on power sources, mainly in the most industrialized areas. Among the hydroelectric plants under construction, there is an atomic power plant scheduled to operate in 1970. The expansion of the hydroelectric system of the country has contributed to the establishment of rural electrification projects in certain areas. However, there is a need of professionals trained in this field.

1.3. Economy.

The economical development of Brasil is traditionally based on agriculture. Exports of coffee, rubber, cocoa, cotton and rice were the main agricultural products responsible for imports equilibrium of raw materials and manufactures. In recent decades a rapid industrialization replaced imported products, and resulted in a decrease in the proportionate contribution of agriculture to the gross national products.

Presently Brazil produces much of its domestic needs for automotives, wheel tractors, farm machinery and exports such products as business machines, machine tools and electronic equipment.

Along the period of 1947/51 and 1963/67, the average annual growth of the agricultural sector was 4.1%, whereas that of the industrial sector was 7.9%. The smaller agricultural growth for this period may be interpreted as a reflex of an economic policy that identifies economic growth wholly with industrialization.

Under this context it may be expected that industrialization is to intervene in the agricultural growth. However, even today over one half of the labor force in Brasil is employed in agriculture, which continues to be a significant economic factor in the cost of living and in that of industrial products. Thus, agriculture in Brazil is and will be the main provider of foreign exchange to pay for the imports of fuel and industrial machines which are imported for the development of the country.

A general analysis of the tendencies of the brazilian economic for the late years indicates a significant increase in agricultural production and mining. Estimates indicate a 5% growth of the gross internal product in 1967, a corresponding agricultural growth of 9.6% and a relatively small industrial growth of 1.8%. In 1968 the index of industrial growth was 12% whereas that of agriculture remained stagnated.

1.4. Farm machinery industry.

On the late fifties a stimulus was provided for the establishment of an automotive industry in Brazil. This was achieved through governmental policies restricting the imports of similar models that were to be manufactured in the country, and favoring imports of components needed by the industries. The establishment of that industry should be supported by an emergent national industry of automotive parts and others that were to be attracted by the market. The production of 10 automotive factories from about 31,000 units in 1957 reached 225,000 units in 1967, with an increasing rate of nationalization by weight of the vehicle. About one half of the output were passenger cars and the other half commercial vehicles.

The wheel tractor industry was established in 1960, supported by the infra-structure of the automotive industry and in the same patterns. This event contributed to consolidate the domestic industry of farm machinery and equipment established with low probabilities of success since the early fifties, in the main producing areas of the country. The tractor marketing caused an increase in the farm equipment demand, to the extent that now-a-days about 150 factories are producing in Brazil a wide range of machinery and equipment for soil tillage, cultivation, transport, processing and handling needed for the national agricultural production.

The annual production of the 10 tractor factories in Brazil is 13,000 units of light, medium and heavy models, with a weight index of nationalization of over 98%. Annual brazilian needs in agricultural tractors are presently estimated to near 25,000 units considering an annual replace of 10,000 units. Tractor factories are manufacturing only 9,500 units which is far below the needs. A series of reasons may have contributed for the relatively low demand of tractors, such as: delayed and relatively expensive maintenance of the machines, lack of knowledge on the part of the farmer to efficiently utilize the tractor, and the relatively high selling price of the unit. Besides, other reasons have been attributed and interpreted as a reflex of high taxation of the product, financing policies and others resulting and related to the development policy of the country.

Mechanization has not impressed the expected impact to increase brazilian agricultural production. The estimated index of mechanization in Brazil is one tractor for every 400 cultivated hectares. For the State of Sao Paulo this index is about one tractor for each 100 cultivated-hectares, with a rural population of about 35%. The establishment of these industries in Brazil provided excellent conditions for the manufacture of equipment needed in other fields of agriculture, such as: soil and water conservation, irrigation and drainage, handling and processing of agricultural products, etc. The food processing industry in Brazil has increased substantially in the last years, mainly as a result of population increase in more developed areas. The Institute of Food Technology of the State of Sao Paulo and the Faculty of Food Technology of University of Campinas have collaborated a great deal to the development of such industry.

1.5. Transport.

The brazilian system of transport is located mostly in the coastal areas because of the predominantly coastal population and to serve the export sectors. Most of the 40,000 km of railways were built around 1900 to serve the States of Sao Paulo, Minas, Rio de Janeiro and Parana. The expansion of the highway system during the last decades has imposed a considerable competition to sea and railroad systems of transport. This expansion was mainly due to the advent of Brasilia, the availability of national transport vehicles and the need to transport the production of rice, corn, cotton and meat of the West to the big centers. Presently the road system in Brazil has 20,000 km paved, 100,000 km unpaved and 450,000 of rural earth roads; the latter are quite affected during rainy seasons, which interferes with the transport of certain crops.

Total transport volume is now-a-day estimated as 62 billion ton-km by roads as compared to 18 billion ton-km by railroads and 15.5 billions ton-km by river and coastal shipping.

2. Soils and agriculture.

2.1. Soils.

In general, brazilian soils are tropical latosols, mainly red or yellow, highly leached due to rainfall and permeability, and with a low nutrient holding capacity. If podozolic soils occur, their characteristics are similar to the lotosols, except for a higher nutrient holding capacity and greater susceptibility to erosion. Except for the semi-arid zone of Northeast region, the pH values of the brazilian soils are high, i. e., between 4.5 to 5.9

The available land for expansion of cultivated area in Brazil is of a rather low fertility. However, research and experience have shown that these soils can be highly productive if adequate management, pH correction and fertilization practices are exercised. As a consequence of the rapid expansion of the road system, a substantial increase of the cultivated area should be expected in a rather short period. This fact emphasizes the need of qualified personnel to introduce and implement adequate soil conservation and management practices, in order to avoid a continuous shifting of farmers looking for less exploited lands.

Considering the potential and the position of Brazil in Latin America, it is very important for the region that careful attention be given to the establishment of projects viewing a better utilization of the complex soil-plant machine.

2.2. Main crops.

Generally speaking, any known crop can be produced in Brazil. Brazilian commercial agricultural activities started in the beginning of the 19th century, with sugar cane crop and cattle raising, followed by coffee planting, in 1850. Since then, coffee production had been the main support of the national economy throughout its succesive phasis of development.

Along the agricultural development of the country, coffee producing areas, searching for more productive lands, were located in the states of Rio de Janeiro, Sao Paulo and Parana. Nowaday the main producing states are Parana, Sao Paulo, Minas Gerais and Espirito Santo, the first two accounting for above 80% of the total production.

Coffee plantations in the state of Sao Paulo are undergoing a renewal, in order to utilize new varieties and agronomical techniques. In Brazil there are about 120 researchers involved in coffee investigation, and they have contributed considerably to improve varieties, agronomical techniques, production and other aspects. As regards to these sectors, more related to agricultural engineering, much has been done regarding soil conservation. However, attention should be directed to the mechanization of the harvesting process which at the moment is done almost entirely by hand. This is an engineering problem that requires a solution for brazilian conditions without neglecting what has been done in Hawaii and in other countries.

Data on cultivated area, estimated production and value of production for other main crops in Brazil, can be seen in Table 2. Aside coffee, cotton, sugar cane, corn and rice crops are among some of the most important export products.

	Cultivated area (1,000 ha.)	Estimated production (1,000 tons)	Value in NCr $1,000
Pineapple	30.5	225.0	40,226
Cotton	3,720.0	1,692.0	601,428
Peanuts	694.0	751.0	139,201
Rice	4,291.0	6,792.0	1,402,133
Oats	27.6	21.3	3,802
Banana	255.6	402.9	313,686
Sweetpotato	185.0	2,228.0	103,665
Potato	217.4	1,466.5	232,526
Cacao	473.0	195.0	143,203
Coffee	2,792.0	3,015.0	1,088.755
Sugar Cane	1,681.0	77,086.5	812,898
Onion	48.3	250.2	68,011
Barley	22.2	17.2	4,302

Mandioca	1,914.4	27,268.1	706.339
Corn	9,256.3	12,824.5	1,186.430

Table 2. - Principal crops of Brazil, cultivated area,estimated production and value of New Cruzeiros for 1967.

As to cotton, there are two main producing areas: in the South zone the variety upland predominates and the production of the states of Sao Paulo, Parana, Minas Gerais, Mato Grosso and Goias accounts for two thirds of the national production; in the North zone the variety "moco" predominates and is planted in every state of the Northeast and by some of the East region. The possibilities of cotton production expansion in Brazil are good. Presently there are 80 researchers involved with cotton investigation, who have contributed for the development of this crop.

Regarding mechanization, experiments conducted in the South zone indicate a series of problems limiting the use of cotton pickers, as follows:

Variety, soil preparation, initial cost and maintenance of the machine, together with other economical and social problems related to cotton picking crews. The use of strippers in Brazil is limited by the equipment available in the cotton gins, which are not adequate to handle stripped cotton. Research is needed to develop equipment and techniques for plant protection of insects and diseases for almost every crop in Brazil.

Sugar cane is cultivated in two areas in Brazil. The Southern area covers mainly the state of Sao Paulo, Rio de Janeiro, Minas Gerais and Parana. In the Northern area the main producers are the states of Pernambuco and Alagoas. About 180 brazilian technicians are dedicated to sugar cane research, and their work has contributed to make sugar cane one of the first export products. The average yield of the country from 1950/54 to 1960/64 increased by 10%. At present the average yield in Brazil is about 45 tons per ha. The yield of the state of Sao Paulo that accounts for about 30% of the national production is 60 tons per ha.

Future expansion of sugar cane crop is regulated by the "Instituto do Acucar e do Alcool" of Brazil through policies restricting installation of new mills and controlling production prices of the two producing areas, by favoring exportation through the north area. By 1970, following the installation of new mills and a new planning of crop and product development, it is estimated that Brazil will produce about 100 million bags of sugar.

Much improvement has been done to advance mechanization of field operations, transportation and harvesting of sugar cane crop in the South area. Practically all the equipments needed for crop development and industrialization of theproduct are manufactured locally. However, studies are needed to develop a more efficient harvesting system, as a process beginning with standing cane in the field and ending when the cane reaches the mill. This seems to be one of the main problems affecting sugar cane production in the South area whose harvesting system involves considerable hand labour.

Table 2 shows values for corn which indicate the importance of the crop for the country. Corn planting is practiced under satisfactory agricultural techniques in the main producing areas. Machinery and equipments needed in all phasis of the crop production are also manufactured locally.

The main rice producing states of Brazil are: Rio Grande do Sul, Sao Paulo, Goias, Minas Gerais, Maranhao, Parana and Matto Grosso, in which most of the 60 specialists dedicated to rice research are found. At present, more than half of the rice produced in the country is not irrigated. In the state of Rio Grande do Sul, the main rice producer, the 300,000 ha of irrigated rice are carried out with a good mechanization and fertilization index and with a yield of about 60% higher than that of the other producing states. In Minas and Sao Paulo most of the rice is produced upland; irrigation is practiced only in areas close to the rivers. Rice plantations in Goias and Matto Grosso are quite extensive, but little attention is payed to fertilization and soil conservation practices, resulting in a relatively low yield. The main reasons for this procedure is probably the existance of large farming areas and the fact that this crop is adaptable to soils with relatively low nutrient content.

In general, the problems facing the rice growers in Brazil are: mechanization of harvesting, transport and storage and the lack of stability or of an adequate minimum price for the product. A relatively low number of harvesters is involved in the production process and maintenance is uncertain and costly. In addition to this, the establishment of industries to manufacture combines locally does not seem to be progressing satisfactorily.

It is thought that the above mentioned crops are some of the most important and that they provide an idea of the agricultural production problems facing brazilian agriculture. Therefore, for purposes of saving time the other crops referred in table 2 will not be commented.

In general, agriculture in Brazil is lacking of capital investment directed to the sector, is practiced on the basis of extensive lands and involves considerable manual labour. The use of fertilizer reaches an index of 12 kg. per ha of cultivated land, which is approximately the index of Mexico and about one third that of the United States.

With regard to cattle raising, Brazil seems to have one of the largest herd of the world amounting to 70 million heads. However, much has to be done as to quality of the herd, despite of the efforts being made to improve it. Livestock production has an important role in the economy of the country; the main products are: beef, milk, wool and eggs. In 1965, 2 billion tons were produced, of which 70% came from beef cattle. Most of brazilian cattle originates from "Zebu-Creole" crossing and finishing is mostly done with grass. Sao Paulo and Bahia are major finishing states and Minas, Matto Grosso and Goias are the main breeders. It seems that one of the major problems causing considerable losses in meat production is to provide adequate forage and sufficient amount of water for the range cattle during the dry season.

2. 3. Irrigation.

Generally Brazil does not present an arid climate; therefore, it is not a country with traditions in irrigation. The agriculture producing areas normally receive sufficient rainfall to produce certain crops. The zone most affected by rainfall irregularity is the "drought polygon", which is not considered an arid zone, but does not present perennial rivers to provide irrigation water. Irrigation practices in this zone are limited by construction cost of hydraulic control structures and water distribution systems that meet the high fluctuations of rainfall. With the population increase of the Northeast region and the implementation of governmental projects for the area, it may be expected that modern irrigation practices will replace old traditions and impart new horizons to the economy and welfare of the northeastern population.

With a total irrigated area of about 350,000 ha, irrigation has not contributed significantly to the agricultural production of Brazil. Most of the irrigated lands are found in rice zone of Rio Grande Do Sul, where it is practiced with water from small reservoirs, accumulated during the winter rainfall season, or with water pumped from rivers. In the state of Sao Paulo, Paraiba Valley, extensive rice and truck crops are irrigated. Rice is also irrigated in some areas of the states of Minas and Rio de Janeiro, and along flooded planes by the rivers in the tates of Maranhao and Parana.

In general, it seems that the factors limiting irrigation practices in Brazil are the high construction cost and the capital investment required, and the relatively abundance of land and rainfall. However, sprinkler irrigation may be expected to be intensified in areas of significant agricultural production, as a supplement and safety measure against losses experienced due to irregular precipitation. Furthermore, government authorities seem to be aware of the importance of this practice and its relation to the multiple use of river basins as an integrated programme for fluvial transport, irrigation, etc. The Paraiba Valley project, state of Sao Paulo, is an example of projects being carried with these purposes. Studies of the basin are complete, the polders are practically built, but completion of the project is withheld because of the considerable amount of capital investment required. The participation of international agencies to help in the completion of the project would be of a great asset foi almost twenty million people living in the area. Drainage techniques as applied to agriculture seem to be practiced mostly in the highly productive zones. Here again, the relative abundance of land and hence cost favors the farmer to look for another area readily adequate for agriculture rather than to reclaim the apparently inadequate land.

3. Agricultural College Education.

3. 1. Colleges, enrollment and courses.

Agricultural college education in Brazil is offered by the "Escolas Superiores de Agricultura" or "Faculdades de Agronomia", which require four years of study for the degree of "engenheiro-agronomo". The "Escola Superior de Agricultura Luiz de Queiroz", (ESALQ), of Piracicaba, University of Sao Paulo, requires five years of study to graduate an "engenheiro agronomo".

Table 3 shows figures related to number of agriculture schools in Brazil, student enrollment at the end of each year, of staff members and of students that have completed undergraduate work for the period of 1966-68.

Years	Schools	Staff	Registration at the end of the year	Students that finished
1966	19	884	4881	893
1967	20	1031	5293	1081
1968	22*	978	5560*	1200**
1969	22	---	5300	--

Table 3. Data referring to the number of superior schools of agriculture, of the faculty, registrations, schools and students that will finish during 1966-68.

With regard to graduate courses in agriculture, of the 300 students in Brazil doing graduate work in 1963, 171 were in the State of Sal Paulo.

Compared with other branches of education, the number of students attending agricultural colleges is relatively small for a country mainly supported by agriculture, as can be seen in table 4.

	1966	1967	1968
Philosophy, Sciences and General Arts	40722	48369	66163
Law	35773	42687	51498
Engineering	26322	31946	37698
Administration & Economy	22405	27813	35925
Medicine	17282	20560	24307
Dentistry	6694	7055	7851
Agriculture	4881	5293	5560
Total No. of students in Sao Paulo	43385	54474	71084
Total No. of students in Brazil	173777	207205	258303

Table 4. Data referring to the number of students registered in undergraduate courses in 7 branches of teaching in Brazil, years 1966 to 1968.

In 1968, approximately 5% of the total number of college students in Brazil was enrolled in agriculture, and about 1200 completed requirements. Over 60% of these graduates were from the states of Sao Paulo, Rio Grande Do Sul, Minas Gerais and Parana.

* At the beginning of the year.

** Estimated.

Recent studies indicate the existence of a socialization process that encourages students to take up careers which traditionally have the highest prestige. This behaviour seems to be related with cultural values attributed by students to careers involving manual and non-manual labor in their activities, as an indication of occupational hierarchy. Despite of the necessary caution in drawing a general conclusion, this behaviour can be considered as a good indicator for more developed areas such as that of Sao Paulo and other industrialized areas of Brazil.

In general, the curricula of agricultural colleges involve 80 to 85% of courses in biological sciences and applied agriculture, and the remaining in basic and applied engineering. Under the present concept of the agricultural engineering profession, in Brazil there is no undergraduate programme being offered up to this moment.

All "Escolas de Agricultura" offer the degree of "engenheiro-agronomo" to the graduating senior, but lately some are attempting for a diversification of fields in the final stages of the curriculum. The courses are offered in a year basis of two semesters, from March through June and from August through the middle of December, with three one-hour theory classes and one three-hour laboratory class per week. The following list may give an idea of the courses offered:

First year:	Mathematics and Statistics
	Physics and Meteorology
	Zoology
	Botany
	Inorganic Chemistry
	General Agriculture
Second year:	Organic and Biologic Chemistry
	Mechanics, Power and Machinery
	Geology and Mineralogy
	Entomology
	Genetics and Plant Breeding
	Forestry
Third year:	Soils
	Surveying and Road Constructions
	Fertilizers and Fertilization
	Horticulture
	Plant Pathology
	Animal Husbandry (general)
Fourth year:	Rural Construction, Irrigation and Drainage
	Technology of Agricultural Products
	Food Technology
	Crop Science
	Animal Husbandry (special)
	Rural Economy and Sociology

The majority of "engenheiros-agronomos" involved in agricultural engineering problems in Brazil, acquired complementary training through self-teaching and/or by attending short specialization courses locally or in foreign countries. In Brazil there are presently four Master of Sciences and one Doctor of Philosophy in Agricultural Engineering, all graduated in the U. S. A.

3. 2. Tendencies of Agricultural Engineering Education at the University of Sao Paulo. The "Escola Superior de Agricultura Luiz de Queiroz", (ESALQ), University of Sao Paulo (USP), has about 180 staff members, 1000 undergraduate students and 120 graduate students. The undergraduate curriculum allows the students to attend courses containing about 20% of basic and applied agricultural engineering subjects. This is possible because in the fifth year the student is allowed to divert his studies toward one of the following fields of specialization: Agronomy, Rural Eco-

nomics and Sociology, Food and Agricultural Products Technology, Animal Husbandry and Rural Engineering.

Among other post-graduate courses offered at ESALQ, there is one in Power and Machinery that leads to a degree of "Magister Scienciae". In this course there are presently about 15 professors teaching disciplines such as: mathematical analysis and statistics, thermodynamics, electricity, rural electrification and instrumentation, besides other courses related to farm power and machinery, special problems, seminars and orientation of thesis work. In general each discipline is taught in a four-month basis, with three one-hour theory classes and one three-hour laboratory class per week. It is estimated that a full time dedicated student will complete the 30 credits required for the master degree in 18 to 24 months. The main institutions cooperating in the graduate courses at ESALQ are: the Inter-American Institute of Agricultural Sciences, providing scholarships, the Rockefeller Foundation, providing fellowships and equipment, the Ohio State University, with professors, fellowships and other aids, as part of an agreement with the USP.

In the recently approved university reform of the USP, the department became its basic unit. Also, several schools located outside of the main campus (Sao Paulo) were brought to the category of campuses, based chiefly in the academic status of the staff members. The ESALQ of Piracicaba is a new campus of the USP, and a School of Odontology and another of Forestry were added to the existing schools of "engenheiro-agronomo" and home economic. Studies are being made for the annexation of the Civil Engineering School owned by the Local Municipal Foundation, to the campus of Piracicaba.

The institution of the Rural Engineering Department and the annexation of the Civil Engineering School to the campus of the ESALQ, originated an academic movement aiming to transform the graduate course in power and machinery in a rural engineering course, which should culminate in an agricultural engineering undergraduate course, in the future.

For this transformation it is estimated that the presently available facilities are sufficient, it will require part of equipment, staff training and new staff members. Presently the Rural Engineering Department has 15 professors engaged with courses on power and machinery, rural construction, irrigation, drainage, surveying and road construction. For the graduate course in rural engineering, aside the Civil Engineering School, the departments of Mathematics and Statistics, Physics and Meteorology, Chemistry, Soils, Geology and Mineralogy, Food and Agricultural Products Technology could cooperate offering appropriate courses.

The transformation toward an undergraduate programme is expected to take place in five years, in order to adequately train staff members and meet the standards. Generally, the following steps should be taken starting December 1969.

Staff training courses: including courses in Mathematics for engineers, general mechanics, elasticity and strength of materials, machine design, structure design, instrumentation and scientific methodology in agricultural engineering. These courses would be taught by present staff members of ESALQ in cooperation with professors of the Engineering School of Piracicaba and that of Sao Carlos, University of Sao Paulo. The strengthening of research training in agricultural engineering should be done mainly through experts provided by Ohio State University.

Outside the country training: five staff members of the Rural Engineering Department should be selected and sent to the U. S. A. or other countries to work toward graduate degrees in agricultural engineering, in the fields of soil and water engineering, rural planning and construction, power and machinery and agricultural products processing. According to administrative financial resources, it is also intended to contract three more staff members for the next year.

Reformulate the Master of Science in power and machinery to offer to the "engenheiro-agronomo" a Master of Especialization in Rural Engineering, beginning 1970. Concerning to this reformulation, some considerations will be given further in this work.

Establishment of regional study plan: in cooperation with private and governmental organizations, an attempt should be made to determine the agricultural engineering problems demanding immediate consideration.

The results would be conveyed to students through seminars presented preferably by personnel outside to the department.

Recommendations of various nature related to the profession should be sent to the Federal and State governments, mentioning: that priority should be given to international projects willing to support programmes in agricultural engineering; that governmental technical positions related to agricultural engineering be occupied by an "engenheiro-agronomo" at least holding a Master of Science in one of the specializations of agricultural engineering to provide stimulus for the profession and to advancement of study. The same kind of recommendations should be addressed to industrial and agricultural professional societies and associations, in order to increase the demand of professionals trained in agricultural engineering.

Publications should be prepared and distributed, pointing out the need of qualified agricultural engineer and what they can do in the solution of problems of agriculture and related industries.

The primary concern in the revision of the Magister in power and machinery to transform as one in the specialization of rural engineering should be to orient the formation and information of the "engenheiro-agronomo" toward agricultural engineering. This could be achieved through basic and applied courses in engineering and agricultural engineering, which would inculcate the physico-mathematical thinking as the basic "tool" orienting the solution of engineering problems related to agriculture. The courses in mathematics should include solution of differential equations, infinite series and advanced vector analysis, aiming the formation of the students. The courses related to physics should contain mainly thermodynamics, electricity and electronic. The latter directed to the application in rural electrification and instrumentation. The courses in general mechanics should involve statics, fluid statics and chiefly particle and system dynamics, elements of fluid dynamics and theory of elastic deformation.

The applied engineering courses should include machine design, structure design, soil physics and elements of soil mechanics. The following courses could be offered in rural engineering : farm tractors and engines, farm machinery, rural electrification, rural construction, irrigation and drainage system design, methodology of research. Other courses could be offered as optional, such as: important design factors of tillage machinery; photo-interpretation of soils; applied hydrology; soil and water conservation machines; application of radioisotopes to agricultural engineering problems.

3. 3. Closure.

A general analysis of the development, needs and important role of agriculture for the welfare of the brazilian people indicates that true development is not likely to be achieved without intensifying educational and research programmes related to rural activities. Upon them will rely a successful implementation of new technological factors and the search for new ones, which will generate the demand of adequate transport, storage and marketing systems. In this concert it seems evident the need for qualified professionals involved in the solution of agricultural problems and their important contribution to the development of the country.

Theme 1.

6. THE STATUS OF AGRICULTURAL ENGINEERING EDUCATION IN LATIN AMERICA: CHILE by Mario Ibáñez Cifuentes, Universidad de Concepción, Chile.

General background of Chilean agriculture.

Chile is a long narrow country, bounded on the north by Peru and on the south by the Antartic continent. It has a very variable weather that causes an extremely diversified agriculture. A central valley is formed between the Andes on the east side, and the costal range on the west side, and it is here that the most important agricultural activities are developed. This central valley is irrigated with water coming from several rivers running to the ocean through the range of mountains.

Agricultural zones in Chile (See Table No. 1)

Crops in order of importance (See Table No. 2)

Types of soils.

Soils in Chile may be classified in a very general way in three types comprising the following groups that appear from North to South as:

1. Arid soils.
   a) Grey desert soils
   b) Red desert soils
   c) Calcic brown soils
   d) Coastal red soils

These soils are found in the northern part of the country and they have very little agricultural importance.

2. Transitional soils
   a) Non calcic brown soils
   b) Forest brown soils
   c) Coastal prairies

These soils are found in the central zone and central southern part of the country and they are very important in agriculture.

3. Humid soils.
   a) Lateritic redish-brown soils
   b) Soils from volcanic ashes
   c) Soils of cold prairies
   d) Tundra soils

These soils are developed in the central-southern part of the country and they are very important in agriculture. These soils are developed in the end of the country and they are very important in agriculture, particularly for animal pasture.

TABLE No. 1

AGRICULTURAL ZONES IN CHILE

ZONES	Total area thousand	Total cultivated area thousand (ha)	Irrigated area thousand (ha)	Annual precipitation (mm)	Agriculture
NORTE GRANDE BIG NORTH Tarapaca and Antofogasta Provinces	178	13	11,2	0 25	Agriculture of little importance (horticulture, fruits, pastures)
.....					

ZONES	Total area thousands km^2	Total cultivated area thousands (ha)	Irrigated area, thousands (ha)	Annual precipitation (mm)	Agriculture
NORTE CHICO (Small north) Atacama and Coquimbo Provinces	120	194	13,08	0 114	Agriculture in transversal valleys of relative importance (cereals, horticulture, fruits, vineyards, pasture and small livestock)
NUCLEO CENTRAL (Central nucleus) Between Valparaiso and Nuble Provinces	93	2.158	1.051,8	130 1.300	Irrigation agriculture in the central valley. Very important (mediterranean crops, fruits, wines, cereals, horticulture, intensive cattle raising)
NUCLEO CENTRAL SUR (Central southern nucleus) Between Concepcion and Temuco Provinces	54	1.920	171,9	1.400 1.800	Agriculture in central valley with supplementary irrigation (cereals, pastures, sugar beets, plantation timber)
REGION DE LOS LAGOS (Lake Region) Between Valdivia and Puerto Montt Provinces	48	1.072	--	1.800 2.500	Central valley agriculture with no irrigation (potatoes cereals, sugar beets, pasture, cattle raising, natural forest)
REGION DE LOS CANALES (Channels Region) Between Chiloé and Magallanes Provinces	248	183	0,5	300 2.865	Extensive sheep raising, natural woods
	741	5.540	1.248,38	-	

TABLE N°2

CROPS IN ORDER OF IMPORTANCE (CORFO, 1965)

OASIS CROPS (CULTIVO DE OASIS)	Cultivated area, thousands of Has.
Cereals (wheat, oats, corn, barley, rice, rye)	1.151,3
Legumes (beans, lentils, peas, chickpeas)	148,7

... OASIS CROPS (CULTIVO DE OASIS)	Cultivated area, thousands of Has.
Roots and tubers (potatoes, sugar beets)	103,7
Vineyards	103,0
Edible oil seeds (raps, sunflower)	80,3
Fruits	77,0
Horticultural crops	62,2
Textiles (fiber hemp, flax)	4,5
Industrial oil seeds (hempseed, flax seed)	3,8
Tobacco	2,2
TOTAL:	1.736,7

NOTE: Source of Tables 1 and 2: "Geografía Económica de Chile". CORFO 1966.

TABLE N°3

SUMMARY

	Area Thousands of Has.
Total crops	1.736,7
Cultivated pastures	1.203,3
Natural pastures	1.600,0
Fallow and others	1.000,0
TOTAL CULTIVATED LAND:	5.540,0

Markets for the agricultural products in Chile.

Chile is not an exporter of agricultural products and all its agricultural production, with few exceptions , is directed to satisfy the needs of the country. In the last decade it has been necessary to import foods such as wheat, meat, etc.

In general terms we can say that there are three main internal markets for the agricultural products from the country.

1. Central Zone. - In this area we find the highest concentration of population in the country, and therefore, it represents a wide market for agricultural products.

2. Northern and Southern Zones. - These areas offer a good market for agricultural products although they have less concentration of population due to their limited productivity.

Rural and urban population.

An analysis of the last census shows a migration of rural population to the big urban centers. The reviewed figures of the 1960 census show that since 1952 there have been an increase of 10% of the active population of the level of people older than 12 years old. In 1960 the active rural population was the same as that in 1952 (648,000 pop) but the percentage of the total population decreased from 30.1% in 1952 to 27.5% in 1960. Estimates for 1970 indicates that the population of Chile will be of 9,969,000 inhabitants, with 7,364,500 in the urban areas and 2,604,500 in the rural areas.

This situation clearly indicates that it is very important to train adequately the rural active personnel working in agriculture with the purpose of increasing productivity and obtaining a better standard of living for the people.

Problems requiring agricultural engineering solutions.

1. Agricultural Machinery.
   a) Selection of agricultural machinery suited to the conditions of the country.
   b) Training of technical personnel.
   c) Training of technical operators
   d) Technical assistance on the use, maintenance and repair of equipment.
   e) Research on adaptation and aplication of equipment.
   f) To develop local manufacturing of equipment, implements, tools, etc.
   g) To develop marketing policies .

2. Irrigation and Drainage.
   a) Incorporation of new areas with irrigation.
   b) To regulate the present irrigation system.
   c) Soil reclamation and conservation.
   d) Application of operational methods.
   e) Research and training of personnel at every level.

3. Farm Structures and Rural Planning.
   a) Lack of technical personnel needed to carry out the planning of rural infra-structures.
   b) The Agrarian Reform that is taking place in the country requires a great quantity of farm structures and rural houses. Personnel technically trained in this area are needed.

4. Processing of Agricultural Products.
   a) There are big losses in agricultural products due to many factors. Among these we can mention: long distances between production centers and markets, unfavorable weather conditions, lack of good secondary roads, seasonal agricultural production, deficiencies in harvesting, handling, packing, storing, etc.

Agricultural Engineering Education in Chile.

1. General background.

Agricultural education in the country is basically offered at three levels:
a) High level, represented by five schools of agriculture in the universities of the country.
b) Intermediate level, represented by technical schools of agriculture under dependance of the Ministry of Education and of some universities. There are no centers of agricultural products processing.
c) Basic level, represented by farm-schools for primary students of the rural areas. There are no specialized personnel.

Agricultural Engineering education in Chile is mainly under the schools of agriculture, although in many other professional careers such as civil engineering and architecture, courses in surveying, drawing, hydraulic, drainage, buildings materials, etc. are offered, but with no specific orientation toward agriculture.

Within the other levels of education some aspects related to Agricultural Engineering are also studied, but only with the purpose of providing a complement to the general agricultural education.

There are some institutions that offer training courses related to agricultural engineering, such as those offered by the National Institute for Training (Instituto Nacional de Capacitación, INACAP) at the level of tractor operators and agricultural mechanics and courses for tractor operators offered by the Chilean Army in cooperation with the Corporation for Development of Productivity (Corporación de Fomento de la Producción).

The schools of Agriculture of the Universidad de Chile and of the Universidad de Concepción, are the only ones which have organized Departments of Agricultural Engineering. The other three schools offer isolated courses in Irrigation, Farm Machinery, Farm Building, Surveying and so on.

2. Department of Agricultural Engineering, School of Agriculture, Universidad de Concepción.

a) Administrative organization.
This is one of the six departments forming the School of Agriculture and academically, administratively and economically it is dependent of a Council headed by the Director of the School. The internal administration of the Department and the relations with the other Departments are handled by a student-faculty committee headed by the head of the department.

b) Academic organization.
The academic organization of the School of Agriculture as well as that of the Department of Agricultural Engineering are contained in the rules and regulations of the School of Agriculture and in the Academic Program of the Agricultural Engineering Department. Both documents are attached.

3. Priorities of Specialization in Agricultural Engineering in Chile.

According to the needs of the country it is possible to establish clearly two priorities:

a) First priority: Agricultural Machinery, Irrigation and Drainage.
b) Second priority: Processing of Agricultural Products and Farm Structures.

4. Present and Future situation of professionals who have specialized in Agricultural Engineering in Chile.

At present none of the universities of the country graduate agricultural engineers, and the agronomical engineers specialized in this field are not enough to meet the needs of the country. The professionals who graduate in this area, are at present small in number and it is considered that teaching of agricultural engineering should be intensified to tackle and solve all problems that the country has in this area.

With all these antecedents the Universidad de Concepción has considered the necessity of establishing a School of Agricultural Engineering, on a national basis to prepare professional adequately trained to solve the problem in this area. To achieve this objective efforts of all universities and institution related to the field will be joined.

Advise was asked from FAO Regional Officer for Latin America, Mr. J.D. Berlijn, and a project was elaborated with this help. At this moment, this project is under the consideration of the Chilean Government.

Theme 1.

7. THE STATUS OF AGRICULTURAL ENGINEERING EDUCATION IN LATIN AMERICA: ECUADOR, by Rafael L Jarre Vinces, Faculty of Agricultural Engineering , Universidad Técnica de Manabí, Ecuador.

1. Study of the Agricultural Education in Ecuador.

The Agricultural Education in the country, at every level, is an exclusive responsibility of the central government, through the Directorate of Agricultural Education of the Ministry of Agriculture and Animal Husbandry for the training of agronomists and agricultural technicians, at the medium level; of the Department of Agricultural Engineering of the Agronomy and Veterinary Medicine Faculty of the Central University, for the training of "ingenieros agrónomos" with an overall view of agriculture and with a tendency to the agricultural engineering side, and the specialized Agricultural Engineering Faculty of the Manabi Technical University where professionals are trained, where after five years of study, subject to the presentation of a thesis, a practical and oral examination they are awarded the degree of "Ingeniero Agrícola" (Agricultural Engineer).

In the Country there are two educational levels for the formation of technicians, agricultural technicians and agricultural professionals.

a. Medium level.
b. High academic level.

a. Medium level. - The Manabí Technical University is in charge of an industrial technical high school for the development of a Bachelor in Secondary Education, dividing it in the following branches: Agriculture, Mechanics and Electricity under a six years plan of studies, at the end of which the student can either follow on to the university studies or take a qualified job in the country. On the other hand, the Directorate of the Agriculture Education of the Ministry of Agriculture and Animal Husbandry is in charge of the direction and administration of several high schools and agricultural schools of medium level throughout the country.

Agricultural Technical High schools (Divided cycle).

Medium level

LUIS A MARTINEZ	Ambato	Tungurahua
SIMON RODRIGUEZ	Latacunga	Cotopaxi
TROPICAL	Daule	Guayas
ODILON GOMEZ	Chone	Manabí

Schools of Agriculture.

Medium level

QUININDE	Quininde	Esmeraldas
MANUEL ENCALADA	Pagua	El Oro
PUEBLO VIEJO	Pueblo Viejo	Los Ríos
SAN GABRIEL	San Gabriel	Carchi
OTAVALO	Otavalo	Imbabura
CHINCHI	Chinchi	Chimborazo

Schools under Mission Agreements.

Medium level

LEONARDO MURIALDO	Archidona	Napo

MIGUEL CAMBOA	Francisco de Orellana	Napo
BOMBOIZA	Bomboiza	Napo
CALASANZ	Cañar	Cañar

The technical bachelor degree takes 6 years and the title "agronomo" is awarded. In the agricultural schools, the period of studies is 4 years and after completing the students are graduated as agricultural technicians. In the agricultural high schools as well as in the agricultural schools, teaching is at the medium level.

b. High Academic Level.

1. Faculty of Agronomy & Veterinary Medicine of the Central University.

The Faculty of Agronomy and Veterinary Medicine of the Central University has an agricultural engineering department which by now is in the process or organization and development under the direction of a FAO expert. This Department is in charge of the following courses: Farm Structures, Farm Machinery, Agricultural Meteorology, Irrigation and Drainage, Topography, and Technology of Agricultural Products, which under the present conditions does not guarantee the complete preparation of the future agronomist to solve the most critical and urgent problems of the agriculture in specialized areas, such as: Hydraulics, Farm Machinery, Farm Structures and Processing of Agricultural Products that the country requires.

The general plan of the Faculty of Agronomy and Veterinary Medicine restrict students and its professionals in the specific field of agronomy, devoting its time to use and to apply the practical and technical knowledge in agriculture. The Faculty does not offer and could not offer a complete plan of studies leading to the agricultural engineering title based on the plan for agronomist; if it is wanted, an specific plan could be prepared for professionals in the field of agricultural engineering.

2. Faculty of Agricultural Engineering of Manabi Technical University.

The Manabi Technical University was created by legislative decree of October 29 of 1952, and was approved by the Executive in December of the same year. Under this decree the School of Agricultural Engineering was born and it is unique in the country so far, it began to operate on June 25, 1954. In May, 1955, opened the second school, the Agronomy School, and in May 1956, the School of Veterinary Medicine was inaugurated. These three schools formed the Faculty of Agricultural Engineering and Veterinary Medicine until the 21 of October, 1968, when the above mentioned schools were raised up to be the Faculties of Agricultural Engineering, Agronomy and Veterinary Medicine respectively. Since the 25 of June, 1954 till the 21 of October, 1968, the School of Agricultural Engineering worked under the teaching system of Trimestral Academic Year with a plan and programme of studies which permitted the formation of professional with general knowledge of agronomy and fields related to the specific studies of Agricultural Engineering. With the creation of the Agricultural Engineering Faculty, and from October 21, 1968, the Board of Directors of this high agricultural institution carried out a complete revision of the plans and programmes of studies, using as a model the general plan of the Agricultural Engineering Faculty of the National Agrarian University at La Molina, and by their vigorous efforts they oriented the Faculty towards a system of specialization of higher level of specific fields of knowledge and techniques. Commencing December 30, 1968, and due to a resolution given by the Board of Directors of the Faculty the academic regime for the studies of Agricultural Engineering has been set in ten cycles with a duration of 80 days each and with a total requirement of 200 credits, prior to the exams for the degree, and for the granting of the degree.

2. 1. Organization of the Agricultural Engineering Faculty.

The organization of the Agricultural Engineering Faculty at the present time is a dynamic and capable one so that without any doubt it will enable a notable improvement in the formation of the future professionals training them to solve the complex agricultural programs which hinder the development of the country.

2. 1. 1. The Faculty Council is the administrative and governing organism of the highest level in

the faculty whose responsibilities are set up by law, the regulations of the University and the regulations of the Faculty.

2. 1. 2. The Council of Directors is the organism in charge directly of the administrative, academic work and discipline of the Faculty.

2. 1. 3. The Dean is the executive officer of the faculty. He has the authority for it and he is responsible for the immediate direction of the affairs according to the general rules that are established by the Faculty Council and by the Council of Directors.

2. 1. 4. The Sub-Dean is the person that replaces the Dean during his absence.

2. 1. 5. Departments:

Farm Machinery, Farm Structures, Rural Planning, Irrigation, Soils and Soils Conservation.

The new plan of studies leads to the title of Agricultural Engineer oriented towards an specific field according to the limitations and capability of the students. Due to the changes that occurred in the Faculty, the Departments of Farm Machinery, Farm Structures and Rural Planning, Irrigation, and Soil Conservation were created, having the specific function of controlling the orientation of the specialization that is given in every department and also the research and the teaching of related subjects, with prepared programmes for every unit.

Every department has a Head or Director, designated by the Council of Directors, who is in charge of programming, teaching and research in each specialization. .The courses given have theoretical and practical content.

This new way of planning will permit a better and more solid preparation of the agricultural engineer because the new plan of studies starting from the 7th cycle, involves six intensive specialized courses that will guarantee a high academic standard. Every Department possesses small laboratories and some sections of experimental fields in order to complement partially the education process.

2. Agricultural Engineering Demand in the Country.

The conclusion reached by the present faculty of Agricultural Engineering, based on the experience of its professors, graduates and students is that in general the agricultural development of the country depends on farm machinery.

If to this experience you add criteria from other groups of professionals, they show that Ecuador, or any other agricultural country, cannot develop their agriculture without the use of farm machinery and the techniques of agricultural engineering. Without the guidance of this type of professionals a complete agrarian reform cannot be carried out and the old traditional structures, which hinder the agricultural development of the country, are kept on.

Appendix 1, at the end of this paper, contains the figures of agricultural production and of the cultivated area in Ecuador during 1967 according to the different geographical regions. Besides, it shows the different works partially done with farm machinery in each of the crops, as well as the suplement activities of irrigation required for the vegetative period and the process for the commercialization and industrialization.

A. In Farm Machinery.

According to the figures given in the same annex, it is possible to see that the country has to give priority to the development of farm machinery, and from there to go on to the next stage that constitutes the processing of the agricultural products ; if we consider that out of the 55 agriculture products analized, only in 5 of them is the harvesting of the crops carried out by farm machinery, 9 are sown mechanically and a nearly constant number that fluctuates between 32 and 38 perform plowing, grading and ridging.

Though we realize that the factors that control the yields in agriculture are many and very complicated, it would be impossible to detail them at this time; at the same time it would be a large and difficult task to enumerate the factors that have lead to the stagnation of Ecuatorian agriculture. Nevertheless, it is worthwhile looking closely at one of the factors that has a major effect or the level of the yields from the land: the use of agricultural machinery.

If, so far, a large agricultural development has not been achieved and neither the indian of the mountains or jungle has been integrated to the agricultural production it is because from one side the big land owners have not agreed to the introduction of new technologies , such as the farm machinery, nor have they permitted the development of new cultivated areas having labor not only cheap but in many cases free; on the other hand the programme of small land owners and the fragmentation of the land that instead of being a favorable factor for the development is a serious limitation for the farm mechanization. Because they hardly satisfy the minimum needs of the families, they are kept on the margin of the economy.

B. In Irrigation and Drainage.

Looking at Annex 1 of our reference, it is shown that 52 out of 55 of the agricultural products require in one way or another some irrigation to meet the minimum water requirements. Such figures can only be considered to the extent that they will give an idea of the situation, to understand that water is a decisive factor in the agricultural production. When nature does not supply, man has to look for it moving to very far places where water is found either as overland water or subsurface water, and utilizing it as artificial irrigation. In other situations when agriculture can only take place during the short winter season, we have to accept that with some methods of artificial use of water, crops will be sown and collected with more frequency, increasing in this way the annual yields. For this reason, the second priority in the determination of needs of specialization in agricultural engineering is lead to the formation of professional people with broad knowledge in the use and distribution of water. The economical and agricultural development of Ecuador depend mainly on the planning and execution of irrigation programmes. The country requires permanent irrigation structures such as: dams, offtake gate systems, wells and pump, whose works demand the knowledge of Agricultural Engineers.

The hydraulic problem is very complex, because after the construction of many irrigation systems there should be a systematized and technified operation of watering, with the objective of using water to a maximum in a rational form with the application of Engineering techniques. This task is completely beyond the training of Agronomists and Civil Engineers and it falls in the domain of an specialist in the subject, that is the agricultural engineer who is formed in the Agricultural Engineering Faculty of Manabi Technical University. The shortage, to say the least, of this type of professionals has forced the Institutions of our country to send groups of Civil Engineers abroad in order to obtain a specialization in Irrigation and Drainage to take care of the plans and agricultural development programs that the government is carrying on. Due to the lack of hydraulic technicians that are required to move on the modern development of the agriculture of the country, the Agricultural Engineering Faculty of Manabi Technical University possesses a plan and programme of studies that guaranty a solid preparation of a very high level of the human element in this technical field.

C. In Processing of Agricultural Products.

As mentioned above the processing of agricultural products constitutes a further stage to the sowing and collection of the crop, thus it should be assigned the third place in the scale of priorities in the Agricultural Engineering specializations. This criteria is emphasized with the figures that are shown in Appendix No.1 where it can be seen that less than 50% of the listed agricultural products are processed. They undergo, in most of the cases, a primary transformation; and, in a few cases, a complete transformation for final human consumption.

Agricultural Engineering plays an important part in the rural development, a balance should be established among the local conditions, the various forms of agricultural improvements and of industrialization.

Industrialization of agricultural products is in the development stage and the professionals who are in charge of the industrial plants of the country belong to different technologies. This fact limits the production and the consumption due to the lack of technical knowledge to obtain the least cost and highest quality products.

The Agricultural Engineering Faculty has not created the Department of Processing Engineering although processing has the third place in priority, but the lack of specialized staff for teaching has forced to the Board of Directors of this institute to pospone this goal, until an agricultural engineer in this specific field is available.

D. In Farm Structure and Rural Planning.

In some zones of the country, the agricultural rural communities require for their development the assistance of the agricultural engineer, in order to plan technically the settlement of their living houses, to build farm house, roads, silos, technical electrification for the existing rural agricultural zones.

For these conditions, the Agricultural Engineering Faculty of the Manabi-Technical University is forming professionals specialized in Farm Structures and Rural Planning (giving basic and fundamental courses that are required for this subject that will be able to give suitable solutions to the physical planning of the settlements, the rural housing and some other farm problems within the agricultural development. This is accomplished through the basic and fundamental courses that are given at the agricultural engineering faculty.

So far the agricultural engineers and agronomists have been in charge of this task which is not in their domain. The great variety of the rural living conditions that existiin the country create important problems of design, selection of materials and construction that can be solved only by agricultural engineers.

E. In Soil Conservation.

It was said that Ecuador bases its economy especially on agriculture, for that reason understanding the soil, its rational use and its conservation constitutes the basis of scientific and profitable agriculture. However, up to date the farmers are not conscious that the low yields of the farms are due to the elementary use of the soil, consequently the agricultural engineers are supposed to establish a new orientation in the correct use of the soil and to show that it is an important necessity to try to maintain the soil as a source of national wealth and on which the future of Ecuador is built.

Good soil management and its conservation should be planned along technical principles, taking into account the analysis of the factors that limit its agricultural capacity, because it requires a broad knowledge of the techniques and practices of agriculture that are required in each case.

The aim of the Agricultural Engineering Faculty in this field is that its action radius should reach the centres where it is researching; if this is true the agricultural engineers should be very well prepared to identify the problems, to look for the possible causes and to apply their knowledge in the most efficient way in order to find the best solution to those problems. Consequently, it has been decided that the soil conservation should be a compulsory subject in the curriculum of the faculty, eventhough in the scale of priorities it does not have a principal place.

To face these shortcomings that were delaying the agricultural development of the country, the College of Agricultural Engineering of Manabi Technical University was created in 1954 with the objective of preparing capable elements to solve the variety of problems that involve agricultural machinery,irrigation, farm structure and rural planning, process of agricultural products that are joined with the analyzed factors.

3. Employment opportunities for Agricultural Engineers.

The employment opportunities are scarce because the agricultural engineering in the country is in the stage of development, however there are many possibilities for the future if we consider that: a) the total number of agricultural engineers and agronomists that now-a-days are in the country is 459, according to the "Survey of Agricultural Education, Research and Extension", 1965, published by the Inter-American committee of Agricultural Development (CIDA). Most of these professionals are engaged with the agricultural services of public organisms, semi-public and private; and b) for the professionals that the future development of the country will require, according to the same paper should be: 1.055, 1.365 and 2.325 for the years 1975, 1980 and 1995 respectively.

On the other side the objectives and goals proposed in the national development plans that will increase the agricultural production, force the country to prepare a considerable number of professionals specialized in the different fields that will make it possible to obtain these goals and to maintain the rhythm of the assigned development giving opportunities for agricultural engineers to participate in the ambitous change not only of the social stru ctures but also of the professional employment prospects.

Using the same publication mentioned above 9 out of 459 professionals agricultural engineers and agronomomists are not working in the field of agriculture, it means that the remaining 450 professionals are distributed in the following way: 426 working for the public agricultural services, semi-public and private; and 24 engaged in private farms.

If we relate the 450 agricultural engineers and agronomists that are working in agriculture to the 370,000 farms that existed in 1965, the ratio would be one engineer for every 630 farms, this figure is low enough for a country which is mainly agricultural like Ecuador, it leads us to the conclusion that it is necessary to prepare more professional people who will be capable of working for the changes that should be introduced in order to get into the development stage.

As far as the specialized fields are concerned, it is interesting to examine the distribution where the agricultural engineers and agronomists are working. Excluding 43 who work for the forestry service, 60 who represent the 15% of the total work on research; 118 (25%) on extension; 61 (15%) on education; and 144 (35%) in some other agricultural services; besides that, 24 (6%) work in private farms.

4. Evaluation of the existing Agricultural Engineers to satisfy the needs of the country.

Looking at the same total, it can be noted that 416 agricultural engineers and agronomists work for the government in the Ministry of Agriculture and in public organisms of the Ministry; and 34 work for private institutions of which as mentioned before 24 work in farms and the 10 remaining in private enterprises.

The analyzed situations according to the statistics lead us to the conclusion that there is a great deal of opportunities of employment for agricultural engineers and agronomists, who have been trained for education in agriculture, farm management and research, thus it is necessary to train professional people in some other fields, such as Research and Rural management. Besides the figures shown for the needs of the country according to the future demand, it is also important for this study to determine which fields are affected by this increase, considering mainly that there is lack of professional in specialized fields as important for the agricultural development as are research and rural management. To this, it has to be added that, if in the future the number of farms in production will increase, most of them will need professionals to manage and to increase the average yields of the farms; this means that the private enterprises will hire most of these professionals, expecting that the number of professionals engaged with the government will decrease.

The data in Appendix No. 2 reinforce this conclusion, in it we can see the number of graduates from the Agricultural Engineering Faculty, it shows among other aspects that at the present time there are not enough graduates to satisfy the demands of the country, mainly to fulfill the requirements of research and farm management.

5. Determination of the teaching needs in Agricultural Engineering in the country.

From the above said, we can clearly conclude that teaching of agricultural engineering in Ecuador so far, has not met the present needs of the country. Perhaps it is a result of the lack of a policy of a professional defense by which the agricultural engineers could be located in their proper field of action, which, as it was said, are oriented toward farm machinery, irrigation and drainage, farm structure and rural planning and primary processing.

It is clear that if the agricultural engineering faculty will receive the total support of the govern ment and of the public and private organizations which are engaged with the development of the country, it will improve and be forced to broaden and deepen the areas of knowledge in order to fulfill those needs that, so far, have not been given in the proper way.

6. Flexible curriculum for teaching Agricultural Engineering.

At the Manabi Technical University as well as in the rest of the Ecuatorian universities, the yearly system of teaching is traditionally divided in quarterly courses. In every year the student can take between 9 and 11 courses. It means that in 5 years that are required to obtain the agricultural engineering title it is necessary to approve between 45 and 55 subjects in a rigid way. If it is true that this system is working preparing professionals in a broad base, it does not in some other cases satisfy personal needs of the students, neither does it give them the facilities in order to prepare for specialized professionals according to the needs of the country.

With this background the agricultural engineering faculty at the beginning of this year organized the plan of studies to achieve the agricultural career under a system of flexible curriculum instead of the traditional system of academic year.

With the inclusion of the flexible curriculum in our faculty, better professionals will be obtained and it will permit students to select their specialties according to their preferences.

The flexible system consists in the careful preparation of the general structure of 46 subjects imposed by the agricultural engineering faculty and by 24 courses of specialization in farm machinery, irrigation, farm structure and rural planning, soil and soil conservation, from which the student will select 6 courses according to his preference.

The Faculty will offer the basic courses for the human and scientific formation of the students and the elective courses of specialization which reinforce the scientific and technical knowledge that are necessary for the professional training.

To obtain the professional title, 200 approved credits are required; the credit is the unit of evaluation of every subject. One credit means a theoretical class hour per week or 2 to 3 hours of practical work per week.

The sequence of the courses to obtain the agricultural engineer title are published in the catalogue of the agricultural engineering faculty beginning on page 19 up to the 24.

7. Actions to develop a Post-graduate Programme in Agricultural Engineering.

So far, only the Manabi Technical University has shown some interest to establish a very well planned post-graduate course in agricultural engineering.

Except the farm machinery department of the central university of Ecuador, analyzed at the beginning of this talk, there is no other known institution that has done anything in order to carry on post-graduate teaching in agricultural engineering.

However, on the other hand, the Agricultural Engineering Faculty of the Manabi Technical University considering the responsibility that it has to the country, and in joint thinking with professors and students has begun a plan and programme of studies, which will ensure that the students will have sufficient knowledge to be able to solve the problems that the Ecuatorian agriculture has in farm machinery, irrigation and drainage, farm structure and soil conservation.

The details of this ambitious program that started this academic year can be seen in the catalogue of the agricultural engineering faculty that will be distributed to the participants of this Panel.

8. Some background of the Ecuatorian Agriculture.

Because of its special location and because the equinoccial line passes through it, Ecuador is a country that has a diversified economy with reasonable natural resources. However, labor and capital are unevenly distributed in the country and the latter is very scarce.

The Andes range that crosses the country from North to South is divided in two branches, the Eastern and Western which determine the presence of three geographically different zones: the Coast, the Highlands and the Jungle, each with its own regional economic characteristics that are determined by specific agricultural production.

The same appendix number 1 shown at the end of this paper tells us that out of 55 listed crops, there are 47 in the Highlands, 39 in the Coast, 36 in the Jungle and 20 from the Islands of Archipielago de Galapagos Region.

In the Highlands, agriculture has been organized in such a way that the production is internally consumed and it is needed to satisfy the food needs of the Ecuatorian people settled in the country. Among those crops the principal ones are: wheat, produces 1,727,948 qq*; barley 1,788,600 qq; corn 3,976,200 qq; carrots 91,400 qq potatoes 8,765,000 qq; sugarbeet 67,610 qq; lentils 21,655 qq and fruits, such as apples, oranges, peaches besides that the main export crop is pyrethrum with a total production of 79,770 qq.

On the other hand, the tropical lands of the Coast are worked in such a way that they satisfy the food demands of the Ecuatorian people with crops as rice with an annual production of 1,935,420 qq., beans 75,930 qq., lemons 302,590 qq., peanuts 112,300 qq., orange 1,970,100 qq., stems of green bananas 20,926,000 and pineapples 892,510 qq., ; it also produces some other type of exportable food crop, among these it can be mentioned bananas 76,843,670 bunches per year, cacao 1,309,000 qq.; coffee 1,104,600 and castor beans 497,580, besides some other crops such as: cotton with a production of 332,670 qq., that is utilized mainly in the National Textile Industry. The Jungle region in the Eastern part of the country has a rudimentary organized agriculture, yet, it uses its environment to develop horticulture, for that reason the main commercial agricultural products are sweetpotatoes 150,000 qq. per year, lettuce 4,900 qq., little oranges 773,500 qq., and manioc 877,650 qq.

From the above figures it can be seen that about 75% of the agriculture production in the coastal region is oriented to the foreign commerce, while only 25% of the agriculture products from the Highlands is exportable.

On the other hand, it should be pointed out that the production of bananas is of fundamental importance in the Ecuatorian economy, because , on average it represents about 35% of the agriculture production of the country. During the last 10 years the exported amount has risen more than 300%.

It should be mentioned that one part of the natural regions of the country, which is important for its development, is located in steep slopes of the Andes and, consequently they require the use of some other techniques for the management of the soil for its conservation and in general, for everything related to its exploitation. To clarify what was mentioned above, the following table presents the distribution of the natural resources:

Natural region	Surface (Thousands of Ha.)
Coast	7,338
Interandean	4,126
Andes Range	6,778
Jungle	25,560
Insular (Galapagos)	800
TOTAL	44,602

* quintales (qq): 100 lb.

Source of information: Ownership of the land and socioeconomical development of Agriculture.

Besides, it can be stated that so far a low proportion of the natural resources of Ecuador are used, and it does not have a uniform distribution, for example: in the Highlands, the present used land is the total available useable land, but, in the Coast there is an appreciable reserve of useable land.

8. Rural people versus urban people.

As far as the rural people, devoted to agriculture are concerned, it should be pointed out that the agriculture population is the fundamental base of the human potential of the country. Approximately 2. 8 millions out of the 5 millions inhabitants of the country, have settled in the rural environments, and most of them work in the farms.

Besides, it can be seen that the greater percentage of the agriculture people is settled in the Highlands provinces, while in the Coastal provinces, there are only 40% of the agriculture people, Manabi and Guayas are the most crowded cities, both together have 70% of the agriculture population in the region.

To close it, we can say that the biggest problem that Ecuador has to face in special reference to Agricultural Engineering, is Farm Machinery, and with the use of it, new agriculture land can be incorporated, and in some cases the yield of the crops could be improved.

APPENDIX I

CROP AREAS AND PRODUCTION HARVESTED

ECUADOR, 1967

PRODUCTS	SIERRA	LITORAL	ORIENT	ARCHIP. COLON	TOTAL REPUB.	MECHANIZED Parc. a' G S S*C'sV	Labors	IRR & DRAIN.	PROCESSING
Avocado									
Production (qq)	506. 160	84. 950	4. 770	6. 825	602.705				
Area (Ha'	2. 227	702	30	78	3. 037				
Capsicum						x x x	x	x	
Production	39. 990	3. 260	1. 110	16	37. 376				
Area (Ha)	430	94	13	1	538				
Garlic						x x x	x	x	
Production	66. 628	---	---	30	66. 658				
Area	902	---	---	1	908				
Sesame						x x x x	x	x	
Production	405	24. 099	---	---	24. 549				
Area	46	1. 582	---	---	1. 628				
Cotton						x x x x x	x	x	x
Production	14. 200	332. 670	15	---	346. 885				
Area	1. 304	22. 400	2	---	23. 706				

PRODUCTS	SIERRA	LITORAL	ORIENT	ARCHIP. COLON	TOTAL REPUB.	MECHANIZED Parcial labors a G S* S* C' sV	IRR. & DRAINAGE	PROCESSING
Peas						x x x x	x	
Production	391.430	432	---	10	391.872			
Area	30.920	27	---	1	30.948			
Rice						x x x x x	x	x
Production	503.980	1'935.420	8.250	15	2'447.665			
Area	23.332	89.502	675	1	113.510			
Banana						x	x	x
Production	18'542.500	76'843.670	430.000	45.000	95'861.170			
Area	37.022	164.679	865	150	202.716			
Cabuya -Hemp						x x	x	x
Production	439.190	33.698	3.940	360	476.188			
Area	13.438	1.295	141	100	14.974			
Cocoa						x		x
Production	36.910	1'309.000	1.290	---	1'347.200			
Area	7.250	256.600	215	--	264.065			
Coffee						x		x
Production	336.250	1'104.600	7.770	9.000	1'457.620			
Area	37.835	167.624	880	2.000	208.339			
Sweet potato						x x x x	x	
Production	58.100	98.540	15.000	1.200	172.840			
Area	756	1.217	152	30	2.155			
Sugar Cane						x x x x x x	x	x
Production	4'558.565	2'255.345	714.100	240	7'528.250			
Area	74.379	22.575	11.050	8	108.012			
Barley						x x x x x	x	x
Production	1'788.600	2.200	442	--	1'791.242			
Area	143.900	110	26	--	144.036			
Onion						x x x	x	
Production	1'260.750	---	4.580	500	1'265.830			
Area	2.495	---	12	3	2.510			
Onion						x x x	x	
Production	878.240	---	680	36	878.956			
Area	3.942	---	8	1	3.951			
Coconut						x	x	x
Production	2.074	310.360	---	180	312.514			
Area	21	1.617	---	1	1.639			
Cabbage						x x x x	x	
Production	2'364.950	38.260	32.410	2.300	2'437.920			
Area	2.069	42	43	3	2.157			

PRODUCTS	SIERRA	LITORAL	ORIENT	ARCHIP. COLON	TOTAL REPUB.	MECHANIZED Parcial labors						IRRIGATION & DRAINAGE	PROCESSING
						a	G	S°	S'	C'	sV		
Couliflower						x	x	x			x	x	
Production	283. 120	--	2. 160	227	285. 507								
Area	458	—	8	1	467								
Anona											x	x	
Production	329. 355	23. 550	--	150	353. 055								
Area	990	90	—	1	1.081								
Chochos						x	x	x			x	x	
Production	54. 600	--	--	---	54. 600								
Area	2. 964	--	—	--	2. 964								
Peaches											x	x	x
Production	37, 060	--	--	--	37. 060								
Area	437	--	--	--	437								
Beans						x	x	x			x	x	
Production	752. 800	75. 930	3. 350	100	832. 180								
Area	74. 610	4. 534	251	7	79.402								
Vetch						x	x	x			x	x	
Production	432. 390	225	33	--	434. 653								
Area	33. 573	15	5	--	33.593								
Castor Oil											x	x	x
Production	520	497. 580	--	400	498. 500								
Area	10	21. 577	--	10	21. 597								
Lettuce						x	x	x			x	x	
Production	308. 930	3. 310	4. 900	40	317. 180								
Area	740	9	20	1	770								
Lentil						x	x	x			x	x	
Production	21. 655	—	--	--	21. 655								
Area	3. 152	—	--	--	3. 152								
Limes											x	x	
Production	7. 810	4. 520	1. 730	--	14. 060								
Area	105	27	21	--	153								
Lemons											x	x	
Production	187. 230	301. 590	4. 160	5.400	499. 380								
Area	760	878	28	60	1. 726								
Corn						x	x	x	x		x	x	x
Production	3'976. 200	963. 740	69. 500	1.450	5'010. 890								
Area	308. 700	51. 586	3. 735	90	364. 111								
Peanut						x	x	x			x	x	x
Production	82. 650	112. 300	540	---	195. 490								
Area	3. 693	7. 796	48	---	11. 537								

PRODUCTS	SIERRA	LITORAL	ORIENT	ARCHIP. COLON	TOTAL REPUB.	MECHANIZED Parcial labors						IRRIGATION & DRAINAGE	PROCESSING
						a	G	S'	S°	C'	sV		
Mangos												x	x
Production	61. 300	288. 400	2. 180	---	345. 880								
Area	131	614	4	---	749								
Mandarines											x	x	
Production	115. 130	99. 280	7. 354	400	222. 164								
Area	314	490	67	2	873								
Apples											x	x	x
Production	71. 640	--	---	--	71. 640								
Area	775	--	---	--	775								
Mellocos						x.	x	x			x	x	
Production	264. 800	---	50	--	264. 850								
Area	2. 607	--	4	--	2. 611								
Oranges											x	x	x
Production	1'941. 600	1'970. 100	26. 700	60.000	3'998. 400								
Area	2. 875	4. 597	89	120	7. 641								
Cocona						x	x	x			x	x	
Production	268. 305	---	773. 500	1. 000	1'042. 805								
Area	810	---	2. 297	2	3. 109								
Potato						x	x	x	x		x	x	x
Production	8'765. 000	2. 226	200	1. 500	8'768. 926								
Area	48. 130	53	14	15	48. 212								
Papaya											x	x	
Production	1'032. 290	412. 070	151. 420	3. 300	1'599. 080								
Area	1. 692	933	204	3	2. 832								
Pineapples						x	x	x			x	x	
Production	284. 340	892 510	39. 040	500	1'216. 390								
Area													
Piretrum						x	x	x	x		x	x	x
Production	79. 770	--	---	--	79. 770								
Area	8. 963	--	---	---	8. 963								
Plantain											x	x	x
Production	8'025. 500	20'926. 000	1'887. 450	6. 000	30'844. 950								
Area	11. 160	28. 826	2. 135	15	40. 136								
Beet						x	x	x			x	x	
Production	67. 610	---	---	---	67. 610								
Area	297	---	---	---	297								
Watermelon						x	x	x			x	x	
Production	2. 860	430. 400	---	5. 500	438. 760								
Area	15	1. 836	---	20	1. 871								

PRODUCTS	SIERRA	LITORAL	ORIENT	ARCHIP. COLON	TOTAL REPUB.	MECHANIZED Parcial labors a	G	S'	S°	C'	sV	IRRIGATION & DRAINAGE	PROCESSING
Tobacco						x	x	x			x	x	x
Production	1. 146	30. 510	95	---	31. 751								
Area	44	1. 609	10	---	1. 663								
Tomato						x	x	x			x	x	x
Production	1'094. 475	168. 500	200	60	1'263. 235								
Area	1. 443	375	2	1	1. 821								
Grapefruit											x	x	x
Production	20. 650	235. 710	312	---	256. 672								
Area	43	471	9	---	523								
Wheat						x	x		x	x	x	x	x
Production	1'727. 948	---	---	---	1'727. 948								
Area	79. 585	---	---	---	79. 585								
Grapes						x	x	x			x	x	x
Production	10. 808	---	---	30	10. 838								
Area	130	---	---	2	132								
Manihot						x	x	x			x	x	x
Production	821. 800	5'402. 500	877. 650	2. 500	7'104. 450								
Area	10. 390	15. 965	7. 250	20	33. 625								
Carrot						x	x	x			x	x	
Production	91. 400	---	1. 770	100	93. 270								
Area	491	---	21	1	513								
Carrot						x	x	x			x	x	
Production	59. 820	---	5. 700	100	65. 620								
Area	501	---	18	1	520								
Zambos						x	x	x			x	x	
Production	610. 410	1. 400	3. 570	280	615. 660								
Area	3. 500	10	14	2	3. 526								
Pumpkin						x	x	x			x	x	
Production	201. 660	362. 640	1. 680	220	566. 200								
Area	2. 177	1. 882	7	2	4. 068								
Pastures						x	x					x	
Area	934. 085	597. 300	245. 700	1. 200	1'778. 285								
Total of parcially mechanized operations, irrigation and processing:						38	38	32	9	5	51	52	25

A: Plow - C': Harvest - G: Grade - S' : Furrowing - S°: Seeding - sV: Vegetal sanitation

Source: Ecuatorian Estimated Production, 1967. Ministry of Agriculture Livestock.
Prepared by: Faculty of Agriculture Engineering University.

APPENDIX No. 2

UNIVERSIDAD TECNICA DE MANABI

ENROLLMENT OF STUDENTS AND GRADUATES IN THE FACULTY OF AGRICULTURAL ENGINEERING

Period	Number of registered students	No. of graduates	No. of graduate students
1954-1955	19		
1955-1956	15		
1956-1957	22		
1957-1958	20		
1958-1959	26	12	
1969-1960	29		1
1960-1961	16	4	
1961-1962	11		1
1962-1963	13	3	1
1963-1964	8		2
1964-1965	15	3	1
1965-1966	20	2	1
1966-1967	36	1	1
1967-1968	65	-	1
1968-1969	69	5	1
	384	25	10

Source: Secretaría de Facultades de la Universidad Técnica de Manabí.
Prepared by: Instituto de Investigaciones Económicas y Estadísticas - U. T. M.

Theme 1.

8. AGRICULTURAL ENGINEERING EDUCATION AND RESEARCH IN MEXICO by Edgar E. Mora, National School of Agriculture, Chapingo, Mexico.

INTRODUCTION.

Agricultural Engineering deals with the application of the basic areas of engineering to the specific conditions and requirements of agriculture as an industry and as a field of applied science.

The agricultural engineering graduate is a professional who has received training both in engineering as well as in agriculture. He has the necessary experience to combine both disciplines and is capable of developing, designing, organizing and directing the engineering aspects of agriculture and related industries.

The fields covered by agricultural engineering can be summarized as follows:

a) Power and machinery.
b) Agricultural constructions .
c) Electrification.
d) Process engineering.
e) Irrigation, drainage and soil management.

Graduates of this profession are trained to work in the aforementioned areas, developing technical assistance activities, in education and research, for private enterprise, or for government agencies, in problems of soil and water conservation and management; for machinery and agricultural implement manufacturers; for contractors for work related with agricultural engineering; for agricultural product processing industries and for construction equipment manufacturers.

At present in Mexico there are fifteen agricultural schools and colleges which train both agricultural engineers and agronomists with more or less similar curricula. It can be said that the present number of graduates is not sufficient to meet the country's needs as regards to those areas pertaining to agricultural engineering.

This area is of utmost importance for the agricultural development of Mexico and the training of a decisive role in the correct application of the techniques to be used to achieve optimum use of the productive resources of the nation's agriculture.

POWER AND MACHINERY.

This area of agricultural engineering is covered in a very general fashion in the professional training of the country's agronomists and agronomical engineers and, to date there is no post-graduate education and research to this regard.

Agricultural machinery is defined as that which, even though it might be used for other purposes, has been especially designed to perform the work practices and operations necessary for agricultural enterprises to carry out their productive function.

The country has over 100,000 tractors working on 4 of the 28 million arable hectares and of which nearly 17 million are actively exploited, while 14.5 million hectares are harvested. This means that 75% of arable lands are worked under animal traction.

At present, the market offers a great variety of agricultural machinery for soil preparation, planting , for cultivation , applying fertilizers, grading and drainage, irrigation, pest and disease control, harvesting and conditioning of products, haulage and storage, etc. etc. , which the country purchases and manufactures. The 4 main brands use approximately 40 to 60% of local materials.

Sophistication of agriculture, to a large extent, depends on the degree of mechanization and the aforementioned figures show the large gap which, to this regard, exists at present.

Agricultural schools and faculties in the country only give general courses on agricultural machinery. At the National School of Agriculture of Chapingo, which is the one with which I am more familiar, the 8 branches of the agronomical engineering profession receive yearly courses in general mechanics and agricultural machinery. Only two branches, Phytotechnics and Soils, receive an additional course of specialized agricultural machinery which does not constitute an adequate training in this area, which is so important for agricultural engineering. Even though it is true that the agricultural industry school gives 2 courses per year on mechanical engineering and the Irrigation School gives one course a year on hydraulic machinery, these courses follow the specific needs of each specialized field.

Mechanical engineers come to this school, for despite the fact that they have been trained in their specialty, they lack the complementary agronomical formation necessary for efficient design, construction and, above all, research in agricultural machinery.

AGRICULTURAL CONSTRUCTION.

This field has received little study at present in Mexico. Its fundamental principles are based on European and Northamerican techniques. It requires more research on the part of institutions and agronomical engineers who have to do with the use and characteristics of regional construction materials. The National School of Agriculture through its irrigation department complements undergraduate education with training on water supply and the disposal and possibilities of use of sewage. To this regard we can say that at the Irrigation District No. 3 , Tula, Hidalgo State approximately 36,000 Haz. are irrigated with sewage waters from Mexico City.

The experts which at present are involved in this field usually complement their studies in European countries and the U.S.A.

At present, the government agencies are promoting work on this field by means of projects involving regional programs going from housing studies and improvements in peasant homes to the construction of fully planned and financed agricultural and cattle structures and rural roads.

In 1954 the Secretariat of Agriculture and Cattle Raising created the General Agricultural Engineering Bureau, actively assisting the aforementioned programs and the Official Banks, building artifitial insemination, cattle raising development and agricultural and cattle training centers, as well as small water storages for domestic uses, water troughs and ancillary irrigation systems, dedicated mainly to the "ejido" sector.

Other specialized areas of the profession receive sequential annual courses on Mechanics, Stability and Agricultural Constructions to cover their specific needs.

ELECTRIFICATION.

This is another of the agricultural engineering areas which is insufficiently covered at the agricultural colleges and faculties of the country. The subject is discussed very generally and we can state that the electrical engineering courses given at the agricultural engineering Faculty of the National School of Agriculture are dedicated mainly to covering the needs in this area.

To this regard we can also point out that electrical engineers participate in rural electrification activities for purposes of providing electric power in the rural areas. In the last two years the Federal Committee on Electricity of Mexico has carried out a major effort to offer a solution to this important aspect of the national infrastructure; however, education and research in this area of agricultural engineering is very far behind the real needs, for the training of the professional cadres which must work in this field has not been fully organized and the aforementioned electrical engineers are the ones who participate in this process without having received a complementary training in agriculture.

PROCESS ENGINEERING.

The institutions carrying out formal work in this area are the Faculty of Agronomy of the University of Sinaloa, the Institute of Technology and Higher Studies of Monterrey in its Department of Food Technology and Maritime Products, and the Department of Agricultural Industries of the National School of Agriculture of Chapingo, Mexico. The first one has recently organized courses on agricultural product conservation and processing; the second one has been in operation for several years and has carried out excellent work, specially on maritime product technology, and the third one, even though it has been in operation since 1927, has organized its education and research activities only as of 1957. There have been attempts at offering post-graduate courses on Food Technology at the National Politechnical Institute and Ibero American University, but as yet they cannot be considered as fully established, especially at the latter institutions.

In Mexico, there are about 50,000 agricultural industries (1) of different types and classifications, primary and complementary or, depending on the processes they use, there are stabilization, extractive and transformation industries.

Out of the total exports of the country over 30% are formed by industrialized agricultural products and approximately 20% are non-industrialized agricultural products.

The majority of the technologies applied have been developed by foreign firms operating in the country.

Expansion and improvement in the use of agricultural products is taking place rather slowly if compared to the country's needs.

Recently a General Bureau of Rural Industries has been created, while other agricultural industry official agencies exist; Public Banks also have within their organization some offices dedicated to this aspects, but as yet the efforts and resources channelled to these activities can be considered as insufficient.

It has been proposed that an institute for agro-industrial, research be created next year if sufficient resources necessary to this end are obtained.

The Agricultural Industry Education and Research Department of the National School of Agriculture of Chapingo, Mexico, which we have already mentioned, trains agronomical engineers specialized in industry, having knowledge of Engineering, Agronomy, Chemical and Biological Sciences, Technology and Economics.

Studies within this profession are designed to prepare the student for planning of industrializable agricultural production, including manufacturing processes, plant design and operation, as well as establishment of quality standards for raw materials, processes and manufactured products.

The Post-Graduate School of the Faculty has under consideration the establishment of the agricultural industry branch and the pertinent project is under study.

In general, activities related to agricultural process engineering involve the participation of similar professionals such as chemical engineers, biochemists, mechanical and electrical engineers, biologists, etc We must point out again that the latter do not have the specific training required for staff and personnel in this area of agricultural engineering.

IRRIGATION, DRAINAGE AND SOIL MANAGEMENT.

Since Mexico has limited hydraulic resources and arable lands, study of this area has become of the ut-

(1) By Agricultural Industries we understand all small or large production units using agricultural or rural products as raw materials. This includes agriculture itself, all lines of cattle raising, forestry, continental fauna and fish farming, for purposes of handling them, conditioning them or bringing about their conservation and/or partial or total transformation.

most importance. It is known that only approximately 14%, that is, approximately 17 million hectares of the total national surface is cultivable, of which at present only some 4 million are under irrigation and account for nearly 60% of the national agricultural production.

Consequently, all the colleges dedicate a major percentage of their time to studying soil and water resources for a better use to the benefit of national agriculture.

The Agronomical Engineer, specialized in Irrigation at the National School of Agriculture, is adequately trained to make optimum use of rain, surface and ground waters receiving an appropriate knowledge of the hydrological cycle. He is furthermore trained to select and build the adequate storage and conveyance structures for the different agricultural zones, minor conveyance structures and optimum application of irrigation to the plots. He thus receives the necessary training on the water-soil-plant relationships, to improve yields, increase the efficiency of the use of irrigation waters, good soil management and control of irrigation and river water quality, to avoid salinization and to prevent and/or recover swamp lands.

At present, due to the importance of soil and water resources, research in this field is beeing carried out throughout the country, not only at the agricultural colleges but also in different Official Agencies such as the Secretariats for Agriculture and Cattle Raising and Hydraulic Resources. Some private institutions also participate actively.

Mexico has developed the necessary mechanisms to train researchers at the National School of Agriculture and the Monterrey Technological Institute, where at present the degree of Master of Science in Irrigation and Soils is given.

The Irrigation and Drainage Branch of the Post-Graduate School of the National School of Agriculture, at present has a large number of local and foreign students. Due to the country's needs in this field, different sections have been created such as Soil-Water-Plant Relationships; Irrigation; Salinity; Drainage and Management and Use of Hydraulic Resources.

CONCLUSIONS AND RECOMMENDATIONS.

Mexico does not have Agricultural Engineering departments or faculties as such. The agricultural higher education institutions train agronomists and agronomical engineers, while the latter, in some institutions, only receive general courses related to the areas of agricultural engineering, while in others , such as the National School of Agriculture, it is broken down into Departments of industrial Engineering and Irrigation Research and Education; however, it is felt that there are certain weaknesses in the areas of power and agricultural machinery, agricultural constructions and rural electrification. It is therefore believed necessary to organize an Agricultural Engineering Faculty having Departments corresponding to the 5 aforementioned areas. Work is being carried out on this matter at present.

Due to the major needs of the Nation's agricultural development and the trascendental contribution which could be provided by the application of agricultural engineering techniques, it is felt that it is indispensable to strengthen educational and research activities in the areas involved under agricultural engineering in Mexico.

The opportunity made possible by this panel on the subject to determine the present situation, establish objectives as well as the guidelines of agricultural engineering educational research activities at the undergraduate and post-graduate levels in Latin American countries is worth to praise and merits the contribution of our major and best efforts so that, since the importance of these activities for the development of our region has been proven, we might achieve channeling of the necessary and sufficient resources to achieve a correct application of the techniques which, to the extent required by the characteristic conditions of each zone of Latin American countries, may be developed. Countries which for a long time shall see the agricultural or rural sector as a major element in their economies, and which have served as the basis for the development of the other sectors of the economies of advanced countries.

Theme 1.

9. STATUS OF AGRICULTURAL ENGINEERING EDUCATION IN PUERTO RICO, by Jorge H. Rodríguez-Arias, Puerto Rico.

The Mayaguez Campus of the University of Puerto Rico, also historically known as the College of Agriculture and Mechanic Arts-- a land-grant institution-- is solely responsible for agricultural engineering education in Puerto Rico.

Following is some information of interest pertaining to the history, organization, government and other relevant aspects, as drawn largely from the newest University Catalogue (1968-69).

HISTORICAL SKETCH.

The University of Puerto Rico was an outgrowth of the Normal School, for the training of public school teachers, which opened in 1900 at Fajardo, and the following year was moved to Río Piedras. On March 2, 1903, the Normal School was incorporated by the Legislative Assembly into the University of Puerto Rico, an institution with a vastly broader program.

The extension of the benefits of the Morill-Nelson Act to Puerto Rico in 1908 made possible the University's rapid growth. The College of Liberal Arts was established at Río Piedras in 1910, and the following year the College of Agriculture in Mayaguez was authorized by the Legislature.

The necessity of a College of Agriculture was pointed out as early as 1907 by D.W. May, Director of the Federal Experiment Station in Mayaguez. The development of this idea was successfully carried out by him with the able assistance of Carmelo Alemar and José de Diego. For several years courses in Agriculture were offered in Río Piedras and other localities, but the College of Agriculture was not organized in Mayaguez until 1911. By September 1912 the first full-sized classroom building had been completed. That year the name of the College was changed to the College of Agriculture and Mechanic Arts.

A general reform of the University in 1942 was followed by the establishment of the Mayaguez Campus under the authority of a Vice-Chancellor and reorganized into three colleges, each under a Dean: the College of Agriculture, the College of Engineering, and a new College of Sciences. The University then expanded rapidly. Colleges of Humanities, Natural Sciences, and Social Sciences were also founded at Río Piedras. In 1950 the School of Medicine located in San Juan, was established. It further augmented the facilities for professional preparation already offered by the Colleges of Law and Pharmacy, both established in 1913, as well as by the School of Business Administration and the School of Tropical Medicine, which were begun in 1926. The School of Dentistry was started in 1957.

The foundation in 1946 of a Division of General Studies in Mayaguez marked a turning point in the expansion of the University on that campus, which resulted in the inauguration of a Bachelor of Arts Program in 1957. In 1959 the College of Sciences and the Division of General Studies were combined into a new College of Arts and Sciences . The establishment of Puerto Rico Nuclear Center in 1957 and the construction of its main facility in Mayaguez, marked another phase in the growth of the University there, and the beginning of graduate studies and research in Nuclear Sciences, Radiological Physics, and Mathematics.

A new University Law was enacted and then approved in January, 1966. According to this Law, the University is reorganized into three autonomous campuses (Río Piedras, Mayaguez, and San Juan) , each with its own Chancellor, and a separate Division of Regional Colleges.

The University of Puerto Rico in Mayaguez.

Formerly known as the College of Agriculture and Mechanic Arts of the University of Puerto Rico, "el Colegio", as it is popularly known, is located on the outskirts of Mayaguez, Puerto Rico's third largest city, thirty air minutes from San Juan, at the western end of the island. Besides the three instructional divisions-- The Colleges of Arts and Sciences, Engineering, and Agricultural Sciences-- The Agricultural Experiment Station and the Agricultural Extension Service are also part of the Mayaguez Campus.

A land-grant institution, "el Colegio" was founded in 1911 and is coeducational, bilingual and non-sectarian. Situated amidst 400 acres of rolling hills and beautifully landscaped grounds covered by a remarkable display of native and exotic flora, "el Colegio" is scarcely a mile from the seashore and the white sandy beaches and coral formations of the western coast of Puerto Rico.

Experiencing the biggest building program in its history, "el Colegio" has witnessed in recent years the erection of many new facilities, classrooms and laboratories. These facilities include the Engineering Building, largest building in the University; the College Center, two dormitories for men, the Darlington Building, the magnificent new library, and a new extension of the General Studies Building devoted to the Liberal Arts.

The current enrollment exceeds 7,000 students and the faculty number is approximately 400. More than 600 foreign students, together with a large number of faculty representing the Caribbean area and Latin America, as well as Europe and the Orient, make the College a cosmopolitan crossroad of the Americas.

Accreditation.

The University was fully accredited and admitted to membership in the Middle States Association of Colleges and Secondary Schools on April 29, 1946. It has been a member of the Association of Hispano-American Universities since 1955. In 1960 the College of Engineering was accredited by the Engineers' Council for Professional Development.

Government.

The Council of Higher Education is the governing body of the University. Its membership consists of the Secretary of Public Instruction and eight additional persons who represent the public interest in higher education. The Council elects its President from among its members. All members are appointed by the Governor, with the advice and consent of the Senate of Puerto Rico. With the exception of the Secretary of Public Instruction, they serve six-year terms.

The Council of Higher Education meets in regular sessions according to an annual calendar which it approves and published each year. It may hold extraordinary meetings at other times when so directed by the president or required by five of its members.

The President of the University, who is appointed for an indefinite term by the Council of Higher Education, is the executive director of the University. Subject to the approval of the Council, he appoints the Chancellors of the Río Piedras, Mayaguez and San Juan campuses of the University, and the Directors of the Regional Colleges.

The University Board is composed of the President of the University, the Chancellors of the three campuses, the Director of the Administration of the Regional Colleges, the Director of Finance, and three additional members appointed by the President with the approval of the Council, and one representative from each Academic Senate. This Board acts as a central advisory body to the President and collaborates with him in carrying out the University program.

There are also administrative boards on each campus composed of the Chancellor who is its president, the Faculty Deans and two Academic Senators elected from among those members of the Senate who are not ex-officio. On the Mayaguez Administrative Board, the Agricultural Experiment Station and the Agricultural Extension Service are represented by their Directors. These Boards act in relation to the Chancellors in a way which is similar to that in which the University Board acts in relation to the President.

The Academic Senate of Mayaguez is a body consisting of the members of the Administrative Board, the Librarian and representatives, elected from the faculties, whose numbers must be not less than twice the number of the ex-officio members. The Academic Senate has the authority to formulate regulations concerning all academic matters.

Colleges and Faculties in Mayaguez.

The Mayaguez Campus of the University of Puerto Rico comprises three divisions of studies: the College of Agricultural Sciences, the College of Arts and Sciences, and the College of Engineering.

The College of Agricultural Sciences as established in 1968 includes the Faculty of Agriculture, the Agricultural Experiment Station, and the Agricultural Extension Service. The Office of International Programs in Agriculture and the Office for Programs and Planning in Agriculture are two new divisions created under the College of Agricultural Sciences.

The College of Agricultural Sciences offers courses leading to the Bachelor of Science degree by following a special program, or a general program, with majors in Agricultural Business, Agricultural Education, Agricultural Extension, Animal Science, and Mechanical Technology in Agriculture; and to the Master of Science degree in Agriculture.

The College of Engineering offers a five-year program leading to the degree of Bachelor of Science with majors in Chemical Engineering, Civil Engineering, Electrical Engineering, Industrial Engineering, and Mechanical Engineering; and to the Master of Science degree in Civil, Electrical, Mechanical and Nuclear Engineering. In addition the College of Engineering through the Technical Institute Program offers the Associate in Science degree in the fields of Drafting and Building Construction, Electrical Power and Electronics, Mechanical Design and Metalworking, and Surveying and Highway Construction.

The College of Arts and Sciences offers courses leading to the Bachelor of Arts degree with majors in Economics, English, Humanities, Latin American Studies, Political Science, Social Science, Sociology, and Spanish; the Associate in Arts degree in General Nursing; the Bachelor of Science degree with majors in Biology, Chemistry, Geology, Mathematics, Medical Technology, Nursing, Physics and Pre-Medical Sciences; the Master of Science degree in Biology, Chemistry, Mathematics, Physics, Radiological Physics and the Master of Arts degree in Hispanic Studies.

Agricultural Experiment Station.

The main objective of the Agricultural Experiment Station is to develop and carry out a comprehensive program of research in the production, utilization and marketing phases of agriculture so as to provide basic knowledge for the advancement and development of the agricultural industry; and to device new means of efficiently increasing the total volume of agricultural production in Puerto Rico. In addition to this basic function, the Station is authorized to carry on research for the improvement of the rum manufacturing industry and for the industrialization of the total agricultural production.

The Station was originally established in 1910 by the Sugar Producers Association of Puerto Rico, which ceded the Station lands and buildings to the Government of Puerto Rico three years later. In 1933 the Station was transferred to the University by Legislative action, thus making it eligible to receive Federal grant-in-aid funds.

Sixty seven per cent of the Station's annual budget of approximately 4.8 million dollars is derived from funds allocated by the Legislature of Puerto Rico; nearly 30 per cent is derived from Federal appropriations under the Hatch Act and 4 per cent, from donations and contributions.

In addition to the Main Station at Río Piedras, there are six substations located at Isabela, Lajas, Corozal, Adjuntas and Ponce. The Department of Agricultural Engineering is located on the Mayaguez Campus. The Food Technology Laboratory and the Rum Pilot Plant, the Main Agricultural Library, and the Computer and Statistical Center are located at the Main Station in Río Piedras.

Agricultural Extension Service.

The Agricultural Extension Service works in cooperation with the United States Department of Agriculture. Officially a division of the Mayaguez Campus of the University of Puerto Rico, it belongs to the educational section of the National Association of State Universities and Land-Grant Colleges. It operates with funds provided by the Commonwealth and the Federal governments, as well as funds provided from non-public sources.

By virtue of a cooperative agreement between the University of Puerto Rico and the United States Department of Agriculture, the Agricultural Extension Service initiated its work in Puerto Rico in 1934. Prior to this date agricultural development work had been carried on by the Bureau of Agricultural Development of the (then) Department of Agriculture and Commerce. The organization is headed by a Director appointed by the Chancellor of the University of Puerto Rico in Mayaguez with the approval of the Federal Extension Service in Washington, D.C.

The Extension work of the Island is divided into five (5) regions. These in turn are subdivided into 17 districts and 67 areas. At each area level there is a planning committee made up of local people who discuss the program of work to be developed and help the agents in the preparation and conduct of yearly plans. Extension work is basically an educational program, with technical assistance, for the improvement of the standards of living and the general welfare, principally in the rural areas. Agents devote time to youth development work thru 4-H clubs for boys and girls.

College of Agricultural Sciences.

The College of Agricultural Sciences, offers four year plans of study leading to the degree of Bachelor of Science in Agriculture. A total of 142 semester credit-hours are required for production not including Military Science or Physical Education.

General Agricultural Sciences Curriculum leading to the Bachelor of Sciences Degree in Agriculture.

The development of modern agriculture is based on the application of Science to agricultural processes and problems. The general agricultural sciences curriculum therefore provides the student with a basic and broad foundation in the agricultural sciences, at the same time offering practical specialization in the field of his particular interest during his senior year. The curriculum aims, furthermore, to assist the student in developing such cultural attributes as will enable him to perform well as a member of society and in his personal and professional dealings with people.

Students choosing this curriculum may elect to specialize broadly in either Animal or Plant Science, or more specifically in any of the fields of Agricultural Business, Agricultural Education, Agricultural Extension or Mechanical Technology in Agriculture by following the corresponding optional program.

HISTORICAL BACKGROUND AND EDUCATIONAL PHILOSOPHY AS A BASIS FOR THE PRESENT CURRICULUM.

As could be expected, though certainly with an understandable time lag, Puerto Rico did not escape the effects of the drastic changes experienced by continental United States over the past century in their social, economic, and technological environment. Parallel with and superimposed on these effects, Puerto Rico has witnessed similar but greatly accelerated changes of its own over the past two decades which have added considerably to the impact on our socio-economic structure and hence on the requirements of our University curricula and related programs, very particularly those in Agriculture. Interwoven with and emerging above the many other well recognized phenomena which have characterized these transformations, stands out most conspicuously-- at least before the eyes of those directly concerned with Agriculture-- the changing agricultural pattern of Puerto Rico along with its concomitant effects upon the training and educational needs of agricultural manpower, the fulfillment of which is preeminently the responsibility of our University.

Thus despite our traditional predominantly agricultural economy-- which should and will inexorably continue to prevail to a greater or lesser degree throughout the foreseeable future-- the almost explosive growth of other sectors of the Commonwealth economy, particularly the manufacturing and urban construction industries, has set up tremendous stresses in the island's agriculture which coupled with the effects of many other fortuitous adverse factors not strange to agriculture anywhere in the world, have inevitably created the impression of a serious crisis. This, among other causes, has undoubtedly accounted for the trend of diminishing enrollment in agriculture which was particularly evident over the first half of the decade and has even deluded many into the fallacy of questioning the importance of the role that the agricultural curricula and related programs should have within the context of the University's obligation to serve the people of Puerto Rico.

Yet this is precisely the time when professional people can best serve the field of agriculture, and hence when greater attention and renewed emphasis should be paid our agricultural programs. This has called, however, for a realistic and thorough reexamination of our various curricula amd programs with a view to more effectively respond to our changing social, economic, and technological environment, and to the attendant transformations taking place in the general framework of our agriculture. Preeminent among the latter has been the continuing shift from an obsolete "hoe-and-machete" type of farming with an abundance of cheap labor and relative freedom from economic and social pressures to an increasingly mechanized agriculture endeavoring towards the highest levels of efficiency in order to successfully maintain its rightful position in the social and economic structure of the island. Again similar changes are now beginning to occur-- and are apt to proceed at an everlasting pace-- in the developing countries of this hemisphere and other parts of the world; and the role that our University is likely to play in hemispheric education particularly serving Central and South American countries must also be taken into consideration.

An all important characteristic of the emerging agricultural pattern in Puerto Rico from the standpoint of revamping our curricula and programs in agriculture, is the increasing need for applying engineering technology to agriculture not only in the more conspicuous area of farm power and machinery but to an equally important extent in soil and water management, farm buildings and conveniences, farm electrification, and agricultural products processing.

Early attempts of the Agricultural Engineering Department-- officially created in 1948-- toward contributing its share to fulfilling this need consisted in making available new elective course offerings aimed at providing practical training in these various areas. Competition by long established electives in other Major-offering departments, a seemingly natural shyness on the part of agricultural students away from subjects presumably requiring mechanical aptitudes and a deeper knowledge of physics and mathematics than was then made available by the prevalent curriculum, and a rather notorious lack of suitable laboratory facilities were unfortunate factors which militated against the fullest desirable attainment of the objective in mind. Thus all too few agricultural graduates, and then only too meagerly, were reached by the Department's efforts to that end.

A significant breakthrough in curriculum development was realized in the year 1960 when after long study and consideration by the Dean and the Faculty a thorough revision of the traditional course offerings and curricula resulted in the institution of new programs of study designed to better equip the students for meeting the present and future challenges posed by our changing agricultural structure. Without sacrificing but rather strengthening the ingredients of a general education considered essential to successful performance both as a citizen and as a professional, the new programs provided for a more solid foundation in the basic sciences of Mathematics and Physics besides the long established emphasis in Biology and Chemistry.

A general Agricultural Sciences Curriculum allowed for broad specialization in either Animal or Plant Science as well as for more specific specialization in any of four different optional fields. This was achieved essentially through programs comprising a core of three years common to all, with opportunity for taking a total of 28 credits in appropriate electives during the senior year. Scheduling a Summer Field Practice between the third and fourth years further provided for a more thorough practical training in the student's chosen field of specialization. By the optional programs between a group termed General Electives and another termed Professional Electives, coupled with proper student counseling, it was sought to more completely achieve the desired curricular balance between the broader and the more specialized emphasis as well as more effectively meet the needs and interests of the particular student.

Besides the General Agricultural Science Curriculum with its various Optional Programs, a Special Agricultural Sciences Curriculum was instituted, especially aimed at students with well defined scientific inclinations who would contemplate pursuing graduate studies in any of the various fields of the agricultural sciences. Along with the above programs the Faculty of Agriculture also introduced a three-year Pre-Veterinary Curriculum designed to meet the needs of qualified students intending to continue studies in Veterinary Medicine in the United States.

THE CURRICULAR OPTION "MECHANICAL TECHNOLOGY IN AGRICULTURE".

The institution of the new programs afforded the opportunity to introduce an Option in Mechanized Agriculture (designated in a later revision as "Mechanical Technology in Agriculture") precisely aimed at fulfilling the growing need of preparing agricultural students for the practical application of engineering principles to the problems generally encountered in the type of modern farming toward which the evolving agricultural pattern is now rapidly converging not only in Puerto Rico but, with various degrees of celerity, also in other countries which our agircultural graduates are likely to be called upon to serve. Initially and in order to expedite its adoption, the program followed the same general structure as the other options with the first three years common to all , waiting until the fourth year for achieving the specialization by taking appropriate electives following the supervised Summer Field Practice taken immediately after the end of the junior year.

This arrangement posed the obvious drawback of providing for the field practice prior to acquiring a more substantial fund of academic preparation in the subject matter of the specialization. It was felt, however, that with proper guidance such shortcoming could be partly offset by the opportunities afforded for prior exposure to activities and problems which would enhance motivation and preparedness for more effective learning in the formal courses during the senior year. The seminar courses of the senior year, designed to capitalize on the practical experience thus gained, were expected to further contribute to that end.

Even more significant that the foregoing, very particularly in the case of the MTA (Mechanical Technology in Agriculture) curriculum, was the difficulty encountered in properly achieving the program's technical objectives with only the senior year allowed for specialization. It was then hoped to alleviate this problem by early detection and subsequent orientation of prospective students towards taking advantage of the summer sessions and the semesters with relatively light academic loads (16 or 18 credits) for scheduling such critical courses as Ge Eg 201-Elementary Drawing Ci Eg 301- Agricultural Surveying, and Math 171- Computation-- considered essential prerequisites for some of the important technical courses of the program-- prior to the senior year.

However, the real opportunity to improve of this initial arrangement came as a result of the general revision by the Faculty of Agriculture of the agricultural curricula which became effective at the beginning of the academic year 1964-1965. Thus by differentiating from the General Curriculum starting in the third year rather than in the fourth year it was made possible not only to correct the aforementioned difficulty but to achieve an overall program which could more effectively satisfy the intended objectives of the curricular option.

Following is a breakdown of the total of 152 credits presently required by the MTA option: (presented in full in Appendix B).

I. Required Courses			124
A. Basic Sciences		49	
Biological	12		
Physical	10		
Chemical	16		
Mathematical	11		
B. General Education.		41	
Spanish	6		
English	12		
Economics	3		
Social Sciences	6		
Humanities	6		
Military Science	8		
C. Technical Courses		34	
1. Agricultural Technology	20		
Animal Industries	7		
Agronomy	10		
Agricultural Economics	3		
2. Engineering Technology	14		
General	2		

Civil Engineering	3	
Agricultural	9	
Electives		28
A. General	14	
B. Professional	14	

The courses comprising the group of recommended General Electives were carefully selected mainly from the regular offerings by other departments in the College of Agriculture but also including appropriate courses offered by the Colleges of Arts and Sciences and Engineering. The role of the General Electives is such as to permit adding to the curriculum both depth and breadth within the framework of its established objectives emphasizing particularly its technical aspects. As a means of strengthening the program as well as achieving a more effective utilization of institutional resources three of the General Electives were designed to be offered by three different departments in the College of Engineering as service courses especifically earmarked for the students following this option. It is deemed proper to commend herewith the cooperativeness and spirit of service shown by these departments in willingly agreeing to prepare these special courses in accordance with the particular needs and requirements of our students. Because of the value of two of these courses, namely Elementary Drawing offered by the General Engineering Department, and Agricultural Surveying offered by the Civil Engineering Department, as prerequisites for other important courses within the Professional Electives group they were to be incorporated to the core of required subjects at a later revision of the program.

The group of Professional Electives comprised the balance of the Agricultural Engineering Department course offerings exclusive of those already forming part of the required courses. Their role is essentially concerned with providing thenecessary technical training to enable the agricultural graduate to successfully tackle the problems of modern agriculture which involve the application of engineering technology. While a wide enough range of electives, both within the General and Professional groups, is made available to suit the needs and preferences of the individual student it is aimed by proper counseling and orientation to achieve the highest possible degree of balance and coherence to most effectively serve curricular objectives.

It should be emphasized at this point that the professional courses making up the specialized training of students following this option, while administered by the Agricultural Engineering Department and therefore carrying the name of Agricultural Engineering in their catalog numbers, are by no means and could not possibly be of an engineering rigor; hence the name "Mechanical Technology in Agriculture" of this particular program. As is well known, other names with which this type of program is designated in other Land-Grant institutions in the Unites States are "Farm Mechanization", "Agricultural Mechanization", "Mechanized Agriculture", and "Agricultural Mechanics". In some of these institutions graduate studies leading the M.S. degree are also offered within this same type of program. It will be seen that in all of the aforementioned names the use of the term "engineering" is carefully avoided aiming to distinguish these programs from the other type of curriculums--whose administration is also a major function of Agricultural Engineering Departments-- leading to engineering degrees with specialization in Agricultural Engineering and normally granted by the Faculty of Engineering. As distinct from those in the MTA curriculum the professional courses in this other type of programs are designed with strictly engineering rigor and are necessarily preceded by prerequisite course sequences involving more advanced mathematics and physics besides the basic engineering sciences such as fluid mechanics, thermodynamics, and solid mechanics.

Yet in designing the MTA courses it is aimed to provide subject matter content and impart instruction at a level fully commensurate with both the student's background and capabilities and their intended role as agricultural professionals and public servants. It is strongly felt that this group of agricultural specialists are destined to fill a long existing gap in the ranks of agricultural professional manpower in Puerto Rico and to effectively contribute to the satisfactory solution of many pressing problems now confronting Puerto Rican agriculture, not to mention their likely contribution to the agriculture of many developing countries of this hemisphere.

Theme 1.

10. POST GRADUATE AGRICULTURAL ENGINEERING EDUCATION AND RESEARCH IN LATIN AMERICA COUNTRY STATEMENT - COMMONWEALTH CARIBBEAN by L. G. Campbell,

A. AGRICULTURAL ENGINEERING EDUCATION.

1. Institutions for Training.
2. Institutions with Agricultural Engineering Departments.
3. Specializations required.
4. Employment opportunities.
5. Outline of courses in a proposed curriculum.
6. Interest in curriculum development in Agricultural Engineering at the University of the West Indies.

B. A BACKGROUND TO AGRICULTURE OF THE CARIBBEAN REGION.

1. The environment.
2. Economic crops.
3. Future developments and the expected role of Agricultural Engineering.

A. AGRICULTURAL ENGINEERING EDUCATION.

1. Institutions for training.

At the professional level, agricultural engineering training opportunities have not in the past been available in the Commonwealth Caribbean.* Agricultural Engineers serving in this region have traditionally received their training from institutions in Canada, United States and Great Britain, and more recently in Israel. At the University of the West Indies, it is normal for students reading for a first degree in agriculture to take a full course** in crop production systems and mechanization. Limited facilities are available for qualified graduates to pursue studies towards a higher degree or diploma with specialization in some aspects of agricultural mechanization, field engineering or crop processing.

For the near future the Faculties of Engineering and Agriculture are planning jointly to offer a curriculum leading to a professional qualification at the first degree level B.Sc. (Eng.) in Agricultural Engineering.
Opportunities will also be available on a broader front for training at the post graduate level.

2. Institutions with Agricultural Engineering Interests.

In all of the larger territories, and some of the smaller ones, the Ministries or Departments of Agriculture have one or more positions for agricultural engineers on their establishment. In Jamaica Trinidad and Guyana, these government establishments have three or more on their staff sharing the responsibilities for land development and soil conservation planning, designs and establishment of drainage and irrigation systems, the management and maintenance of mechanization schemes, etc. Unfortunately, in the last ten or so years it has been difficult to fill all the positions for agricultural engineers, and these establishments have operated under severe handicap. The other islands which do not have agricultural engineers in the government service, have normally depended on the University of the West Indies for guidance and assistance in matters relating the engineering in agriculture in the public sector. Up to the moment there has been only one agricultural engineer at this institution. His main responsibilities are in organizing the courses offered to students in the Faculty of Agriculture, supervising post graduate students and conducting research. He is also frequently used by governments of the region on special assignments, for short term "in service training" courses or as consultant. It is envisaged that a minimum of two additional agricultural engineers will be needed on the establishment of the U.W.I. to complete a team with others in the engineering faculty in mounting the new professional curriculum which it is proposing to offer.

In the private sector the larger farming organizations, sales and service firms have positions for agricultural engineers on their establishment. They also experience difficulties in securing the services of qualified people to fill these positions.

3. Specializations required.

Livestock farming forms a small part of the agriculture of the region and the environmental requirements for animals here are simple and unlikely to cause a high demand for agricultural engineers. There is however a strong need for engineers to serve in field engineering, resource management and conservation, power and machinery application and crop processing. The major agricultural enterprises needing these services include sugar, rice, banana, citrus, cocoa, coffee, coconuts, forage crops, vegetables and root crops.

4. Employment opportunities.

(i) Employment opportunities for agricultural engineering can be found in (a) the government service- for design, development, management and maintenance, teaching and extension work, (b) the University of the West Indies- for teaching and research, design and development work, (c) the Farm Institutes for teaching and development, (d) the larger farming organizations or plantations- for design, development, management and maintenance and (e) the sales and service industries - for development, sales maintenance and promotional work.

(ii) There are no graduates at the moment from the regional institutions to meet the needs.

(iii) It is hoped that the proposed curriculum in agricultural engineering by the University of the West Indies if the funds are forthcoming for mounting it will meet the needs in the foreseeable future.

5. Outline of courses in a proposed curriculum.

The requirements to register for the proposed course at the University of the West Indies, in addition to that for the University matriculation *, shall include:

either (a) Advanced level passes in the General Certificate (U.K.) in Mathematics (Pure and Applied) and in Physics; and Ordinary level pass in Chemistry, or
(b) Advanced level passes in the G.C.E. in Pure Mathematics, in Applied Mathematics and in Physics and Ordinary level pass in Chemistry, or
(c) Successful completion of the Preliminary year in the Science Faculty of the U.W.I.
(d) Any other equivalent qualification approved by the Faculty.

The schedule of courses** to be taken are as follows:

PART I (This is a common year with Civil, Chemical, Electrical and Mechanical).

1. Mathematics.
2. Science of Materials.
3. Applied Thermodynamics.
4. Strength of Materials and Theory of Structures.

* Matriculation requirement is normally.
2 "A" level passes and 3 "0" level in the G.C.E. or 3 "A" level passes and ' "0" level in the G.C.E. or The U.W.I. Preliminary Year Examination.
** Each course provides for 2 lectures and one 3- hour lab. per week for the full academic year.

5. Mechanics of Machines.
6. Applied Electricity.
7. Engineering Drawing.
8. Fundamentals of Engineering and Machine Shop Practice.

PART II (This year is largely common with Civil and Mechanical Engineering).

1. Mathematics.
2. Theory of Structures.
3. Mechanics of Fluids.
4. Design of Machines.
5. Applied Thermodynamics
6. Agricultural Science.
7. Elements of Economics
8. Surveying.

PART III (In this year there is a choice of specialization).

Field Engineering Group.

1. Mechanics of Fluids.
2. Soil Mechanics and Geology.
3. Drainage and Irrigation Engineering.
4. Either Agricultural Engineering I or Agricultural Engineering II.
5. Special Research or Design Project.
6. Farm Management and Production Economics.

Mechanical Group.

1. Electrical Technology.
2. Agricultural Engineering I
3. Agricultural Engineering II.
4. Either Drainage & Irrigation Engineering or Applied Thermodynamics.
5. Special Research or Design Project.
6. Farm Management and Production Economics.

6. Interest in Curriculum Development in Agricultural Engineering at the University of the West Indies.

It is because the Faculties of Engineering and Agriculture of the University of the West Indies recognize the potential role of Agriculture Engineers in the development of a region whose economy is based largely on agriculture, that they have put forward the proposal for training agricultural engineers. The curriculum was developed by a joint faculty committee. It was approved by both faculties and supported by the academic board at the Trinidad Campus. The proposals were also given first priority by the Planning and Development Committee of the University.

They have gone forward to the University Administration for funding and this may be a major obstacle to be overcome but as soon as this is done the course will be included in the University calendar.

B. A BACKGROUND TO THE AGRICULTURE OF THE REGION CARIBBEAN.

1. The environment.

The Commonwealth Caribbean presents a wide variety of conditions for crop and animal production. The islands in the northern and eastern arc of the Caribbean chain are relatively small and enjoy an oceanic type of climate. Some are volcanic in origin, with mountainous and steep terrain and very little flat land. The rainfall in these may range from 60"-200" per annum, over relatively short distances of 6-15 miles and the time distribution is uneven. Other islands which may be coraline or sedimentary in origin have flat to rolling topography but generally with lower rainfalls. The rest of the region- Guyana and British Honduras, have large areas of low lying, poorly drained land, some savannah type country and gently rolling terrain in the remainder. The mean temperature is about 78°F, the range being from about 65° F to 94°F, - the greatest variation occurring in 24-hour period and not between seasons.

The main factor limiting crop production in these areas is generally rainfall. There are dry seasons ranging from three to five months and these may occur in two distinct periods in any year depending on latitude. During the wet months when as much as 80% of the annual precipitation may occur, there are the problems of excess moisture in soils with impeded drainage, and rapid run off on the hilly lands which have been cleared and inadequately prepared for safe use.

In general, the flat or moderately sloping lands are taken for plantation type agriculture while the poorer and more difficult to manage hill lands are occupied by small farmers, many of whom practice some shifting agriculture.

2. Economic crops.

The major economic crops of the region are sugar cane, bananas, citrus, coconuts, cocoa, coffee and some spices, most of which are exported to contracted markets mainly in the United Kingdom and to a limited extent in North America. The location or distribution of these crops has been dictated by the rainfall pattern, topography and availability of labour. The bulk is produced by plantations using abundant labour but the contribution of the small farmer is important though it manifests many undesirable features including low productivity and poor quality. Minor crops include various fruits, starchy staple foods, (root crops and grain) and vegetable crops. These are mainly for local consumption and are produced almost entirely by small farmers. The livestock industry is of lesser importance. In the larger countries- e.g. Guyana and British Honduras, ranching in the savannah areas meet some of the local demand for beef, while in the Jamaica and some of the drier islands there is more intensive management of beef cattle. The dairy industry is not strong. Some of the islands produce all or a large part of their needs for poultry and pork products but the bulk of the feed for these industries is imported from outside the region.

3. Future development and the expected role of Agricultural Engineering.

The region represents a total land area of approximately 99,603 square miles and a population of approximately four million persons, but of which Guyana and British Honduras alone account for 91,867 square miles and 663,620 persons. The part of the region comprising the islands is relatively small in area and densely populated. The whole region depends to a large extent on agriculture, but there are many obstacles to agricultural operations due mainly to steep terrain fragmented and small size of farming units, poor soils and bad distribution of rainfall which may also be inadequate in some regions for some crops.

Historically, the region has enjoyed varying degrees of agricultural prosperity during the last three hundred years, depending to a large extent on the economic and political climate in the metropolitan countries of Europe and North America. The agriculture was export orientated during those years, producing raw materials which were processed, refined or used in manufacturing industries abroad. In turn much of the food and clothing for the population was imported. In recent years the trend has been towards less dependence on imported food stuffs, beverages and other imported materials which can be produced locally, while maintaining adequate production of export materials in order to sustain a high degree of balanced trade and commerce in the region.

At the same time the policies of the governments of the region attempt to raise the productivity of labour and land to the extent that the population can afford a standard of living which can be regarded as satisfactory on western standards. On the other hand, the population growth has been uncomfortably high (2.5-3% per annum) in a region limited in land area and other natural resources. Future developments in agriculture will be significantly influenced by these factors as well as the natural physical problems affecting efficient production.

The two main forms of the land tenure will have to be rationalized. The size of small holdings will have to be reviewed in the light of scale of operations and economic returns which will sustain an adequate living standard for the owners and operators. Likewise, the very large plantations which have depended on an abundant supply of cheap labour and fortuitous environmental conditions, will have to be reorganized along lines where management will be able to harness the most economic forms of available power and machinery for field and processing operations. It will also be necessary to have better control of the natural environment in order to achieve higher production and productivity from the lands and labour. The difficulties of production on steep slopes, shallow and rocky soils, uneven rainfall, etc. will have to be overcome while ensuring that sensible and adequate provision is made for conservation of the natural resources for sustained production. In all the aspects of land and water conservation and management as well as production operations for agriculture, there will be greater dependence on people sufficiently trained in the science and art of engineering and agriculture.

The priorities for the future include development of production systems to raise efficiency on the traditional small farm as well as on the extensively managed plantations and estates. As labour values increase relative to other sources of power and as competition for existing labour by tourism and manufacturing industries in the region increases agricultural enterprises will have to rely on highly skilled workers who can justify higher wages based on productivity. The agricultural engineer will be depended upon to establish the procedures and develop the equipment to enable such changes. Efforts at new systems development may call for radically different approaches from currently accepted principles. The agricultural economies must also become more balanced and less subject to wide fluctuations. This will necessitate greater diversity in agricultural enterprises and may require the production of new crops and / or expansion of minor crops both for local as well as for export markets. The production field will thus widen even further and increase the challenge for the engineer in power and machinery applications and systems engineering.

The environment for optimum productivity is generally not fully understood for many tropical crops. Even in those crops for which there is a fair degree of information, the procedures or techniques for modifying the existing environment when necessary, has not yet been worked out. The agricultural engineer specializing the environment control, including soil and water development and management and conservation, is expected to play major roles in this.

Crop processing has not yet reached any degree of sophistication. Much of the drying, fermenting, polishing, grading, etc. can stand considerable improvement in methods and efficiency. A large percentage often over 50% of some crops may fail to reach markets because of poor drying, damage by pests, improper grading, or complete absence of methods of processing to enable their keeping for subsequent distribution. This too, can be an exciting specialization for potential agricultural engineers in the region.

The importance of the agricultural sector of the economy of the region is shown in Table 1. It gives an indication of proportion of the population depending on agriculture and their relative efficiency.

TABLE 1. THE PEOPLE, LAND AND AGRICULTURE OF THE COMMONWEALTH CARIBBEAN

Territory	Area (Square Miles)	Total Population (1960)	Proportion of Total Population in Rural Areas (1960)	Proportion of Total Working Population Engaged in Agriculture (1960)	Proportion of Total Land Area in Agriculture (1) 1956/59 (2) 1961	Density of Persons per Sq. Mile of Agricultural Lands (1960)	Contribution of Agriculture to Gross Domestic Product (1960)	Proportion of Total No. of Farms in the Size Group Less than 5 Acres (1) 1957/58 (2) 1961	Proportion of Total Area of Farms in the Size Group Less than 5 Acres.
Jamaica	4,411	1,606,546	70.2	37.9	42.9(2)	.849	12.4	71.3(2)	11.8
Trinidad & Tobago	1,980	827,975	54.3	19.9	35.0(1)	1,296	11	83.4(1)	12.6
Grenada & Carriacou	133	88,667	89.5	43.3	56.0(1)	1,215	39	87.4(1)	22.9
Antigua & Barbuda	171	54,060	60.0	31.1	61.4(1)	515	25	90.8(2)	26.9
Barbados	166	234,575	79.4	26.4	69.8(2)	2,022	28	97.4(2)	13.4
Dominica	305	59,916	76.8	52.0	16.4(1)	1,198	43	78.1(1)	12.7
Montserrat	32	12,167	84.2	46.7	65.0(1)	608	38	92.7(1)	16.1
St. Kitts, Nevis & Aguila	150	56,693	53.9	45.1	50.0(1)	746	43	93.9(1)	12.5
St. Lucia	238	86,108	82.3	53.1	36.8(1)	989	35	80.2(1)	14.9
St. Vincent	150	81,466	80.4	42.7	43.8(1)	1,253	41	87.1(1)	22.5
Guyana	83,000	560,620	n.a.	35.0	6.5	104	27.3	-	-
Br. Honduras	8,867	103,000	n.a.	42 (1965)	3.0	387	-	-	-
All territories	99,603	3,771,793		33.8	8.9	425			

Source of data: A Digest of West Indian Statistics (1965), Department of Agricultural Economics & Farm Management U.W.I. St. Augustine.

Theme 1.

11. STATUS OF AGRICULTURAL ENGINEERING EDUCATION IN LATIN AMERICA: VENEZUELA by Amanda Dagger and Ismael Granadillo, Venezuela.

I. STATUS OF AGRICULTURAL ENGINEERING IN VENEZUELA.

A. Characteristics of Agricultural Engineering Education and the Agencies Implementing it.

Agricultural Engineering in Venezuela is provided by the Agronomical Engineering Schools of the Faculties of Agronomy of the Central University of Venezuela (UCV), Zulia University (LUZ), Central Western Region University (URCO) and Eastern University (UDO), as part of the training of Agronomical Engineers, through their respective Agricultural Engineering Departments.

There are no major differences in the curricula of the four schools. We can mention the fact that at URCO and UDO general Agronomical Engineers are trained, while at UCV and LUZ there is a certain degree of specialization in certain agricultural science areas, achieved through the so-called orientations, among which is Agricultural Engineering. The students following this orientation, in addition to general knowledge in Agronomy, receive some specific knowledge on some aspects of Agricultural Engineering.

1. Agricultural Engineering Education at the LUZ Faculty of Agronomy.

It has been entrusted to the Agricultural Engineering Department which coordinates the following compulsory courses:

- General Draftsmanship, Mathematics I, II and III, Physics I and II, Surveying I and II, Agricultural Machinery I and II, Hydraulics, Irrigation and Drainage and Rural Construction I and II, and the following vocational courses:

- Rural Electrification, Irrigation and Drainage II, Photogrammetry, Farm Planning, Agrology and Agricultural Machinery III.

It can be stated that out of 47 compulsory courses, 14 correspond to Agronomical Engineering, 29 to electives and 6 correspond to Agricultural Engineering.

According to the 1966 Dean's report, the Faculty's training has the following weaknesses:

a) Defficient education of some newly entered freshmen.
b) Excessive number of courses in the first semester.
c) Possible technical and educational defficiencies among the faculty.

At present the creation of four schools is under study:

- Agronomy, Animal Husbandry, Agricultural Engineering and Soil Sciences.
The Agricultural Engineering School shall provide education in depth on the following subjects:

- Irrigation and Drainage, Agricultural Mechanization, Rural Electrification, Agricultural and Cattle Product Processing, Water and Soil Conservation, Penetration Routes, Rural Construction and Rural Planning (the total number of students of this Faculty increased from 46 in 1959 to 431 in 1966 and seems to have reached a plateau).

2. Agricultural Engineering Education at the UCV Faculty of Agronomy.

a) Agricultural Engineering Department. Courses given; training is carried out through the Agricultural Engineering Department, created in 1959, formed by 9 courses, whose task is coordinated by a Departmental Committee constituted by all Department Chiefs from among which the University Council appoints the Department Head.

There are also internal Faculty, Budget and Personnel Training and Education Committees.

The Department provides the following courses:

	Credits
Advanced Algebra and Analytic Geometry	4
Physics	3
Technical Draftsmanship	1
Calculus	4
Rational Mechanics	3
Land Surveying	5
Agricultural Machinery I	3
Agricultural Machinery II	3
Rural Constructions	3
Irrigation and Drainage	4
Statistics	3
TOTAL CREDITS:	36 (20.93% of the total credits corresponding to compulsory courses).

all of which are compulsory for all Agronomy students.

Agricultural Engineering Orientation Courses:

	Credits
Semester No. 7	
Advanced surveying	2
Hydraulics	2
Semester No. 8	
Irrigation and Drainage II	2
Materials Strength, Soil Mechanics and Structural Calculus	3
Semester No. 9	
Small Irrigation System Project	2
Rural Roads	2
Semester No. 10	
Rural Construction II	2
Agricultural Machinery III	2
Operation and Development of Irrigation Systems	3
TOTAL CREDITS:	19 (10% of the total required credits to obtain an Agronomical Engineering Degree).

The oriented students receive 55 credits in Agricultural Engineering, which represents 28.7% of the total 191 credits required for the degree. Note: 1 credit : 1 lecture or 3 lab. hours (The general Agronomical Engineering School curriculum is attached).

b) Objectives Established for an Agricultural Engineering Orientation.

Once the General Agricultural Engineering Objectives were set up, taking into account the country's present development stage, which established well-defined areas within its broad field of application, the orientation plan set up as its objective that of trying to fill, as far as possible, the gap caused by the scarcity of Agricultural Engineering professionals. For this purpose, education is provided on:

a) Basic engineering aspects.
b) Engineering aspects applied to Agriculture.

Thus Agronomical Engineers with basic knowledge of Irrigation and Drainage, Rural Construction and Agricultural Mechanization are trained, the first aspect being given priority.

Agricultural Engineering Department Course Content (Summaries can be obtained by writing to the University)

c) Educational methods used.

Major emphasis is on theoretical and lab work, above all on compulsory courses; travel to different agricultural development areas is encouraged; group discussions are promoted; diverse projects are prepared; visits are made to different irrigation systems and, in the last semester, assistant professor duties are performed.

d) Faculty staff.

At present, the Department has 30 professors of which 14 are Agronomical Engineers, 5 Civil Engineers, 3 Industrial Engineers while the rest are Physicists, Mathematicians and Professionals of other Engineering fields.

Only four have Masters degrees and very few have received some special training after graduation.

e) Installations and equipment.

The Department has offices, laboratories and classrooms amounting to 1731 square meters of built area.

It has laboratories of: Hydraulics, Physics, Agricultural Machinery, Land Surveying, Rural Constructions and Statistics, which are relatively well equipped.

f) Budget.

In the last few years the Department has had a Budget of Bs. 1,965,000.00, allocated as follows:

Fixed Staff Expenses..........	1,750,000.00
Operational Expenses..........	87,000.00
Capitalization Expenses........	128,000.00

3. Post Graduate Courses.

As of 1958 the National Irrigation and Drainage Courses have been given. The two first ones were sponsored by IICA, while, as of 1962, they were the Faculty's entire responsibility.

To date, seven courses have been given for purposes of increasing professional knowledge and training in Irrigation and Drainage among professionals working in these areas. About 120 professionals, mainly Agronomical and Civil Engineers have attended.

The course involves 9 groups of lectures including 16 hours of theory and 16 hours of lab work on the following aspects:

a) Water-Soil-Plant relationships.
b) Surface Hydrology.
c) Soil Classification for Irrigation purposes.
d) Agricultural Hydrology (Optional).
e) Irrigation and Drainage design and operation at the Agricultural unit scale.
f) Small land-dam project.
g) Canal projection and construction.
h) Internal drainage.
i) Ground water.

At present it is being reorganized to establish two of three, three-month courses, per year and to create 2 options directed to:

1. Application and management of irrigation and drainage in the agricultural unit.
2. Designing and operation of small irrigation systems.

4. Institute of Agricultural Engineering.

The Institute of Agricultural Engineering, which shares staff, buildings and equipment with the Department, operates as the agency in charge of research; it furthermore uses the faculty's experimental fields involving a 43 hectares area in Maracay and more than 1,500 hectares in the three zones of the central western region of the country.

At present, it is dedicated mainly to the projects and construction of the necessary buildings at the agricultural stations. It has furthermore started and implemented important work in applied research.

5. Major Items in a Critical Analysis of the Education Provided.

a) Compulsory courses for all Agronomy students.

Teaching of these courses is characterized by facing the general problems and characteristics of the School of Agronomy, which can be summarized as follows:

1. Great gaps in the basic training of students entering the physico-mathematics field.

2. An overload of subjects and credits per semester, which necessarily leads to a training fundamentally based on theory lectures and memorization, without the active incorporation of the student.

3. High percentage of failures, specially in physics and mathematics, where over 80% flunk.

4. Lack of clear objectives at the level of the School of Agronomy, which leads to the absence of definite criteria as to the professional which has to be trained, and the unharmonious and inarticulate development of courses.

5. Course content is adequate but the courses are to extensive for the period of time available.

6. Insufficient laboratory and equipment facilities.

7. The average grade obtained by students passing the courses is 11 (grading ranges from 0 to 20), which is barely over the minimum passing grade, which is 10.

8. In general, the teaching load of every professor is high. This becomes even more serious due to the fact that the Department repeats most of the courses every semester.

b) Orientation Courses.

We cannot properly speak of a curriculum for the Agricultural Engineering orientation since the courses which we could call basic for the orientation do not constitute a structural whole.

We could say that the present curriculum is formed by a group of courses "practically added on to the curriculum of the School of Agronomy".

The objectives set up have been satisfactory, but we believe that in accordance to the development characteristics of the country, and specifically, the development trends of the agricultural and cattle sector, should be revised and improved.

The course content has been adequately determined but they are excessively extensive for the number of credits available for the orientation, which in turn creates an overload for the student.

The educational methods and evaluation systems have been improved, but this task is handicapped by the overloaded curriculum and other defficiencies indicated above.

As regards to the faculty members, we can say that even though , in general, they are quite capable, very few of them have the necessary degree of specialization and professional experience.

To a certain extent, this implies some lack of relationship with the major practices and techniques in use in the country.

Laboratory facilities and equipment have improved in recent years but are still insufficient.

We should point out that in recent years there was a marked decrease in the number of students choosing Agricultural Engineering as compared to the total number of graduates from the Faculty. We believe that this fact was due to:

- the difficulties which most students face regarding physics and mathematics courses, together with the overloaded curriculum and excessive demands of Agricultural Engineering courses, as compared to the number of credits given and to other orientations.

c) The Graduates.

From 1962, when the orientations were established, to date, 71 students in Agricultural Engineering have graduated from a total of 428 graduates of the Faculty. Their distribution is as follows:

YEAR	TOTAL GRADUATES	SPECIALIZED	% SPECIALIZING IN A. E.
1962	20	4	22. 0
1963	50	11	22. 0
1964	41	3	7. 3
1965	71	16	22. 5
1966	64	12	18. 8
1967	83	18	21. 7
1968	99	7	7. 1
	428	71	16. 6

At present there are 25 students in the specialty.

According to the results of two surveys undertaken in September 1968, on occasion of the "First Seminar on the Evaluation of Agricultural Engineering Education at the UCV Faculty of Agronomy", the following information based on 50 answers provided by graduates of the school and 5 employing agencies, can be given.

1. 80% of the graduates of the orientation work in Agricultural Engineering.

2. Irrigation seems to be the graduate's major activity.

3. All the subjects taught in the orientation are applied to some extent in professional activities, especially :
   Advanced Surveying, Agricultural Hydraulics, Irrigation and Drainage II and Operation and Development of Irrigation Systems.

4. The major defficiencies in professional activities are found in the following subjects:

   Soil Physics; Water-Soil-Plant relationships; Irrigation Methods (modified) of Major Usage in the Country; Economical Aspects Related to the Planning of Agricultural Enterprises; Administrative Aspects, Operation, Selection and Adaptation of Agricultural Equipment and Implements; Maintenance of Irrigation Works, Drainage, Climatology, Hydrology and Hydraulics.

5. 52% of answers indicate that Agricultural Engineering education should be based on a semi-specialization in Agronomy. 26% suggested that it be made an independent career.

6. 68% of those surveys feel that the knowledge acquired in the Faculty and especially in the Orientation is adequate to satisfy the demands of professional work

B. Action Tending to Develop Undergraduate Programs in Agricultural Engineering.

The Faculty of Agronomy and specially the Agricultural Engineering Institute and Department are very interested in strengthening and developing their education and research programs in Agricultural Engineering, for they feel there is a need to establish national education plans contemplating a better education and improved especialization in sufficiently developed areas, among them Agricultural Engineering, as well as the establishment of research programs tending to discovering the adequate scientific development routes leading to the establishment of national techniques to solve agricultural production problems.

For this reason, in 1967, with the aid of Engineer Berlijn a request from the National Government to the United Nations through FAO was prepared for purposes of implementing a program similar to that put in practice at the Agrarian University of La Molina (UNDP/FAO/PER/9).

The project's objectives can be summarized in the organization of a regular academic program tending to the education of Agronomical Engineers with detailed theoretic and practical knowledge of Agricultural Engineering as well as the preparation and implementation of a research program suitable to the country's needs.

The project involves the following aspects:

1. Improvement and training of local staff.
2. Establishment of courses in the different areas of Agricultural Engineering.
3. Creation and expansion of the installations and laboratories for educational and research purposes.
4. Establishment and development of research programs in different Agricultural Engineering areas.

The most important areas to be developed are Irrigation and Drainage, Soil and Water Conservation Engineering, Agricultural Mechanization, Rural Planning and Construction and Agricultural and Cattle Products Conservation Engineering.

Unfortunately, and despite the fact that the National Government assigned the project an adequate priority, to date no official notice has been received regarding the acceptance by the pertinent United Nations Agency.

C. Characteristics of Demand for Agricultural Engineers and Job Opportunities.

The agreements and resolutions of the "First Seminar on the Evaluation of Agricultural Engineering Education at the UCV Faculty of Agronomy" state that Agricultural Engineering has full application in Venezuela.

This can be determined from the programs related to this activity which are at present being implemented by different public and private agencies, among which we have the Ministry of Public Works, Ministry of Agriculture and Cattle Raising, National Agrarian Institute, Ministry of Health and Social Welfare, Agriculture and Cattle Bank, Shell Farmer Service and the Faculties of Agronomy of UCV, LUZ, UDO and URCO.

It is estimated that for 1980 some 400 agricultural engineering professionals shall be needed to study and develop the different plans and programs necessary to promote the country's agricultural development.

Among these plans and programs we have:

1. Agrarian Reform plans: Settlement and Land Grant Programs, Programs for Soil Improvement and Recuperation.
2. National Irrigation Plan (It is estimated that for 1985 1'300,000 hectares shall be under cultivation. At present there are about 485,000).
3. Soil Conservation.
4. Recuperation of Saline Soils.
5. Agricultural Mechanization.
6. Housing and Environmental Sanitation in Rural Communities.
7. Storage and Processing of Agricultural Products.
8. Rural Road Network.
9. Integral Development of the Different Geographic Areas: Guayana, Andean Zone, Maracaibo Lake Basin, Central Western, Eastern, etc.
10. Technical Assistance Program.

As regards to research in the different Agricultural Engineering branches its content is determined by the general characteristics of all the productive aspects of the country, the lack of national technology and a scientific research leading to its development. This involves a broad field of activities which must be directed to correcting this situation and guaranteeing an independent agricultural development.

At present, even though there are over 100 Agronomical Engineers unemployed, none of them has specialized in Agricultural Engineering. It is to be expected that with improvements in education they shall be able to compete advantageously in the different work areas which at present are covered by other professionals from other engineering branches, thus expanding the job opportunities for graduates with a certain level of specialization in Agricultural Engineering.

Given the characteristics and present trends of the Agricultural and Cattle Sector, the aforementioned Seminar recommends planning the development of Agricultural Engineering education at the UCV Faculty of Agronomy on the basis of the present orientation, so that in a relatively short period of time the corresponding University School be created. As an immediate objective it proposes the preparation of a curriculum for the Faculty of Agronomy of UCV, having as its basis the establishment of semi-specializations, one of which will be Agricultural Engineering. For purposes of planning the semi-specializations it recommends that education be divided into three cycles:

Basic cycle, Intermediate cycle and Professional cycle. On the other hand, as has already been stated, the University of Zulia plans the creation of schools, within the Faculty of Agronomy, one of which would be for Agricultural Engineering.

The aforementioned statements highlight the need for Agricultural Engineering among the professions related to Agriculture and the need of organizing and planning education and research in its different branches.

II. PROBLEMS OF AGRICULTURAL ENGINEERING REQUIRING SOLUTION.

On occasion of the "First Seminar on the Evaluation of Agricultural Engineering Education at the UCV Faculty of Agronomy" doctor Fernando Key Sánchez read the paper entitled "Some Considerations for the Preparation of an Agricultural Engineering Research Program". Since we feel that this paper summarizes all that has been done to date to study the problems of Agricultural and Cattle Production and to set up priorities between them, we shall quote its most important aspects.

A. National Priorities in Agricultural Production Problems.

Several agencies, especially the National Council for Agricultural Research, have been studying this problem. As yet no widely accepted ranking has been decided upon. Agronomical Engineers José R. León Díaz and Alfredo Bustamante, in a study to this regard taking into account only vegetable agricultural production set up the following ranking:

1. Grains.
2. Coffee and Cacao.
3. Bananas
4. Roots and Tuberous.
5. Textiles and Oleaginous plants.
6. Legumes.
7. Tobacco.
8. Sugar Cane.
9. Fruits and Vegetables.

If animal agricultural production were to be incorporated to this list it is quite possible that beef production would be the first or one of the first in the general list of priorities. It is felt that tropical fruits should rank higher.

B. Ranking of Production Problems.

The aforementioned studies have also established the following preliminary ranking:

Research problems	Ranking
Soil Classification	1
Irrigation (Equipment, supply, frequency)	2
Technical Processes (Quality control, use of side products)	3
Plant Improvement (Climatic areas, genetics, density)	4
Agricultural Practices (Fertilization, plagues and diseases, pruning, shrubbery)	4
Intermediate crops, diversification	5
Production Costs (Installation, maintenance and processing)	6

The aforementioned study has not given due consideration to important problems such as drainage, conditioning of soils for irrigation, mechanization, product conservation and handling, while production costs and productivity seem to be ranked to low as compared to their actual importance. Furthermore, problems related to "utilization and management of heavy and lateritic soils" should be incorporated, since over two thirds of Venezuelan soils are of this type.

C. Tentative Priority Schedule for an Agricultural Engineering Research Plan.

Summarizing the rankings established in the León Díaz- Bustamante Study, incorporating estimates of beef and milk production and including the main aspects to be researched within the field of Agricultural Engineering, the tentative priority schedule and an outline of an Agricultural Engineering research plan was prepared and may be obtained by writing to the authors.

III. ADDITIONAL INFORMATION ON VENEZUELAN AGRICULTURE.

Major crops and their production areas.

Production of the Agricultural Sector, at current prices, amounted to 2,658'595,000.00 Bs. in 1965. Bs. 1,494'597,000. corresponded to the vegetable agricultural sector, while Bs. 984'336,000.00 corresponded to the Animal Agricultural Sector The following crops: rice (unhusked), corn, yucca, potatoes, sesame, cotton, (crude) copra, peanut (unhusked), sisal (fiber), sugar cane, tobacco, onions and tomatoes account for over 53% of the total vegetable agricultural production value and cover over 55% of the cultivated areas for 1965.

Let us now detail the country's major crops:

Rice: Cultivated area: 105,102 hectares. The central Western plains account for 70% of this area.

Corn: Cultivated area: 461,784 hectares. This is a crop broadly cultivated in all the national territory, however, the coastal mountain region and the central plains basin, respectively, account for 58 % and 38% of the total cultivated area.

Beans: Cultivated area: 65,220 hectares. The coastal-mountain region accounts for 74% of this area.

Yucca: Cultivated area: 69,261 hectares. The coastal-mountain region accounts for 68% of this area.

Potatoes: Cultivated area: 16,172 hectares. The mountain zone (a mountain chain formed by the Andes and Coastal Ranges) accounts for 99% of the total cultivated area.

Sesame. Cultivated area: 87,074 hectares. The high Western Plains (Barinas, Portuguesa, and Cojedes States) account for 99% of the area.

Cotton: Cultivated area: 45,919 hectares. The Central Plain Basin accounts for 83% of this area.

Bananas: Cultivated area: 58,317 hectares. The Coastal-Mountain region accounts for 85% of this area.

Cacao: Cultivated area: 70,000 hectares. The Central Coast (Miranda State) and Eastern Coast (Sucre State) regions account for 90% of the cultivated area.

Green Banana: Cultivated area: 60,108 hectares. The Coastal-Mountain region accounts for 84% of this area.

Sugar Cane: Cultivated area: 71,318 hectares. The Central Coastal-Mountain region accounts for 77% of this area.

Tobacco: Cultivated area: 6,513 hectares. The Central Western Plains account for 50% of the cultivated area.
Coffee: Cultivated area: 340,000 hectares. The Andean Region accounts for 70% of this area.

Theme 2. THE PATTERNS OF DEVELOPMENT OF AGRICULTURAL ENGINEERING IN LATIN AMERICA AND THE WORLD.

12. THE DEVELOPMENT OF AGRICULTURAL ENGINEERING IN PERU by J. Quiroz, Agricultural Engineering Programme, Agrarian University at La Molina, Lima, Peru.

1. History
2. Objectives
3. Student
4. Teaching staff
5. Experience gained
6. Project UNDP-OAS-80

1. History.

It is difficult to record objectively events with which one has been closely concerned (fighting hard to overcome obstacles). For this reason, I will briefly list in chronological order the more important events, leaving out my personal thoughts.

In 1869, a period of technical reappraisal, the first Agricultural Institute was born. The plan published in 1870 called it "Normal Farm Institute", and it was for teaching of Agriculture in the Republic of Peru. It started to work in the farms of Santa Beatriz and San Martin, which were acquired by the State. In 1874, the first program was reorganized into the "Primary Practical Agricultural Institute", having a part of the Santa Beatriz area. Later, in March 18, 1901, the Government authorized the engagement of four Agronomists and three Veterinary Doctors from the Belgian Agricultural Institute at Gembloux, and at last, in May the 20th, 1902, the classes started and on July the 22nd the National School of Agriculture and Veterinary Science was officially inaugurated.

Since the creation of this school in 1902, it has awarded the professional title of Agronomist. In the reform years of 1924 and 1925, the Peruvian staff with the assistance of the Belgian teachers expanded the teaching and raised the academic standards. New laboratories for Agriculture, Plant Pathology and Wine Making were established moreover to ensure that the teaching was not just theoretical, a commission recommended in 1926 that the school should have a better location, recommending the "La Molina" farm in the Ate Valley, where we are now.

The organization, at this stage of development included the Chemistry and Physics, Microbiology, Serums and Vaccines, Animal Husbandry and Zoology, Agriculture, Jungle Crops, Forests, Horticulture, Botany and Plant Pathology, Rural Engineering, Agricultural Technology Sections and the School Farm. Buildings were available for Farm Machinery, Cotton Ginning and Milk Plant. It was in 1933 that the School worked totally at La Molina.

The Public Education Law No. 359 passed in 1941, conceeded academic and administrative autonomy to this University, this started an era of action independent from government agencies, autonomy that later was changed when the School came under the Ministry of Public Education.

In the year of 1943, the Veterinary section was organized, which later became the National School of Veterinary Sciences. Finally in 1944, the Institution was called the National School of Agriculture.

In the following years, the processes of creating new Sections continued and courses were grouped together, without going into details, it is worthwhile mentioning that from this time the schools offered courses in Algebra, Calculus, Surveying, Farm Structures and Irrigation.

In 1952, elective courses were established for the last two years, the fourth and fifth, with the object of orienting the students to specialized fields, within the general structure that had been established. In 1957, it should be noted in this context a group of courses in Agricultural Engineering were joined together, mainly

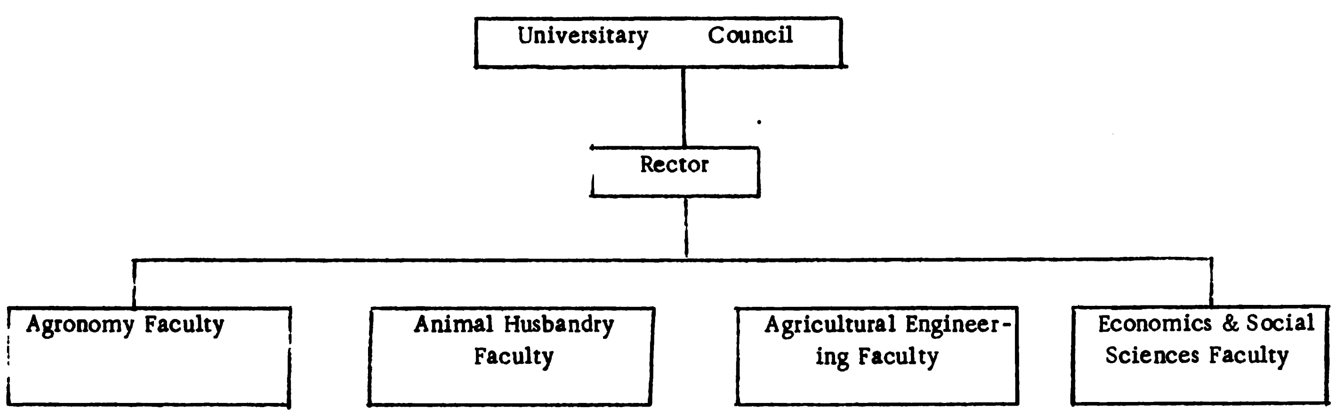
Surveying and Irrigation. These were, then, the first steps leading to the forming, in 1959, of the Institute of Agricultural Engineering, that with Agronomy, Animal Husbandry, and Social Sciences enlarged the studies and the teaching in our campus.

The institute of Agricultural Engineering covers the following fields: Irrigation and Drainage, Farm Structures, Farm Mechanization, Mathematics and Physics (Surveying was included within Irrigation). This all made an organization that had to be implemented with the necessary team of specialists.

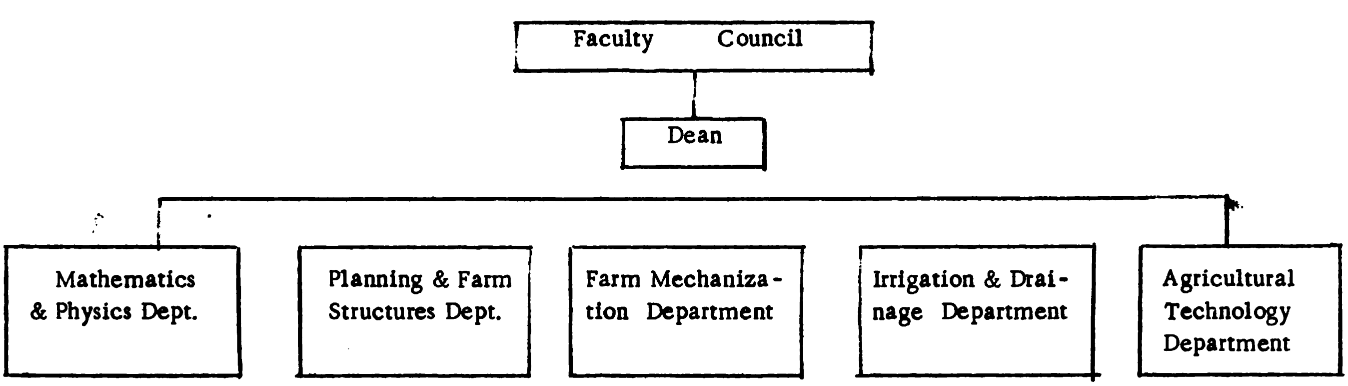
The National School of Agriculture became the Agrarian University by the law 13417 in April 1960 and consequently, the Faculties of Agronomy, Animal Husbandry, Agricultural Engineering and Social Sciences were organized. This law consolidated a movement that had been developing since 1958 with a departmental structure involving flexible study programs based on semesters and credits.

The departments were the academic and administrative units with the responsibility of teaching, researching and extension of their disciplines, working with sections and programs and having their own laboratories, field plots, green houses, etc. This grouping of subjects certainly brought together experts in the same field.

The departments made up the Faculties, which in turn made up the different professions with the following chart as a general working model:



The Faculty of Agricultural Engineering at this stage had the following departmental organization:

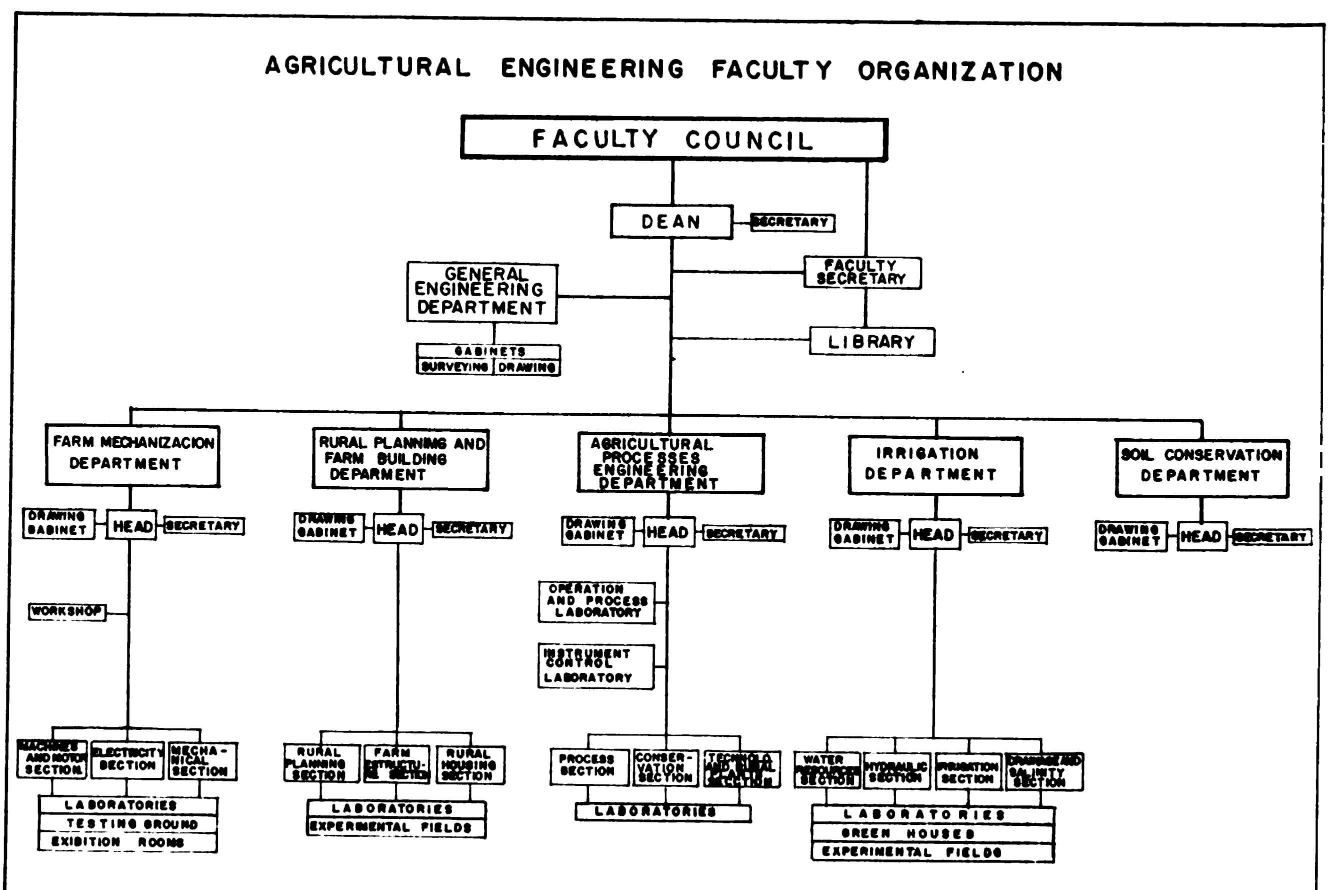


The courses offered by the University are all approved by the students, and extend over one semester. Each course gives one credit for each theoretical class hour or practical session per week. Before registering for certain courses it is necessary to complete pre-requisite courses. The students, to be registered in the Faculty must have received the approval of their Program of Studies for the semester from their advisor.

1.1. Organization in the year 1961.

In 1961, the University started the Science Faculty, for the development of fundamental basic knowledge, and the Faculty of Agricultural Engineering approved the following scheme:

Agricultural Engineering Faculty
Organization



Study Plan. - The Agricultural Engineering Faculty had a Study Plan prepared for the Bachelor Degree in Agricultural Sciences in the specialization of Agricultural Engineering. This plan combined a group of obligatory courses and elective courses offered by the different University Faculties, they could be taken by the students according to their capabilities and limitations, within the structure of a flexible curriculum.

The obligatory courses were divided in two groups:

a) "University Requisites" were the ones that by obligation all Agrarian University students had to take, and
b) "Agricultural Engineering Faculty Requisites" were the ones that had to be taken by the students of the Faculty.

The elective courses grouped in the same way:

c) "Technical Electives", those that students selected from the course list that the Faculty considered convenient for the preparation in a given field of Agricultural Engineering; and
d) "Free Electives", those that the students chose freely in accordance with their advisor.

The Faculty granted the degree of Bachelor of Sciences in the specialization as Agricultural Engineer to those students who obtained 200 credit units, according to their study program, the distribution was:

a. University requisites	47 credit units
b. Faculty requisites	115 credit units
c. Technical elective courses	28 credit units
d. Free elective courses	10 credit units
Total:	200

From the 28 credits of the Technical Electives, at least 15 should be taken from the department, where the student had his main orientation.

The Faculty also granted the professional title of "Agricultural Engineer" to the Bachelors in this field that followed an approved course, and submitted a satisfactory professional thesis.

University Requisites:

Fac.	No.	Name	Pre-requisite	Credits
C	CB-101	General Botany	None	4
C	CQ-101	General & Inorganic Chemistry	None	4
C	CM-101	Mathematics	None	4
C	CM-103	Analytical Geometry	CM-101*	4
C	CM-104	Differential Calculus	CM-101	4
C	CM-201	Integral Calculus	CM-104	4
C	CF-201	Physics I	CM-104-CM-201*	4
C	CF-202	Physics II	CF-201	4
ECS	E1-101	Spanish I	None	2
ECS	EL-301	Technical Writing	None	2
ECS	EE-101	Fundamentals of Economics	None	4
ECS	Es-101	Introduction to Sociology	None	4
		Humanities	None	3
				47 units

* Simultaneous.

Faculty Requisites:

Fac	No.	Name	Pre-requisite	Credits
IA	IG-101	Drawing	None	2
IA	IG-102	Descriptive Geometry	None	3
IA	IG-201	Technical Drawing	IG-101; IG-102	2
IA	IG-202	Surveying I	CM-101; IG-101	3
IA	IG-203	Surveying II	IG-202	3
IA	IG-301	Statics	CF-201; CM-201	3
IA	IG-302	Dynamics	IG-301	3
IA	IG-501	Engineering Economics	120 credits	3
IA	II-301	Fluid Mechanics	IG-201; IG-302*	3
IA	II-401	Irrigation & Drainage	CF-202; AC-301	4
IA	Im-301	Machines & Machine Components	IG-201; CF-201	3
IA	Im-302	Electric Circuits & Machines	CF-202	4
IA	Im-303	Tractors & Engines	CF-202; IM-801	4
IA	IM-401	Farm Machinery	IM-303 or IM-90	4
IA	IP-301	Building Materials	CG-101; CA-101	3
IA	IP-302	Strength of Materials	IG-301	4
IA	IP-401	Structures	IP-302	4
IA	IP-402	Building Procedures	IP-301	3
IA	IP-403	Rural Design I	IP-402*	3
IA	IP-501	Rural Planning Standards	IP-403;IG-501*	2
IA	IT-301	Thermodynamics	CF-202	4
IA	IT-302	Heat Transfer	IT-301	2
**IA	IT-401	Process Engineering	CF-202	4
C	CB-102	General Zoology	None	4
C	CG-101	Geology	None	3
C	CQ-102	Organic Chemistry or CQ-103 Biochemistry	CQ-101	4
C	CM-102	Algebraic Analysis	C?-101	4
C	CF-203	Meteorology & Climatology	CF-202	3
ECS	EA-301	Administrative Principles	EE-101	3
ECS	EP-501	Principles of Law or Rural Law	None	3
ECS	EA-302	Accounting	EE-101& 76 cred.	3
A	AS-201	Soil Science	CG-101;CQ-101	4
A	AC-301	Crop Science	AS-201	4
A		Crops		3
Z	ZP-201	Animal Husbandry	CB-102	4
				45 units

Technical Elective Courses:

The Technical Elective courses offered by the University are the following:

IA	IG-601	Surveying III	IG-203	4
IA	IG-602	Photo-interpretation	CF-202;IG-203	3
IA	II-601	Hydrology	CG-101;CF-20	3
IA	II-602	Applied Hydraulics	II-301;IG-601;II-601**	3
IA	II-603	Irrigation System Design	I' 401	3

* Could be simultaneous

** Not a requisite for those that follow the same Department.

Fac	No.	Name	Pre-requisite	Credits
IA	II-604	Drainage of Agricultural Lands	II-602;II-603	3
IA	II-605	Irrigation Projects	IG-501;II-604	2
IA	II-606	Ground Water and its Use	II-601	3
IA	II-607	Control & Administration of Water	II-401	2
IA	IM-601	Farm Machinery Design	IH-302 ; IM-301	4
IA	IM-602	Land Preparation Machinery	IM-303	2
IA	IM-603	Seeding and Crop Machinery	IM-303	3
IA	IM-604	Tillage Machinery	IM-303	3
IA	IM-605	Earth Moving Machinery	IM-602	2
IA	IM-606	Organization of Farm Machinery Operations	IM-602;IM-603 IM-604;IM-605	2
IA	IM-607	Rural Electrification	IM-302;IP-403	3
IA	IM-608	Electronics	IM-302	3
IA	IM-609	Principles of Vibratory Mechanics	IP-302;IM-301 IM-601	2
IA	IM-610	Lubrication	IM-303;II-301	2
IA	IM-611	Drainage Machinery	IM-605	2
IA	IM-612	Organization & Control of Spare parts	IM-606	2
IA	IP-601	Soil Mechanics	IP-302	3
IA	IP-602	Rural Design II	IP-403	4
IA	IP-603	Rural Design III	IP-602	4
IA	IP-604	Rural Housing	IP-403	3
IA	IP-605	Reinforced Concrete I	IP-401	4
IA	IP-606	Rural Sanitation	II-301;IP-403	3
IA	IP-607	Structural Analysis I	IP-605	4
IA	IP-608	Rural Planning	IP-501;IP-603	3
IA	IT-601	Dehydration	IT-302	3
IA	IT-602	Unit Operations	Physical-Chemistry	4
IA	IT-603	Material Handling	IM-301	3
IA	IT-604	Pumps	II-301;IM-301	3
IA	IT-605	Refrigeration	IT-301;IP-301	3
IA	IT-606	Instrumentation	IM-302	3
IA	IT-607	Selection & Evaluation of Process Equipment	IG-501	3
IA	IT-608	Plant Design	IG-201;IT-602	3
IA	IS-601	Soil Conservation I	AC-301;II-602 IM-605	3
IA	IS-701	Soil Conservation II	IS-601	3

Recommended Curriculum for the Different Years.

1st Semester	Credits	Second Semester	Credits
CB-101 General Botany	4	CM-104 Differential Calculus	4
CQ-101 General & Inorganic Chemistry	4	EL-101 Spanish I	2
CM-101 Mathematics	4	IG-102 Descriptive Geometry	3
CB-103 Analitical Geometry	4	CB-102 General Zoology	4
		CQ-102 Organic Chemistry or CQ-103 Biochemistry	4

* Could be simultaneous.

1st Semester	Credits	Second Semester	Credits
CG-101 Geology	3		
IG-101 Drawing	2	CM-102 Algebraic Analysis	4
	21		21

2" 1st Semester	Credits	Second Semester	Credits
CM-201 Integral Calculus	4	CF-202 Physics II	4
CF-201 Physics I	4	ES-101 Introduction to Sociology	4
EE-101 Economic Principles	4	Humanities	3
IG-201 Technical Drawing	2	IG-203 Surveying II	3
IG-202 Surveying I	3	CF-203 Meteorology & Climatology	3
EA-302 Accounting	3	AS-201 Soil Science	4
	20		21

3° 1st Semester	Credits	Second Semester	Credits
IG-301 Statics	3	IG-302 Dynamics	3
IM-301 Machines & Machinery Components	3	II-301 Fluid Mechanics	3
IM-302 Circuits & Electric Machinery	4	IM-303 Tractors and Motors	4
IT-301 Thermodynamics	4	ZP-201 Animal Husbandry	4
AC-301 Crop Sciences	4	IP-302 Strength of Materials	4
IP-301 Building Materials	3	IP-402 Building Procedures	3
	21		21

4° 1st Semester	Credits	Second Semester	Credits
IP-401 Structures	4	IT-401 Process Engineering	4
IT-302 Heat Transfer	2	IM-401 Farm Machinery	4
IP-403 Rural Design I	3	EA-301 Principals of Administration	3
II-401 Irrigation & Drainage	4	Cultivation	3
Technical Electives	6	Technical Electives	5
	19		19

5° 1st Semester	Credits	Second Semester	Credits
IG-501 Economic Engineering	3	EL-301 Technical Writing	2
IP-501 Planning Standards	2	EP-501 Rural Law or Principles of Law	3
Free Electives	5	Free Electives	5
Technical Electives	8	Technical Electives	9
	18		19

The Agrarian University reached to an agreement with the Special Fund of the United Nations with the objective of enlarging and developing the Faculty according to the plan of operations with a budget of US$635,500. The executing agency was the Food and Agriculture Organization of the United Nations. The plan, initiated on October 20, 1961, extended over a period of five years, and established the participation of international experts, laboratory equipment, services, and fellowships for the advanced training of professors from La Molina. I would like to record our special thanks for the UNDP-40 for its enthusiastic participation in this enormous task, the establishment of the Faculty of Agricultural Engineering. Likewise the Andean Zone of the Interamerican Institute of Agricultural Scie . es that was present at the inception of the project, and helped us to build up enthusiasm and dedication at that difficult time.

1. 2. Today's Organization.

The Faculty of Agricultural Engineering has not substantially altered the study plan since its inception in 1961, wishing first to obtain the experience necessary to establish clearly defined criteria. These could be used to make changes that would be relevant to the technical, economical and social reality of Peru. Nevertheless some changes have occurred , that were natural and necessary, some courses have been omitted, others are now electives, and new courses have been added, according to the requests of the departments.

The Study Plan we have today for Agricultural Engineering is the following:

a) University Requisites:

Fac.	No.	Name	Pre-requisite	Cred
C	CB-101	General Biology	None	4
C	CQ-101	General and Inorganic Chemistry	None	4
C	CM-101	Algebra I	None	4
C	CM-103	Calculus I	CM-101*	4
C	CM-104	Calculus II	CM-101;CM-103	4
C	CM-201	Calculus III	CM-104	4
C	CF-101	Physics I	CM-103	4
C	CF-201	Physics II	CF-101	4
CS	SL-101	Spanish I	None	4
CS	SL-301	Technical Writing	S1-101	2
CS	SE-101	Principles of Economics I	None	4
CS	SS-101	Introduction to Sociology	None	4
		Humanities		3
CS	SH-201	Introduction to Philosophy	None	
CS	SH-301	General Psychology	None	
CS	SH-101	Logic	None	
CS	SP-102	Introduction to History	None	
CS	SP-301	Fundamentals of Political Sciences	None	
CS	SP-302	Evolution of Peruvian Culture	None	
CS	SP-202	Evolution of Universal Culture	None	
				47 units

b) Faculty Requisites:

IA	IG-101	Descriptive Geometry	None	3
IA	IG-102	Technical Drawing	IG-101*	2
IA	IG-103	Surveying I	CM-104*	3
IA	IG-201	Mathematical Analysis for Engineers	CM-201*	4
IA	IG-202	Statics	CM-201* ; CF-101	4
IA	IG-203	Dynamics	IG-202 ; IG-201	4
IA	IG-204	Surveying II	IG-103	3

* Could be simultaneous.

Fac.	No.	Name	Pre-requisite	Cred.
IA	IG-301	Strength of Materials	IG-202	4
IA	II-301	Fluid Mechanics	IG-203	3
IA	II-302	Applied Hydraulics	II-301	3
IA	**II-401	Irrigation & Drainage	II-302-IG-204-AC-301	4
IA	IM-201	Machines and Machinery Components	IG-102-IG-202-IG-203* IP-201*	3
IA	IM-301	Electrical & Circuits Machines	CF-201-IG-201*	4
IA	IM-302	Tractors & Power Units	IM-201-IM-301-IT-301*	4
IA	**IM-401	Farm Machinery	IM-302	4
IA	IP-201	Building Materials	CG-101-CQ-101	3
IA	IP-301	Building Procedures	IP-201	3
IA	IP-302	Structures	IG-301	4
IA	IP-401	Rural Design I	IP-301-IP-302	3
IA	IP-501	Rural Planning Standards	IP-401-IG-501*	2
IA	IT-301	Thermodynamics I	CF-201-IG-201	3
IA	IT-302	Thermodynamics II	IT-301	3
IA	**IT-401	Process Engineering	IT-302-IM-201	4
C	CG-101	Geology	None	3
C	CF-203	General Meteorology & Climatology	CF-201	4
CS		Principles of Rural Laws	116 credits	3
A	AS-201	Soil Science	CG-101-CQ-101	4
A	AC-301	Crop Science	AS-201	4
A		Crop Cultivation		3
Z	ZP-201	Animal Husbandry	CB-101-40 credits	4
C	CE-301	Introduction to Statistics	CM-104	4
				106 units

c. Technical Elective courses	37 units
d. Free Elective courses	10 units
	200 units

From the 38 unit credits, that belong to the Technical Elective Courses, at least 20 should be offered in the field in which the student is majoring.

The students majoring in the Soil Conservation Department can complete the 20 unit credits as follows:

12 unit credits as a minimum in the Department of Soil Conservation, 8 unit credits as a maximum in the Department of Irrigation, approved by the Soil Conservation Department.

101 faculty requisites unit credits are obligatory for the students majoring in the Departments of Irrigation and Drainage, Farm Mechanization and Process Engineering for, the courses of Irrigation and Drainage, Farm Machinery and Process Engineering are not requisites. The Technical Elective Courses offered by the Faculty of Agricultural Engineering are:

IA	IG-601	Surveying III	IG-204	4
IA	IG-602	Photogrametry	CF-201-IG-204	3
IA	IG-603	General Drawing	None	1
IA	II-601	Hydrology	CG-101-CF-203-IG-201	3
IA	II-602	Plant Soil & Water Relationship	AC-301-IG-201	3
IA	II-603	Irrigation System Design	II-602-IG-204	4

*Could be simultaneous

** It is not a requisite for the ones that follow their respective Departments.

Fac.	No.	Name	Pre-requisite	Cred.
IA	II-604	Administration & Control of Water	II-401 or II-601 or II-90	2
IA	II-605	Drainage of Agricultural Land	II-601-II-603-II-401	3
IA	II-606	Ground Water and its Use	II-601 -II-302	3
IA	IM-601	Land Preparation Machinery	IM-302	3
IA	IM-602	Seeding & Tillage Machinery	IM-302	3
IA	IM-603	Harvesting Machines	IM-302	3
IA	IM-604	Machinery for Earth Moving & Land Clearing	IM-302	3
IA	IM-605	Drainage Machinery	IM-604	2
IA	IM-606	Organization of Mechanized Farm Operations	IM-91 or IM-401 or organized Mechaniz.	2
IA	IM-607	The Mechanics of Farm Machinery	IM-201-IG-301	3
IA	IM-608	Farm Machinery Design	IM-607	3
IA	IM-609	Rural Electrification	IM-301-IP-401	3
IA	IM-610	Electronics	IM-301	3
IA	IP-601	Soil Mechanics I	IG-301	4
IA	IP-602	Rural Design II	IP-401	4
IA	IP-603	Rural Design III	IP-602	4
IA	IP-604	Detail Design	IP-602	4
IA	IP-605	Rural Housing	IP-401	4
IA	IP-606	Reinforced Concrete	IP-302	4
IA	IP-607	Rural Sanitation	II-301 -IP-401	3
IA	IP-608	Structural Analysis I	IP-606	4
IA	IP-609	Rural Planning	IP-501 -IP-602	4
IA	IP-610	Roads	IP-601	3
IA	IP-611	Engineering Economics	120 credits	3
IA	IT-601	Unit operations I	CQ-302 -IG-203	4
IA	IT-602	Unit operations II	IT-601	3
IA	IT-603	Unit operations III	IT-602	2
IA	IT-604	Materials handling	IM-201 -II-301	3
IA	IT-605	Refrigeration	IT-302	3
IA	IT-606	Dehydration and Drying	IT-302	3
IA	IT-607	Processes I	IT-302- CQ-201	3
IA	IT-608	Processes II	IT-607	3
IA	IT-609	Processes III	IT-608	3
IA	IT-610	Instrumentation	IM-301 -IT602	3
IA	IT-611	Selection & Evaluation of Process	IG-501 -IT-603	3
IA	IT-612	Processing Plant Design	IT-603-IT-609*-IG-102 IP-401	3
IA	IS-601	Soil & Water Conservation Engineering	IG-204-II-301-AC-301 CF-203	3
IA	IS-602	Photo Analysis & Interpretation	CF-201-IG-204-IG-201	3
IA	II-701	Hydraulic Design	II-302-IG-601-IP-601 IP-606	3
IA	II-702	Water Quality & Soil Salinity	II-605	3
IA	II-703	Irrigation Projects	IG-501-II-603-II-604	2
IA	II-704	Seminar	Depart. orientation	1-2

Fac.	No.	Name	Pre-requisite	Cred.
IA	II-705	Special Problems	Department Orientation	1-3
IA	II-801	Research	Department Orientation	3-6
IA	IM-701	Control & Organization of Spare Parts	IM-606	2
IA	IM-702	Lubrication	IM-302-II-301	2
IA	IM-703	Seminar	Depart. Orientation	1-2
IA	IM-704	Special Problems	Depart. Orientation	1-3
IA	IM-801	Research	Depart. specialization	3-6
IA	IP-701	Reinforced concrete	IP-606	4
IA	IP-702	Structural Analysis	IP-608-IP-701	4
IA	IP-703	Public Health & Sanitary Engineering	IP-501-IP-607	4
IA	IP-704	Seminar	Department Orientation	1-2
IA	IP-705	Special problems	Department Orientation	1-3
IA	IP-706	Soil Mechanics II	IP-601	3
IA	IP-801	Regional planning	IP-609-IP-703	4
IA	IP-802	Research	Department specialization	3-6
IA	IT-701	Advanced Thermodynamics	IT-302-20 units in the department	3
IA	IT-702	Mass and Heat Transfer	IT-605-IT-606-IT-609-IT-701	3
IA	IT-703	Seminar	Department Orientation	1-2
IA	IT-704	Special problems	Department Orientation	1-3
IA	IT-801	Research	Department specialization	3-6
IA	IS-701	Soil & Water Conservation Engineering	IS-601-IS-602-CE-301	3
IA	IS-702	Watershed Management	IS-602-IS-701*	3
IA	IS-703	Seminar	Department orientation	1-2
IA	IS-704	Special Problems	Department orientation	1-3
IA	IS-801	Research	Department specialization	3-6

To obtain the Bachelor Degree in Agricultural Engineering the courses up to number 800 are valid as technical electives.

The elective courses offered by the Faculty of Agricultural Engineering are:

IA	IP-90	Rural Building	CM-201	4
IA	II-90	Irrigation Principles	CF-201-AC-301	4
IA	IT-90	Processes Engineering Principles	CF-201	4
IA	IM-90	Farm Mechanization I	CF-201	3
IA	IM-91	Farm Mechanization II	IM-90	4

Only after the natural efforts to get facilities and equipment, to complement the ones offered by UNSF-40, the following laboratories were ready in 1965: Irrigation, Soil Conservation, Models, Mechanization, Processes Engineering, Soil Mechanics, Testing Materials, Surveying, Electricity, Hydraulic Testing, Structural Testing, and Erosion Testing. When the new university campus was finished these laboratories have been relocated

* Could be simultaneous

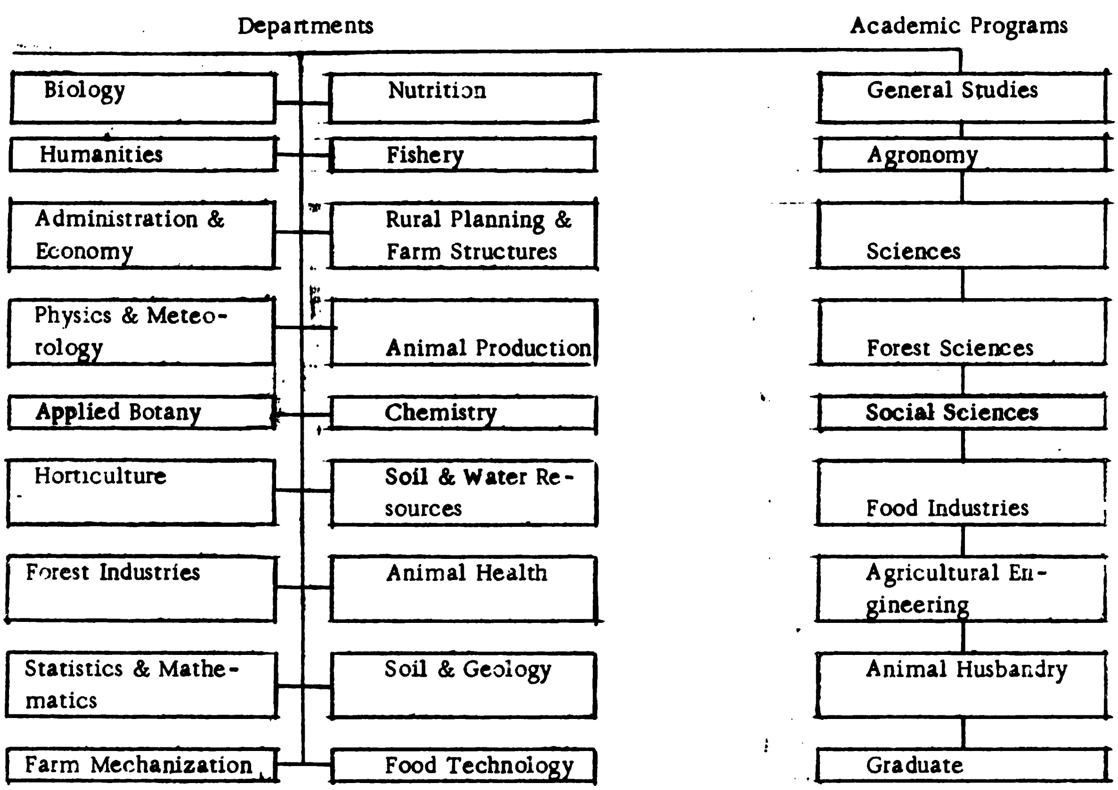
having obtained larger areas and more facilities for teaching and research.

The present university law has given a new name to the university, calling it National Agrarian University, modifying the structure of all universities, although the new law maintains our Departmental status, with flexible studies, semesters, and credits: the administration, government and academic systems have been changed. The name "Faculty" has been changed to Academic Programs. These Programs have to be fully structured. The present law is very controversial.

Under the new university set up, the administrative body of the Agricultural Engineering Program is formed by the departments directly connected and those considered complementary. The former are:

Farm Mechanization.
Soil & Water Resources.
Rural Planning & Farm Structures.

The Mathematics and Food Technology departments are present but as a minority. On the other hand all university departments are at the service of the Academic Programs, that now are the following:



The faculty has issued a number of publications on both research and extension, among which the following are worth of note: Channel lining trials and Channel water losses.

Study by a Hydraulic Model of the Energy Disipator at the foot of a flume Dimensional Analysis and Model Theory.

A study of a hydraulic model of a redesigned offtake at Puntilla.

Ground Water studies in the Ate Zone and Pampa Grande using wells and vibroground techniques.
Effect of humidity levels, irrigation depths, and nitrogen fertilization on forrage sorghum production.
Three humidity level and its Effect on bean production.
Reclamation of saline sodic soils in the Low Piura Valley
Evaporator design for concentrating citrus juices.
Possibilities for industrializing some tropical fruits: cocona, passion fruit, and naranjilla.
Comparative tests of two tomato varieties for processing as: juice, catsup and paste
Mango product canning
Canning possibilities of palmito in Peru
Canning possibilities for green lima beans
Processing tropical fruits
A study of citrus industrialization
Study of an establishment in Tingo Maria
Dairy plants (5 works)
Rural Settlement in La Joya
Planning in Israel.
A typical design in planning
Rural Housing
Pilot project for one Sierra Colony in Peru
Some aspects of silo design
Reinforced brick structures
Strain analysis in flat elastic rings
Sewage disposal in the rural environment
Professional differentiation
Pilot marketing centers for food products, modulated with operational research center in the Central Zone of Mantaro I, II, III.
A modern approach for rural housing.
Rural settlements in Latin America.
Rural development plans.
Some aspects of prefabrication.
Agricultural Engineer's participation in developing programs of rural planning.
Research needs for farm buildings in Peru.
Auxiliary method for publishing farm structures in an agricultural farm.
Uracuza settlement layout, right bank, Marañon river- Amazonas.
National food marketing for Lima- An opinion.
Weight influence and weight transfer in tractor with a mounted implement.
Analysis of unbalanced forces in harvesting machines
Criteria for designing of potato sorters for small farms in Peru.
Mechanization of sugar cane cutting preparation in Cartavio Estate.
Mechanization of corn harvesting.
A prototype design for a hand operated potato sorting machine
Elements and mechanism of farm machinery.
Tractors.
Land preparation machines.
Seeding and tillage machines.
Harvesting machines.
Land clearing and earth moving machines.
Tractors and motors repairs.

2. THE OBJECTIVES

In my 1965 report as a Dean, I expressed:

"Our Faculty sets new paths in the application of Engineering in America and contributes to its development, it has introduced new criteria in the analysis of problems, having therefore created an interest in the country. Agricultural Engineering is the conjunction of Engineering, Agronomy, Animal Husbandry, and Social Sciences, with predominance of the first one, for the solution of problems in the agricultural field in a rational and scientific way. It is not the isolated study of disciplines, it is the indivisible unit that forms the organic reasoning and proposes the concording solutions.

Agriculture has always had engineering problems. In past times problems such as: farm buildings, silos, physical distributions, settlements, regional planning, water conduction, dams, water reservoirs, earth moving, farm machinery, food processing, food handling, erosion problems, etc., were solved by professionals prepared mainly on the agricultural side.

The objectives to be achieved have three stages: teaching, research and extension, teaching is the most important task for a university education. But also, it is true that there is no teaching nor extension without research, because without research it would be impossible to pinpoint our problems, and that research is a necessity for keeping teaching methods and techniques up to date. The University has to leave the campus to know the country's problems to contribute to the National planning and problem solving. It is worthwhile mentioning that the university should be modern and progressive, setting guidelines and the master plans for the solution of our society.

The University should give itself to the nation and search its objectives in the problems that affect the majority, the problems of men in Peru, the problems that the social and economical complex needs. Universities are dynamic since they can apply their intelectual and material values seeking national aims. The University and the people are an undivisible unity and at the same time, they form the conjunction and life of all the factors.

The country affairs should be studied objectively, technically and socially, leaving aside passions or sentiments that deviate from the path of true and sound solutions. The efforts between national institutions and the University should be coordinated with the true desire that extension of knowledge becomes a fact. It is necessary to think that extension is one of the means to overcome underdevelopment or to promote the development of a country. It is useful to express these concepts positively, so that everybody colaborate in this task, within an organic plan.

The country's structure and society organization needs important changes, so it is necessary to form men with a mentality prepared to judge, compare ideas and impose their solutions".

In the 1964 catalogues, one can find interesting information that, I think are valid foundations to give us the objectives that with only a change, mainly of position, present the objectives of the departments and of the Faculty.

Interesting informations are found in the catalogs and analitic programs published around 1964, which I think are interesting sources.

2. 1. Department of General Engineering.

The Department of General Engineering does the job of offering the basic disciplines for the professional training of the student in any of the fields of Agricultural Engineering. The basic courses offered are pre-requisite for:

Planning and Farm Structures, Irrigation, Farm Mechanization, Soil Conservation and Food Processing.

The functions of this Department involve fields such as:
a) Drawing.
b) Surveying.
c) Mathematics.
d) Analytical mechanics and materials.
e) General Engineering.

Drawing includes technical and geometrical works, so the students can understand and produce all types of designs (building and machines).

Surveying trains the student in the procedures representation of lands or building sites and to determine their characteristics directed to multiple purposes. The field of Mathematics gives the pre-requisites for the understanding of courses offered in this department or others. The aim is to give the student a sound preparation that will help him in courses such as: Strength of Materials, Structures, Soil Mechanics, Structural Analysis, Reinforced Concrete, Electric Circuits and Machine Designs, Thermodynamics, Refrigeration, Fluid Mechanics, Hydraulic Designs, etc.

The field of Analytical Mechanics and Materials gives the student knowledge about the internal and external equilibrium of constructions and machinery such as houses, workshops, reservoirs, silos, bridges, irrigation structures, plants , farm machinery, motors, etc. And that are pre-requisites for the field of specialization for all types of designs. The group of courses offered are given by this department, by the department of Rural Planning and Farm Structures and by the Department of Farm Mechanization: all of them preparing the students in a great variety of useful knowledge, about the materials and methodology used in the construction.

2. 2. Irrigation department.

Water is very necessary for the development of the countries. The Department of Irrigation, knowing this fact, gives a solid preparation to the future engineer in all the aspects related to the rational, technical and scientific management of this element.

The Department offers a group of courses with the purpose of first letting the student understand the evolution of water resources in all forms and second water behavior in all kinds of circumstances, natural or man made, such as reservoirs or in movement through different means or hydraulic structures; third, to know the art of applying water to the farm in the proper amount, system and time; and at least, to design the best way of excess water removal and to reclaim affected and designing drainage systems.

The use of this knowledge will make possible a most efficient use of water, natural resource of a great value by all the members of a comunity.

Parallel to teaching, the Department does research trying to solve the main problems related to the use of water, this allows us to give orientation on the more efficient way of using it, solving a material problem, and to keep up to date with scientific advance.

Hydrological Resources Section.

It is important to understand the natural way of collecting water. Knowing the origin, space distribution, etc. it is easier to plan a rational water use.

This section has all the courses needed to prepare the students understanding and evaluate water behavior in nature and consequently research, it is oriented to know the relations of different factors of the hydrological cycle, and to study possible alterations, considering frequency and duration and finally to point out the dangers of water in excess or in defect.

Hydraulic Section.

Theoretical study of laws that govern water behavior under different conditions design of structures for its storage, conduction and distribution are the principal tasks of this section.

Irrigation Section.

Applying water to the fields is really an art, special knowledges are required either for Agronomy or for Water Engineering. It is known that crop production depends a great deal on the manner, amount and time that water is applied. Now, to solve these three points it is important to know: climate, soil, plants, etc. For the above reasons watering planning and design is a difficult and interesting job, and this section gives the students a base through different courses and research giving a special emphasis to the knowledge of our country.

Drainage and Salinity Section.

All water in excess has unfavorable effects on crops, soils, man etc. It is important then to control the excess of water by means of evacuation systems that will convey water far away where it produces no harm . On the other hand it is important to reclaim areas of poor drainage so they can be used for production.

2. 3. Farm Mechanization Department.

The Farm Mechanization Department teaches and researches areas related to tractors, farm machines, earth moving machines, and rural electrification. It has to be kept in mind that the mechanization will save labor, will improve efficiency of farm operations, will reduce production costs and will take away back breaking tasks and it is easy to reach the conclusion that Farm Machinery affects the economy and productivity of the country and of farmers, in the same way as the standard of living of the ones who depend on agriculture either as owners or workers. Industrialization and economic development go parallel to farm mechanization and in general, in the world a smaller percentage of the population has a bigger production, the reason for this being mainly due to the use of Farm Machinery.

Nevertheless, machines require good operation and efficient use. Their design and construction must have these objectives, without loosing sight of the production costs. They have to be properly selected and the costs for unit, area or time should be carefully set.

The Farm Mechanization Department has as objectives the teaching of technical skills in this area and offer courses about components and mechanisms, motors and tractors, farm machinery, organization machine operations, machine design, and rural electrification. Each course has a given number of hours for theory and practical work in order to impart the necessary subject matter, giving an integral picture for the future professional.

The professional areas offered are mainly: Direction of mechanized operations, in enterprises that need it because of its size in the direction and execution of governmental projects for developing arid or tropical areas; in selling, servicing and maintaining of farm machinery; in advising farm machinery factories; in preparation of technicians, and, in general, all related to the use of farm machinery and the use of electricity as a source of power for the farm and as a factor of social and cultural development.

Power and Machinery Section.

The power and machinery section deals with motors, tractors and agricultural machines. It is in charge of giving courses related to this area and of doing relevant research about the use of tractors and of the different machines.

The Electrical Section deals with topics related to electrical circuits, electrical and electronical machines and their application to the rural areas. Related courses to these areas are given by the section and research is carried out towards the most efficient use of electricity as an energy source and for its wider application on electronic devices for automatic controls of agricultural processes.

Mechanics Section.

It is related to all basic mechanics, involved in Agricultural machines designs and construction, that is of the different components and mechanisms used to reach the machine design. The section offers courses in these matters and the testing and research related to the mechanics of machines.

2. 4. Rural Planning and Farm Structures Department.

The Rural Planning and Farm Structures Department has as its main aim the teaching and research of Planning, Design, Structural Computations, Installations, and Farm Building. The areas spans from a simple house to a settlement design.

The department expects that its graduates will be able to investigate planning problems in all aspects with a framework of organization.

Applied mathematics, building materials processes, and planning methods are needed to follow the mentioned objectives. Besides complementary knowledge is needed in the social and economic fields.

Farm Structures Buildings.

The section gives the courses of applied mathematics for computing and designing building elements, materials, building procedures and rural installations. The aim is to teach the technique of building, including stores, animal housing, processing plants, mills, driers, greenhouses, hydraulic structures, etc.

Rural Planning Section.

The section is responsible for teaching the techniques of Rural Physical Planning, that is the regional study and its more useful relation with other regions.

Regional Planning seeks the development of all points, but treating them as a unity, and having in mind that all solutions are not necessarily technical.

The section complements its teaching with the Social Science and Economics Faculty of the Agrarian University.

Rural Housing Section.

The section has to teach and to investigate the necessary techniques that rural housing needs.

Towards this end, the section will study materials, from the different national regions, the building procedures, the structural elements, house designs, services and installations, complementing with the Social Science and Economics Faculty, in the areas of education and financing.

The section will study rural housing on relation to the environment rationally using local materials.

The Planning and Farm Structure Department through its rural housing section will colaborate in solving the national housing problem in the rural areas giving answers or providing technical studies or personnel.

2. 5. Soil Conservation Department.

The rational utilization of land with engineering techniques are the objectives of teaching, research and extention of the soil conservation department.

The conservation of the nation's natural resources is very important. Soils from the three regions, coast, sierra and jungle are constantly deteriorating because of several factors, such as Topography, environment and soil nature. It is important to know the basic principles and the necessary engineering techniques that help us control these factors.

The Department studies in detail the problems of erosion, planning, etc. and renders services to other departments and faculties of the University.

2. 6. Food Process Engineering Department.

The Food Process Engineering Department works to achieve the application of basic concepts of engineering to the different operations of transforming, keeping, storing and handling of agricultural products.

Considering that processes are divided into a series of unitary operations, the Department guides the students into the engineering applied to the processes of each technology. That is computing each operation, selection, design and installation of equipment, and plants to do the processes.

Processing Section.

The section is in charge of developing aspects in Engineering linked to elaboration and to food processing. The section imparts teaching to the student relating it to unit operations in processes such as size reduction, cleaning, selection, mixing, evaporation, material handling, pumps, fans, work simplification, etc.

Conservation Section.

In this section the general processes are studied to keep, change or use the quality of the material based on the control of temperature, relative humidity and time. It also studies the different methods for destroying harmful organisms based on refrigeration, heating, dehydration, drying, etc.

Evaluation and Plant Design Section.

This section is in charge of teaching and research on all technological problems in a general way. This is done for professional and academic preparation or for serving national interests. It studies several topics of Rural Industries, taking into account the processing points of view, but without overlooking the economical and market objectives.

3. The Students.

In either way, students and professor, alone or grouped, seek that university fulfills its ends. The University problems are complex and varied and carry the direction of profound matters that are needed by the country. Within a broad scope of tends and philosophies , some ours and others extracted from other sources, the University made up of men with new ideas as well as men with traditional conceptions.

The problem arises when the movement follows the path of other traditions developed by those who like the bitter sweet taste of the small and the slow. The universities of the world and the universities of Latin America do not escape unrest and moreover they overcome the hopes of those empirical calculations that did not give them the value for the changes.

During the development of the Faculty, I have witnessed student support for Agricultural Engineering, this has meant changes in the administrative structures, in the teaching status; in research and in extension. They have come, year after year, with their support as students and as professionals showing great responsibility that has been for the good of Agricultural Engineering of the National Agrarian University at La Molina.

Because of the prestige acquired, and for the tremendous task in planning and developing people in Peru, Agricultural Engineering has attracted students, reaching very high number, even surpassing other centers in the world. We can observe this in the following table:

Year	Student No. in Agricultural Engineering	Student No. in the University
1962	73	853
1963	115	951
1964	166	1220
1965	293	1407
1966	376	1852
1967	502	1964
1968	565	2210

The necessity of Agricultural Engineers is shown in the number of students enrollment in the past six years, that were 1/7 of the students of Agronomy and 1/3 of the students of Animal Husbandry. But in 1968, our students were larger in number than those in Animal Husbandry, being 80% of the ones in Agronomy and the second largest Faculty in the University. Another important factor is the positions that graduate students are getting having big responsibilities in the country and abroad.

Bachelors graduated:

Year	Number
1964	8
1965	11
1966	11
1967	13
1968	21

At the time of writing this report 32 graduates have obtained the "Ingeniero Agricola" title.

The big demand for Agricultural Engineering studies created two problems: the necessary budget and the required staff for the study plan.

The following table shows the budget we had:

Year	General budget (S/)	Specific budgets (S/)
1962	1'312,935.30	
1963	2'381,991.10	
1964	3'941,589.51	
1965	5'955,651.08	
1966	8'463,532.19	1'000,000.00
1967 (15 months)	10'103,049.00	9'200,000.00
1968	7'880,982.00	9'200,000.00

To these amounts, the money from UNSF-40 has to be added plus the money from other contracts with the Faculty.

The Specific Budgets were granted by the government for research work to be done in the Planning and Farm Structures Department, and for the Drainage Center.

4. The Staff.

The University teacher, as a communication agent, has to fulfill three tasks: personal, social and national. The teacher has to be constantly exposed to the student, reaching his soul, so he can impart his knowledge and his hopes and in turn to obtain the student thoughts. This basic exchange should not, and it is not, paternalistic; but it is the communication between two generations that have two backgrounds and possibly go at different speeds. The teacher is the example for the student, and for this reason has to have ethics and sensibility. The teacher is the best chance we have to get into a comunity for which it is necessary that Social Sciences and Economy be the starting line.

These thoughts come to me precisely when I am writing this paper for it is the idea we are trying to overcome in the Faculty of Agricultural Engineering.

4.1. Staff Number and Specialization.

The following table gives the staff number by department:

Year	Soil Conservation		General Engineering		Soil & Water Resources		Mechanization		Planning & Farm Structures		Crop Processing	
	TC	TP	TC	TP	TC	TP	TC	TP	TC	TP	TC	TP
1963	4	-	3	6	7	3	5	1	4	2	5	2
1964	4	-	4	4	8	3	4	1	7	1	6	-
1965	5	-	5	4	9	2	7	1	8	1	9	-
1966	5	-	4	4	9	-	7	1	10	3	8	-
1967	-	-	4	5	13	-	6	1	12	3	6	1
1968	-	-	5	5	13	4	6	1	14	5	6	1

The Departments linked directly with Agricultural Engineering Program have the following:

Year	Soil & Water Resources		Mechanization		Planning & Farm Structures	
	TC	TP	TC	TP	TC	TP
1969	13	4	6	1	14	4

Technical staff that work in research studies:

Year	Soil & Water Resources	Planning & Farm Structures
	TC	TC
1967	3	6
1968	3	5
1969	3	3

The University wanted to establish a sound Faculty of Agricultural Engineering; and has sent a good number of its staff to different foregin universities. This was because a feeling of rapid progress was in mind, and since the start professors went abroad to study post-graduate courses. This is not only unique in Peru, but also America. Some professors had even a double chance to obtain higher degrees.

List of professors that have obtained higher academic degrees:

NAME	DEGREE	UNIVERSITY	FIELD OF SPECIALIZATION
Ing. Alfonso Alcedan	Magister	Universidad de Ingeniería-Peru	Hydraulics
Ing. Arturo Cornejo	M. S. to obtain Ph. D.	University of Calif. - Davis	Irrigation
Ing. Medardo Molina	M. S. to obtain Ph. D.	University of Stanford	Water Resources

NAME	DEGREE	UNIVERSITY	FIELD OF SPECIALIZATION
Ing. Carlos Vidalon	M. S.	University of Minnessotta	Soil Conservation
Ing. José Aquize C.	M. S. to obtain Ph. D.	University of Calif. -Davis	Irrigation & Drainage
Ing. Francisco Coronado	M. S.	M. I. T. -Massachussets	Hydraulics & Fluid Mechanics
Ing. Enrique Escudero	M. S.	University of Calif. Berkeley	Hydraulics & Fluid Mechanics
Ing. Alberto Ordoñez	M. S. to obtain Ph. D.	University of Calif. Berkeley	Hydraulics & Fluid Mechanics
Ing. Manuel Paulett	M. S. to obtain Ph. D.	University of Iowa	Soil Conservation
Ing. Rodrigo Pizarro	M. S.	University of Utah	Soil Conservation
Ing. Jaime Velazco	M. S.	University of Calif. -Davis	Irrigation
Ing. Fernando Chanduví	M. S.	University of Utah	Irrigation
Ing. Axel Dourojeanni	M. S.	University of Colorado	Watershed Management
Ing. Humberto Yap	Graduated	I. L. R. I. T. -Holland	Drainage
Ing. Jorge Quiroz	Doctoral studies	Universidad- Ingenieria-Peru	Planning & Buildings
Ing. Manuel Miranda	Certificate	University of Trieste-Italy	Structures
Ing. Juan Urbina	Certificate	Univ. North Carolina-	Buildings
Ing. Jorge Cardenas	Magister	ESAN-Peru	Work Administration
Ing. Juan Marquez	Graduated	CAEAM-Italy	Planning
Ing. Rodolfo Muñante	Graduated	CAEAM-Italy	Planning
Ing. Baldomero Rupay	Master	University of North Carolina	Structures
Ing. Eleodoro Zacarías	Graduated	CAEAM-Italy	Planning
Ing. Julio Cavero	M. S.	University of Stanford -Calif.	Structures
Ing. Augusto Bedoya	Magister	Univ. Ingeniería- Peru	Building
Ing. Joaquín Maruy	Graduated	CAEAM-Italy	Planning & Buildings
Ing. Darío Biella	Graduated	Italy	Electric Circuits & Machinery
Ing. Guillermo Carrera	M. S.	University of Michigan	Farm Mechanization
Ing. Jaime Gilardi	Certificate	University of North Carolina	Farm Mechanization
Ing. Leonardo Lecca	Master	University of Michigan	Farm Mechanization
Ing. Freddy Salas	M. S.	University of M. I. T. -Mass.	Food Technology
Ing. Juan Herrera	M. S.	United Kingdom	Food Technology
Ing. Fernando Martínez	M. S.	M. I. T. University-Mass.	Food Technology
Ing. Jorge Aliaga	M. S.	University of California-Davis	Food Technology

The fact that professors had to study abroad meant a great deal of effort for the National Agrarian University, because each professor staying abroad, for one or two years, obtaining the Master degree; had to be covered by another one.

It is important to mention that on different occassions Faculty Staff members have been invited to universities in Europe and America, either to lecture or to assist to important meetings, where they have presented work papers.

5. Experience Gained.

With the over all view presented here , there are important conclusions and experiences to present. I do not want to outline completely each fact, I only want to present the most remarkable features

5. 1. Study Plan Organization.

It is necessary to change the study plan of Faculty of Agricultural Engineering, pointing out the following topics:

Courses should be grouped, so knowledge is not taught in different courses. I have observed that a group of aspects should be grouped and presented in one course, otherwise they are dispersed. This point is with the object of saving courses, giving the students a more rational study load. This will help to have deeper knowledge of Agricultural Engineering problems.

The study plan should be in agreement with the new National Agricultural structure, fulfilling the requirements of the country's change and of Peruvians that once more will own their lands. Just the opposite of what had happened because Peru had been left abandoned. Peruvian agricultural transformation is a fact, and it is necessary to guide Agricultural Engineering in this direction. The study plan should cover more material, such as, sociology, economy, etc. to humanize future technical studies, so that it could prepare students to use its knowledge for his own national reality. The reason for this idea is that the student should not feel a stranger. It is also necessary to enlarge the knowledge of mathematics, physics and chemistry, offering higher level courses that should be provided for Agricultural Engineering students, independent of other academic programmes study plan.

The study plan should offer a general preparation in Mechanization, Irrigation, Planning Buildings, and Food Engineering, so that the graduate could work in all Agricultural Engineering fields. Specialization comes either by professional experience or by graduate studies.

I have to say that our students have felt enrolled in different Departments because of the great number of elective courses they took in them, in some cases up to 36 credits.

5. 2. Studies and Research.

In order to obtain the degree of Agricultural Engineer a thesis should be presented under the guidance of three professors, each one belonging to one of our Departments. The thesis should solve problems in the three fields. This would help in the integral preparation of the student.

The thesis work should be focused to solve integral problems that affect the Peruvian situation, and solutions should be presented in various aspects. This does not mean that there should not be research work done on a given problem or of pure science.

5. 3. The Departments.

The departments should be made stronger. It is urgent to develop our Farm Machinery Department hiring new professors. We need to increase the laboratory equipment and to provide a larger number of specialists to operate them.

It is important to complete the line of Mechanization, we have farm machinery for seeding and harvesting, but we cannot visualize clearly the machinery for food transformation and handling.

We would like to have more professors with the Doctor's degree, this is to improve our graduate teaching and to reinforce the undergraduate levels. Any effort done along this line would be for the benefit of a solid specialization.

Our task has been to establish Agricultural Engineering in Latin America, and it has meant a great effort and sacrifices. It should be recommended to the International Organizations its participation to reinforce initiation of this specialty in the Latin American countries because of its importance in developing agriculture and the country.

I have to clarify that what I have said are not all our experiences, I just presented the more important ones; which are the ones the Panel is most interested in.

6. Project UNDP-OEA-80.

The Interamerican Institute of Agricultural Sciences of OEA and the Special Fund of the United Nations wished to develop Agricultural Engineering in the National Agrarian University at La Molina. Their objective is the development of graduate studies for professors and graduate students in America. To achieve this purpose we have now experts, equipment and scholarships. This enterprise started in 1963, the Master Degree has been awarded in Soil and Water Resources, in April 1970 we hope to offer the Master in Agricultural Engineering. The University through its Graduate Academic Program and its Agricultural Engineering Programme is dedicated to this task, with the help of UNDP-80 members.

Theme 2.

13. DEVELOPMENT OF AGRICULTURAL ENGINEERING IN COLOMBIA by Jorge E. Quintero, Director, Department of Agricultural Engineering, Instituto Colombiano Agropecuario, I.C.A., Bogotá, Colombia

I. INTRODUCTION.

Colombia, like other Latin American countries is trying not only to develop industry, but also agriculture, having made, for example, considerable investments in land improvement and land title granting through the Colombian Institute of Agrarian Reform (INCORA). From 1962 until 1968 the land reform used $2,534,000,000 pesos (about 130,000,000 U.S. dollars) to buy and redistribute 154,320 hectares, to promote land improvement work on 350,000 hectares and to study 700,000 hectares.

The preceding figures give an idea of the interest that the Government of Colombia has in speeding up the Agricultural development of the country.

The agricultural engineer has played a preponderant role in a great part of this work by contributing to the aspects of the overall project that relate to mechanization, maximum benefit analysis of soil and water use, agricultural product handling and processing, etc. Unfortunately, the country did not have sufficient Agricultural Engineers during this period, even though many leaders recognized the need for agricultural engineers, a fact that generated the movement to train Agricultural Engineers not only in Colombia but also abroad.

II. AGRICULTURAL ENGINEERING EDUCATION.

Professional Agricultural Engineering at the undergraduate level was started in 1965 as a section of Agricultural Engineering of the Agricultural College in the National University in Medellin.

Previously there had been attempts to form the profession in other places, but because of the lack of sufficient motivation the results were nil.

Some Colombian students, at the conclusion of high school went to Universities in other countries, where they obtained a B.S. or M.S. in Agricultural Engineering and returned to Colombia. The reception of these men by government and private industry was minimal because this career was considered an encroachment upon the traditional fields of Agronomy and Engineering.

Professionals in other careers, having obtained masters degrees in Agricultural Engineering, sometimes working alone and at other times cooperatively, began to impress the development institutions with the necessity of Agricultural Engineers, giving the contributing power to start the new profession in Colombia.

It was in Institutions like the Instituto for Agrarian Reform (INCORA) and the Colombian Institute of Agriculture (ICA), the two most important integrating agricultural agencies of the country, where groups of Agricultural Engineers formed as an essential part of the development.

These groups basically integrated the plans for establishing the professional teaching of Agricultural Engineering in the National Universities and in the University of the Valley that passed a resolution establishing the career of Agricultural Engineering. The program of the University of the Valley started August, 1968 in Cali.

The latest program to start is that of the undergraduate cooperatively formed between Engineering and Agronomy in the National University in Bogotá. They will receive the first students in August, 1969.

Recently, private industries and governmental agencies have come to utilize Agricultural Engineers with quite good acceptance.

III. THE COLOMBIAN INSTITUTE OF AGRICULTURE.

Because of the success obtained in research of the Agricultural Research Division of the Ministry of Agriculture (D.I.A.), it was deemed advisable to coordinate research, teaching and extension. On June 15, 1962, the President of the Republic followed the advise of various studies and recommendations of commissions and issued Decree 1562 that created the Autonomous agency of the Colombian Institute of Agriculture (ICA) whose responsibility is to develop, coordinate and execute work in research, teaching and extension.

To fulfill these responsibilities, ICA is divided into three sub-agencies (I) Technical (II) Development and (III) Operations.

The Technical sub-agency has the responsibility of organizing, promoting, and directing the: A) Research to increase Agricultural productivity. B) Teaching of Agriculture on the Vocational, undergraduate, and graduate levels through the integration and cooperation with teaching organizations, especially National University and the National Ministry of Education, and C) Study the methods of agricultural extension as well as to conduct social science research necessary to design ways of improving communication methods and practice.

To fulfill its function the Technical sub-agency is composed of 3 divisions: 1) Research, 2) Education and 3) Teaching.

The division of education has for its part the following programs:

1) Program for Graduate Study ICA_Natl. University, 2) Program of Agricultural education coordination at the University level. 3) Program of Agricultural education in grade and high school level and 4) Library and documents center.

IV. THE AGRICULTURAL ENGINEERING in ICA.

A. Creation.

Resolution No. 0550 dated June 1, 1968 officially created an Agricultural Engineering department in ICA on the basis of the National program that had been established. The new Department has equal status with Agronomy, Animal Husbandry, Social Science and Agricultural Economics that now exist. The department because of the interest of the directors of ICA now has apreciable human and physical resources that is necessary to start research in this field, with the objective of cooperating in the national development through Engineering the Agriculture.

B. Site.

The department is located at the National Research Center for Agriculture, "Tibaitatá", situated 14 km. from the city of Bogotá. Because of the regionalization of ICA this Department should be working in all 7 existing regions, but, it is actually possible with the limited manpower to work only in Regions No. 1, Bogotá: No. 2, Montería; No. 4, Medellín and No. 5, Palmira.

C. Organization and Areas of Work.

The four National Programs are:

1) Soil and Water Resource Development.
2) Power and Agricultural Machinery.
3) Engineering of Agricultural Processes.
4) Rural Electrification and Structures.

The Work areas of the programs are:

1) Soil and Water Resource Development.
a) Soil properties, b) Irrigation needs, c) Soil Conservation d) Irrigation e) Drainage and f) Special Investigations.

2) Power and Agricultural Machinery.

a) Motors, b) Agricultural Machines, c) Processing Machinery, d) Special machinery, and e) Machine administration.

3) Engineering of Agricultural Processes.

a) Engineering in the processes of animal production, b) Engineering of the processing of animal products, c) Engineering in the processes of plant production, and d) Engineering of the processing of plant products.

4) Rural Electrification and Structures.

a) Rural structures, b) Rural sanitation, c) Rural electrification and d) Special studies.

V. DEPARTMENTAL ACTIVITIES.

A. Research.

The tropical location of the country in the mountain ranges results in quite varied climate, soil, crops, ecologies and also ethnic groups, that may not make it possible to use research results from other latitudes or localities. The research within the country is essential not only to adapt known theory but for the development of methods and systems appropriate to the local conditions.

The Department of Agricultural Engineering among many other obligations carries on research in the regions previously mentioned. In soil and water resource development, current projects include those to study soil properties, analyzing the different soils for infiltration, permeability, runoff, etc. projects to determine irrigation needs, determine the consumptive use and sources of water and equipment for irrigation; projects about soil conservation implement the application of terraces and systems for slope reduction, methods of doing conservation work, controlling erosion and conservation engineering of watersheds; projects of irrigation through different methods and systems and of projects of drainage, both surface and sub-surface.

In power and machinery project include those related to electric motors, motors, and traction studies; to design and construction of models and prototypes, of machines for seeding and harvesting, of machines for chemical application, machinery for grain handling, of machinery for material handling, earth moving and to studies in cultivation.

In Engineering of Agricultural Processes projects are executed in the application of engineering to plant and animal production, through the design facilities, feed plants, seed cleaning and treating and seed storage; projects of processing plant and animal products include meat preservation, design of graders and cooling systems drying, storage, packaging and transportation.

In Rural Structures study is made of wood; design manuals for steel and wood are written; studies are pursued for design of plant and animal production plants; treatment of water in the farm; selection and use of electrical equipment, and the thermo-dynamic design of structures.

The areas of research are without bounds, naturally it has been necessary to confine research to those problems most immediate. The relation between industry, the research workers, and farmers has been one method of identifying the problems needing attention. It has been the intent, whenever possible, to do research that has an immediate impact on tropical agriculture.

B. Education.

Through a contract with the National University, this Institute carries on a program of graduate study in the fields of Agronomy, Soils, Statistics, Botany and Plant Physiology, Entomology, Agricultural Economics, Phytopathology, Genetics, Plant Breeding, Animal Nutrition, Animal Pathology and Agricultural Engineering.

Agricultural Engineering started in the second semester of 1968. The program actually has 14 graduate students who came from the following institutions:

National University- Bogotá	1
National University- Medellin	2
University of Cordoba-Monteria	1
University of Tolima-Ibague	1
Agricultural Credit Bank	1
Geographic Institute-Bogota	1
Technical University of Tunja	1
ICA - Bogota	6

The students pursue an M.S. in Agricultural Engineering degree as the principal field with secondary fields of Soil and Water or Processing and Machinery.

The majority of the scholastic activity is done in ICA at Tibaitatá with some materials being taught at National University in Bogotá.

The research center has 500 hectares of experimental fields, green houses and storage facilities for agricultural products. Besides ICA, other agencies and industries that serve to complete the agricultural education include the experimental farm of National University attached to the training center for vocational agriculture of the National Agricultural Service, a seed treatment plant of the Agricultural Credit Bank, feed processing plants, an insulation factory, pipe plant, malt producing plant and others in a radius of 5 kilometers.

We have an Agricultural Engineering laboratory and shop to construct models, prototypes and experimental designs. It is used jointly by the four programs of the Department. The services of the Statistics office of ICA are available to make computations.

Students form an integral part of the department and have the obligation to participate in department activities. They work with problems unique to the various temperature zones marked by different elevations and all of the installations of ICA in Colombia are at their disposal.

Since there are so few Agricultural Engineers in the country, the program of graduate study has been initially oriented toward the preparation of professionals from other fields, carrying out a process of "galvanizing" professionals from Agronomy, or engineers from Civil, Mechanical, Electrical, Chemical, etc. Naturally, the program will be oriented in the future to Agricultural Engineering Graduate from National University, Medellin, National University, Bogotá, National University, Palmira, Universidad del Valle.

We have been especially careful to give training in problems of the region or institution from which the student originates. The major professor takes care of this through a flexible scope of training. To make up deficiencies in biology on the part of the Engineers and in physical sciences and the part of the Agronomists, we have remedial course recommendations, that may be taken without credit to give a prerequisite background for the courses offered by the Department.

The teaching staff is composed not only of professionals of ICA, but also of the faculty of Agriculture in National University. All professors must have an M.S. or a Ph.D. degree.

The degree is granted by National University who gives academic backing to the graduate work.

C. Extension.

To successfully make an influential impact, the work of the Department is promulgated through Extension. Some of the best accepted activities among others, includes:

1) A general field day of the Department held the first week in February, in which we show progress of the past year. The programs of Agricultural Engineering of National University are invited to participate with exhibitions of their activities. We offered a round table panel discussion of themes in which the Agricultural Engineer has a major role; we exhibit models or mock ups of out integra-

ted programs of agricultural engineering development.

Agricultural machine manufacturers patronized the exposition by showing machinesproduced and where they can be obtained.

The first field day of the Department was held February 5, 1969, with the Assistance of more than 640 persons from industry, groups and associations, international dignataries, governmental workers, farmers and cattlemen; and 16 companies who exhibited their equipment. We had a full attendance at a round table discussion of the development of a small tractor industry in Colombia.

We believe from the publicity obtained that this field day will be more powerful each year in bringing about coordination of industry in presenting their new developments.

2) We established a National Plan Service through which we offer simple plans for construction of buildings, equipment and facilities. Some give bills of materials and some cost information. We distribute without cost a descriptive leaflet and a blue print is sold at a nominal cost.

Plans are distributed through 42 Extension Agencies, Professional societies and Universities.

3) We have started a service of "Evaluation and Testing Agricultural Machines and Implements", to test under different conditions of climate, soil, crops, etc., to discover the output, adaptability and behavior. This service is offered to the industry to test the function of prototypes before they are placed in the market. Current projects include tests of aluminium silos, evaluation of planters and harvesters, as well as tractors. The tests are contracted with industries that have shown an acceptance for this service.

4) With the National University-Medellin in the Agricultural Engineering Section we have established an extension program that maintains an identification with this branch through research in agriculture; writing of publications and technical information such as mimeographs, technical aids, national plan service plans, bulletins, with the end objective of forming an Information and Public Relations part of the University that relates to industry, educational establishments, and to unions of cattlemen and farmers.

Theme 2:

14. THE DEVELOPMENT OF AGRICULTURAL ENGINEERING IN THE MIDDLE AND FAR EAST by Howard F. McColly, Michigan State University, East Lansing, Michigan, U.S.A.

In thinking of the Middle East and the Far East, the extent of the geography spans one-third of the way around the world. We might think of the area extending from Turkey and Syria in the West to Japan, Taiwan and the Philippines in the East.

Living in this vast area are people of many cultures, doctrines and beliefs. All have influenced each other, and people from the West and other parts of the world have affected these countries and their development.

Agricultural Engineering Objectives.

Agricultural engineering activities are a part of the socio-economic development of any country. In this context, the term agricultural engineering will connote several meanings, ranging from true engineering in the industry of agriculture to farm production mechanization operations. In other words, in some areas farmers who employ considerable mechanization techniques are termed agricultural engineers.

In this presentation I wish to portray the various categories of education in the agricultural engineering area, the training levels involved, and the importance for inclusion in the total professional development. Especially we should bear in mind how such educational and training systems might be involved in the developing countries.

Why is agricultural engineering needed? Certainly, this question must be directed to a goal of an increased measure of well-being for mankind--adequate food, shelter, raiment, and security--and these especially for the rural population.

Agricultural engineering goals are exemplified in several objective interests as follows:

1. To reduce drudgery in agricultural operations.
2. To increase the output per agricultural worker.
3. To reduce losses and waste during harvesting, curing, transporting, storing and using.
4. To improve timeliness of operations.
5. To maximize yields by optimum agricultural operations.
6. To enhance the production and processing of additional types of agricultural products.
7. To convert animal-power feed-production areas to human food needs.
8. To develop and improve water supplies and water control systems.
9. To reclaim abandoned land.
10. To engineer new areas for agriculture.
11. To improve rural living environment.
12. To develop rural sanitation and waste disposal control systems.

The group gathered here does not need elucidation on the scope of these objective interests. Suffice it to point out that agricultural engineers in coping with these programs require training incorporating communications, mathematics, engineering, physical sciences, biological sciences applied to agriculture, economics, administration and human relations. They must be engineering disciplines, and respected by engineering fraternities.

Agricultural Engineering Education.

It is my firm conviction that technical agricultural engineering departments in the colleges and universities must execute the total category of engineering in agriculture from the most technical at the apex down to the basic know-how at the farm operating level. Thus, the need for agricultural engineering applications is conical, with the most personnel needed at the large base - the operating level.

In considering how this vast task is to be accomplished, it is immediately apparent we are concerned with various levels of training which may be classified as follows:

1. Agricultural engineers (technical)
2. Agricultural mechanization majors.
3. Agricultural machinery service technicians.
4. Special training of agricultural students.
5. Training vocational agriculture students.

Agricultural engineering technical graduates usually are employed in design, research and development, and in the technical execution of works as well as teaching in universities and colleges. Some do prefer practical applications as a career, thus adding to the broadening cone of need. Agricultural engineers are often graduates of both Colleges of Agriculture and Colleges of Engineering.

Agricultural mechanization majors should be graduates from agricultural engineering departments and from Colleges of Agriculture. Their curriculum basically includes agriculture, non-technical engineering courses, the same agricultural engineering courses offered to agricultural students, and selected courses in business and economics. Normally, these students do not care for the rigors of advancement in mathematics, theoretical mechanics, and the various civil, electrical and mechanical engineering subjects. The agricultural mechanization major is particularly trained for farm or business operations management including service and training facilities, for hire or custom operations enterprises, for sales opportunities, and for farm operation and management.

Agricultural machinery service technicians are trained specifically for the dealer level or for service centers. In most cases these persons desire to be mechanics rather than farm machinery operators, or to be in machinery set-up and delivery services, trouble shooting, directly training operators at the farm level, and in sales and distribution activities.

The training of these service technicians involves special training in agricultural engineering departments, usually for a two year period, receiving a certificate upon completion of their training. Six months supervised on-the job training should be required between the first and second year.

Normally high school completion is required for these trainees. They are individuals who do not desire academic university work, but do cover the farm equipment practical application activities. Thus, in the agricultural mechanization development schemes, these technicians fit very well into the direct working level where so many workers are needed.

As mechanization advances, there is a tendency for service technicians to just develop through experience, and availing themselves of training opportunities offered by employers, manufacturers, extension workers and others.

Agricultural students experience subject matter in various agricultural engineering courses often categorized as service courses to other curriculae. These people may be training themselves for farm operators or in some phases of agri-business. A large segment of workers come from this group who contribute their efforts in the total agricultural enterprise.

Vocational agriculture teacher training is conducted in most Colleges of Agriculture and Colleges of Education, and the curriculae include farm mechanics options, the subject matter being offered by agricultural engineering departments. High schools, especially in rural areas, have farm mechanics training available. Eventually some of these people matriculate in universities and colleges in academic programs, while others may seek training opportunities particularly aimed at vocational employment.

Training farmers in agricultural engineering applications is accomplished by extension workers from the university level, from the industry involved, by vocational agriculture schools, by associations, by cooperatives, through government programs, and by other means. The ability of farmers to acquire agricultural engineering technology varies according to their literacy level. As the literacy level rises, the training task becomes easier.

Status in the Middle and Far East.

Just what is the status of agricultural engineering in the various countries in this vast part of the world? If we use the classification of the areas of agricultural engineering education and training, we would find a few listings in each classification, but we would also find in many places some very absent categories.

In a farm machinery survey, and agricultural mechanization symposium conducted in Asia in 1967(3), there are many references to agricultural engineering education, training, and the state of the art. Also, the Asian Productivity Bulletin (1) contains statements from the various countries relating to the status and needs in programs involving agricultural engineering.

"In most of the Asian countries, the technical know-how at higher levels is developing satisfactorily. Agricultural engineers, university graduates with agricultural engineering background are proving to be helpful. Some universities in India, Iran, the Philippines and Pakistan have been training agricultural engineers, and to an extent, the present requirements are being met".

We can add to the above countries Japan and Taiwan in the Asian group, with mention being made of the Middle East countries of Iran, Syria, Turkey, Afghanistan, Jordan, Israel and other with programs developing in agricultural engineering. The lack of programs is acute in Nepal, Saudi Arabia and a few others.

The reports state further "that the real weakness appears to be in the lower levels of skilled persons who can operate and maintain the tractors and other agricultural machinery. For this purpose, while technical and vocational training institutions are seeking to meet the demand, an accelerated pace with ad hoc programs if necessary may be needed. At the third level, there is a critical shortage of farmers with adequate technical know-how. Unless adequate extension work is done to meet this shortcoming, the agricultural mechanization program itself will receive a setback".

The literacy level in some Asian countries reaches 95%, while some others have illiteracy as high as 80% The dissemination of information to farmers varies directly to the literacy level and influences the methods employed. It is very difficult to train people in the operation, care and maintenance of modem farm equipment when they cannot read or understand words and pictures. Machines are much different in their requirements for cleanliness and care compared to beasts of burden. Of course there are always some people who are inclined more than others to learn engine mechanics, machinery care, and construction techniques, even though they cannot read.

School boys who marvel at a tractor and dream of operating one, or who admire the water conservation engineer, and other technical endeavors are quite likely to pursue some degree of additional schooling or training to the level of their individual abilities. Also, these youths in working with modem mechanisms conceive new ideas, thus local industries are created, and necessary goods and services are supplied.

The Asian report states "For farm mechanization, the training courses perform an important role. There are three stages of training courses; namely, 1) training of the farmers, 2) training of the trainers, and 3) training of the teachers of the trainers. In case of the farmers training, the level is rather low and the course is teaching the operation of the machinery and simple repairing techniques to them.

In the case of trainers training, including assistant technicians of the local government, the trainees should learn mechanics to some extent. In this case , there is difficulty to find high school graduates for trainees in some countries, which hampers higher level training. A more difficult problem is to find suitable teachers for training trainers. There are some agricultural universities, colleges, and institutions which carry out such courses, apart from their academic studies or basic research works".

SUMMARY

The Middle and Far East countries have agricultural engineering in various levels varying from strong aca-

demic programs down to government programs of action without any country agricultural engineering teaching, research, or extension programs to support them or to enhance the operations.

Agricultural engineering in a country should concern itself with the whole sphere of the discipline. First, a strong agricultural engineering program to educate and train as competent a corps of engineers in agriculture as possible who can furnish sound leadership and enthusiasm. Then, furnish assistance and direction in developing all the other agricultural engineering oriented operations that are needed in serving agriculture.

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Theme 2.

15. THE DEVELOPMENT OF AGRICULTURAL ENGINEERING IN INDIA by S. E. Roy, UNDP/80 Technical Officer, Irrigation and Drainage.

1. 1. INTRODUCTION.

India is a vast country of 540 million people. 80% of the people live in rural areas and make their livelihood from agricultural production contributing over 50% of the gross national product. Rapid strides have been made in providing the infrastructure for developing heavy, medium and light industries and agricultural production has also increased substantially through the application of modern science and technology in the last two decades. However, the population explosion which adds 13 million people per year is both difficult to keep up with in order to feed and provide for, utilizing the meagre financial resources of this populous developing country. India has the largest area under irrigation in the world, with the exception of China. More important perhaps, is that the rate of increase of new areas falling under irrigation is greater than any other country in the world today, being in the order of over two million hectares of land per year. While a decade ago, no tractors were manufactured within the country, at present, 5 companies manufacture almost all components for their respective makes of tractors and a couple of firms manufacture power tillers. Small stationary diesel and spark ignition engines ranging from 1 to 35 horsepower units have increased very rapidly in the last decade. Similarly, the manufacture of fractional to high-horse power electrical motors for pumping and various other uses have also increased at a high exponential growth rate as also that of water pumps. Such items are now manufactured in hundreds of thousands per year. There are now over 2,000 factories manufacturing agricultural implements and machinery of an increasingly wide variety. Rural electrification has spread rapidly from virtually nil at independence to an average of one-third of the half a million villages of the country, while in certain States such as Kesala, Gujarat and the Punjab over 75% of rural settlements are electrified. Road networks buses and trucks and often trains now pass through almost all villages of over 2,000 inhabitants. A storage capacity of food grains to the extent of 5 million tons to serve as a buffer stock against speculation and in case of famines have been rapidly built up in the last decade. Large schemes are afect to modernize the milling of the staple food-grain rice & improve the willing and processing of wheat, maize and pulses. Agro-industries of an increasing variety have begun to sprout up in villages and small towns for better processing of a wide range of food, feeds, and fibre. All this is only indicative of the role that agricultural engineering has just begun to play in the development of this country. The government and the people have just begun to realize the inmense scope that agricultural engineering can play in the developing of a better rural ambient and increasing the agricultural production of the country and at the same time alleviating the burden of rigorous labour of four-fifths of the country's population.

1. 2. Although there were some visionaries that foresaw this need, the steps that were needed to build up the facilities for the education of the engineers to serve the betterment of agricultural production and better the living conditions of our rural citizens, were sporadic and haphazard, till recently. Thanks to our population explosion and a few serious famines, the Government has now realized that the economy and the welfare of the entire country is greatly dependent on improving agricultural production technology. As a result, over the last decade, there has been a very rapid evolution of agricultural engineering education in India that may serve as a guide for other developing nations largely dependent on agricultural production for their national prosperity and the welfare of the majority of their citizens.

II. THE EVOLUTION OF AGRICULTURAL ENGINEERING EDUCATION IN INDIA.

2. 1. As we all know, India was once the jewel of the British Empire till 1947. Since India's independence just two decades ago, the Macalayan system of education that persisted in India long after it was virtually transformed in Britain itself, gradually gave way to the development of a new hybrid system. Although more than slightly confused during the first few years of transition in the attempt to incorporate hopefully, the better features of the American, European and our own traditional systems of education, it is amazing how, at least in the realm of technological education, a smooth-working system has evolved within a decade. Having studied, taught, lived through and survived the experience, I must say that it has always been an enlightening experience if at times, rather confounding. This is not to suggest that we have now reached our goal of a perfectly satisfactory system of education, ideally adapted to our country, or that we have no "challenges" ahead, but merely to marvel at the fact that through it all, some-

thing that appears to make some sense has at last emerged in the area of engineering and higher technological education that promises to lend new leadership for building the foundations for rapid development of our developing country.

2. 2. The first confrontation of the generally Liberal Arts, oriented highly disciplined, lecture, rigorous examination and learn-by-rote British educational system in the educational field in India, was perhaps the foundation of the Allahabad Agricultural Institute in 1910 by Dr. Samuel Higginbottom, an intrepid missionary, who had the strange idea of developing an educational institution to serve those that depended on agricultural production, then approximately 90% of the country, along the lines of a small American Land Grant College right in the middle of Britains prized colony. Dr. Higginbottom was convinced that the answer to India's poverty was the radical improvement of Indian farming. He reasoned and fought desperately against the traditional educational system of the day to attempt to relate education to the real needs of the country, in order to build up India's economy through application of scientific and technological know-how and to raise the income of the millions of farmers that lived in stark poverty, rather than study academic rhetoric for its own sake, in tradition-bound prestigious Universities and Colleges. Higher technological education in the realm of engineering was conducted by a handful of merely 5 or 6 engineering colleges to serve the whole country prior to the forties.

2. 3. In the wake of independence, rapid steps were taken to expand engineering education and develop our own higher educational systems in all branches of science, medicine and technology. In less than two decades, India now has developed over 115 engineering colleges and Universities that impart professional programmes in the traditional branches of engineering and in 1952, the first Indian Institute of Technology commenced courses at Kharagpur in many new engineering specializations at a level of facilities comparable to many in the West. The demand for technological education became so great that by 1964, five Indian Institutes of Technology had opened up with increasingly better facilities and staff.

2. 4. The first Institute to commence Agricultural Engineering as a professional degree curriculum in India was the Allahabad Agricultural Institute in 1942. The curriculum was patterned after the American system with about the same breakdown of content as agricultural engineering programmes in the U. S. A. of that time. Due to the lack of laboratories in Basic Engineering, at the Institute in the forties, students took some of their education at the then well-known Banaras Hindu University for Mechanical Engineering and Electrical Engineering courses, while laboratory practicals for Civil Engineering courses were imparted at the Rootkee Engineering College. Facilities within the Institute were only developed for the teaching of some basic engineering courses and a limited number of applied agricultural engineering courses predomin antly in Farm Machinery, Soil and Water Conservation, Rural Electrification and Farm Structures. This pioneer venture was extremely successful creating a great demand for the agricultural engineering course. This raises eligibility standards to the 20 or 25 seats annually, very high in the first few years. At first, most of the Agricultural Engineering courses were taught by Americans and Mason Vaugh, the pioneering Head of the Department, was undoubtedly the founder and father of Agricultural Engineering in India.

2. 5. Hitherto, there existed only two streams of studies in the realm of agriculture, general agriculture with an orientation in one or the other field, or veterinary science. Agricultural engineering became a small but distinct third stream in the early forties demanding different eligibility standards, chiefly high performance in Physics and Mathematics, the basic science, mathematics, statistics, and applied agriculture courses were taught in the Agricultural Institute while for the basic engineering courses, it was necessary to link up with facilities provided by distant Engineering Colleges. Thus were the pioneer beginnings of this new profession in India, which many serve to guide similar programmes being initiated in other parts of the world.

2. 6. By some stroke of idealistic vision or otherwise, agricultural engineering found pride of place in the prestigious and first Indian Institute of Technology at Kharagpur. Being virtually a high-powered technological institute, the biological and agricultural science courses had to be catered for by staff and facilities within the Department of Agricultural Engineering.

2. 7. The first three years of the 5-year curriculum leading to professional degrees for a dozen or more engineering specializations are virtually common for all students including agricultural engineers at the IIT, Kharagpur. Thus, a rather high standard of physics, mathematics and basic formation engineering courses firmly set the pattern for agricultural engineering education in the country, while the biological and agricultural sciences at

this institute were comparatively weak. A bi-lateral programme of assistance by Illinois University greatly speeded the development of all round facilities and good courses in the rendering of a broadbased integrated agricultural engineering professional programme which graduated its first batch in 1957.

III. THE DEVELOPMENT OF AGRICULTURAL ENGINEERING IN AGRICULTURAL UNIVERSITIES.

3. 1. A major educational development took place in another erstwhile British Colony, India, about a century later than in the U. S. A., as a result of similar legislation that led to founding of the State Land Grant College. In 1956, by an Act of Parliament, the first Agricultural University was established at Pantnager for the State of Uttar Pradesh. The College of Agricultural Engineering began operating in 1959 with the first graduates emerging in 1965.

3. 2. Although there were over 85 agricultural Colleges in India, at the time, nothing before had placed agricultural education on such a high pedestal and given such power, status and funds to develop rapidly the physical facilities, staff equipment and all else of a University to serve agriculture. The building up of better and higher educational facilities was at last recognized by our planners and politicians as the key to raising our agricultural production and bettering the lot of our rural citizens. Further, thanks to Public Law 480, and our constant lack of sufficient food to feed our growing population, USAID was moved to spend Rupees so accumulated against grain dispatches to India on such a worthy cause. Several private foundations also invested more millions of dollars, matched by counterpart funds of the State to develop all faculties of this, the first Agricultural University in India.

3. 3. The biggest and most expensive facilities of the University went into the development of the Pant College of Technology that is considerably better developed than a mere faculty of most Universities. There are full-fledged departments of Mathematics, Civil, Mechanical, and Electrical Engineering, besides Agricultural Engineering in this College which is apparently going the same way as American Land Grant Colleges in developing professional programmes in each of the traditional engineering disciplines, instead of these being maintained to serve the agricultural engineering programme as was originally intended within the larger context of the University serving Agriculture. The College has a well-qualified faculty of 50 or more staff members, and has well equipped laboratories and workshops to reach all courses in general and agricultural engineering.

3. 4. In any case, the ample facilities with a strong engineering base and a balanced physical and biological sciences foundation of the 5-year agricultural engineering curriculum now graduates large batches of 70-80 students each year since 1955. It is due to commence graduate studies from the coming academic year.

3. 5. The next Agricultural University to develop in India was the Punjab Agricultural University having two campuses of Ludhiana and at Hissar. The rapid and well-organized development of this University with excellent all-round facilities has led to the developmwnt of an excellent undergraduate programme in Agricultural Engineering being offered in the College of Agricultural Engineering and Technology of the University campus at Ludhiana. The Departments of Mathematics, Electrical, Mechanical and Civil Engineering serve the Agricultural Engineering programme. A highly trained staff of over 40 impart what may be considered one of the best and the most balanced programmes in agricultural engineering anywhere in the world an outline of which is given in the Appendix. The University graduates 80 students per year and intends to initiate post-graduate courses from the coming year. The development of the college of Agricultural Engineering and Technology has been strongly assisted by the Ohio State University programme and a large member of professors from various American Universities have acted as consultants and advisers to develop the curriculum and the facilities. The programme has also received substantial assistance from the Ford Foundation while the University as a whole has received millions of dollars from PL-480 for building up its infrastructure for imparting education in all aspects of agricultural science and technology.

3. 6. In 1966 the Rajasthan Agricultural University with campuses at Jobner and Udenpur commenced an undergraduate programme in agricultural engineering. Substantial new facilities are being constructed and the staff being increased to teach the basic engineering courses within the agricultural University campus at Udapur the first batch of about 40 students will be graduated next year from this Agricultural University, that has a sound curriculum but yet lacks the facilities and staff for yet imparting all the courses by themselves. A nearby engineering college still assists with the teaching of most of the basic engineering courses.

3. 7. The Jawaharbal Nehru Agricultural University has afiliated Colleges in Gwalior Rewa, Mhow, Raipur, Indore, and Sehore, all of which teach Agricultural Engineering chiefly to students of agriculture. However, at the Central University Campus at Jabalpur, a full-fledged Agricultural Engineering undergraduate education is imparted to approximately 35 students annually. The first graduates will come out in a couple of years.

3. 8. The University of Agriculture, Sciences and Mechanic Arts of Orissa also has a College of Agricultural Engineering and Technology that has a capacity of about 40 students a year. This new programme is also assisted by an American University exchange programme.

3. 9. The new Agricultural University of Maharashtra has several affiliated colleges at Kolhapur, Akola, Nagpur, Parbhain and Poona. Poona is developing a programme in agricultural engineering with assistance from the Pennsylvania State University.

3. 10. The University of Agricultural Sciences, Mysore established in 1965 has campuses at Dharwar and Hebbal which are also in the process of building up a college of agricultural engineering. Similarly, the Agricultural University of West Bengal at Kalyani, and the Andra Pradesh Agricultural University at Rajindranagar are in the process of developing facilities for imparting undergraduate courses in Agricultural Engineering.

3. 11. Thus, it would be seen that with the opening of the new agricultural universities which are expected to develop in each State, agricultural engineering undergraduate education has now assumed considerable dimensions in India. The country at present, already has an annual graduating capacity for undergraduate education as follows:

U. P. Agricultural University	80
Punjab Agricultural University	80
Rajasthan Agricultural University, Udaipur	40
Orissa University of Agricultural Sciences & Mechanic Arts	40
Jawaharlal Nehru Agricultural University	35
The Indian Institute of Technology, Kharagpur	30
The Allahabad Agricultural Institute	30
Total annual graduating capacity	335

3. 12. This number of agricultural engineers compares well with the total now being graduated annually in the U. S. A. When the five other new Agricultural Universities develop their facilities probably within the next 5 years, the number of professional agricultural engineers will rise to around 500 annually, which will exceed the total from all other parts of the world together. When all 17 States in India develop Agricultural Universities as is planned, perhaps 10 years from now, the number of graduates will be in the order of 750 annually after which a levelling off numerically is expected.

IV.A COMPARISON OF UNDERGRADUATE CURRICULA OF AGRICULTURAL ENGINEERING IN INDIA.

4. 1. A breakdown of various curricula of the Punjab Agricultural University, Ludhiana the Uttar Pradesh Agricultural University at Pantnagar, the University of Udaipur, the Indian Institute of Technology, Kharagpur and the Allahabad Agricultural Institute, Florida and Michigan State Universities, as against the proposal made in the brief, is given in Appendix I, disciplinewise as compared with the latest proposed curriculum at La Molina and the curriculum offered at Medellin, Colombia.

4. 2. The greatest variation in various Indian agricultural universities and institutes offering agricultural engineering is in the number of technical electives for choosing in various agricultural engineering specializations. The U. P. Agricultural University has the greatest number of technical electives and lists a wide variety of 14 electives courses at the senior level and another set of 22 courses in more interdisciplinary courses of agricultural engineering. Further students are free to choose from over 20 advanced courses in electrical, mechanical and ci-

vil engineering and mathematics and statistics. It is questionable whether even in such a large State of Uttar Pradesh highly dependent on agriculture where such a large number of electives can be justified or supported for long by internal sources, once aid from assisting programmes ceases. On the other extreme we have the least number of electives in the programme in Udaipur which is just commencing. This appears to be along the right lines in view of the initial stages of the programme, facilities of the staff, equipment and laboratories to support the offering of a large number of elective courses that would be a luxury for Rajasthan to support at this stage. The most commendable and well balanced undergraduate programme in all respects in India, today in the opinion of the author is undoubtedly that of Punjab Agricultural University which could serve as a model for other developing countries desirous of initiating undergraduate programmes in agricultural engineering (for details please see Appendix 2).

V. POST GRADUATE EDUCATION IN AGRICULTURAL ENGINEERING.

5. 1. Post-graduate education in Agricultural Engineering commenced in the Indian Institute of Technology, Kharagpur with its first Master degrees, in 1960. Advisors from North Carolina State University such as Dr. Hassler and Dr. Wiser who are with us here, other members of the North Carolina University and other advisors from Ohio State and other Universities have helped develop the first graduate programmes in Agricultural Engineering in India at Kharagpur, specializing in Farm Machinery and Power, Soil and Water Engineering and more recently in Agricultural Products Processing, Dairy Engineering and Structures. A strong and well-equipped and well qualified staff exists not only for the imparting of basic engineering courses from other departments but also in Agricultural Engineering. This author helped set up and consolidate the programme in Soil and Water Engineering at the Institute. The highest mathematics and engineering standards perhaps, of any agricultural engineering courses in the world exist at this Institute that demands above the rigorous 5-year undergraduate curriculum for the bachellor's degree, an additional 2-years of a 48 credit curriculum for the Master's degree and generally three additional years of full-time work for a Ph. D. in Agricultural Engineering. At present, the Department of Agricultural Engineering at Kharagpur has widened its range of courses and developed programmes to the Ph. D. level, the first Ph. D. having graduated in 1964. The Institute specialized in Farm Power and Machinery, Soil & Water Conservation Engineering, Processing and Structures and more recently in Dairy Engineering having an intake capacity at present of approximately 20 students per year.

5. 2. The Imperial Agricultural Research Institute was initiated in 1905 and had served as a centre of research for tropical agriculture for much of the British Empire till India's Independence when it was renamed the Indian Agricultural Research Institute. The IARI is the Beltsville or rather the Rothamstead of India. In 1958 with a sizeable Rockefeller USAID assistance, the excellent staff and high-powered facilities for research in all branches of Agricultural Sciences were put to the service of education at the post-graduate level. 12 of the 13 Divisions of the IARI rapidly developed and began to offer post-graduate programmes in various well defined specializations. Regretably it was not until 1966 that post-graduate education in the field of Agricultural Engineering could be set up through the efforts of the author, to fill the need of the increasing number of professional level students demanding higher education within the country. The advice and assistance of particularly Mr. G. W. Giles and the Ford Foundation in initiating this programme is deeply appreciated. Being the national institute for research and education for India under the Indian Council for Agricultural Research, the Government sponsorship of the programme is of a high order which promises to build up rapidly to taking 15-20 Master students and 5-10 Ph. D. students annually by 1971. As the IARI is the chief research and advisory Institution at the highest scientific and technological level for the country as a whole, the Division has responsibilities for many coordinated mission-oriented research projects in the field of agricultural engineering such as the Research and Testing Centre for agricultural implements, the Zonal Research and Design Centre for design and development of agricultural machinery, an All-India Rice Processing and Milling Scheme and other agro-industries in the country, the development of Standards for farm power units and agricultural implements and machinery, coordinated research in Soil & Water Technology. Both at the Indian Institute of Technology at Kharagpur and the IARI the Masters programme is of two years after the five-year undergraduate curriculum which is still the standard in the country, although recent efforts have been made in one or two universities to reduce the professional programme to a four-year course. Both the IARI and IIT programme has arrangements for professional research and training for a term on the field, and a thesis as partial requirement. Further, the IARI has a requirement of 45 course credits above the thesis, seminar and high level professional apprenticeship term for the Masters degree.

5. 3. The Allahabad Agricultural Institute has recently commenced a Master's degree programme but this is suffering from lack of funds for building up adequate facilities as it is the State of Uttar Pradesh that has to grant Agricultural University now. From the coming year, however, the ample and excellent facilities of both the Uttar Pradesh Agricultural University at Pantnagar and the Punjab Agricultural University at Ludhiana will commence graduate instruction in agricultural engineering to meet the growing demand from over 300 graduates that emerge from professional programmes each year. It is expected that a capacity of 80 seats for graduate students would develop by 1976 within the country.

5. 4. It is worthy of mention here that an attempt had been made in the Indian Institue of Technology and other Institutions teaching Agricultural Engineering to give a post-graduate one-year programme, somewhat like farm mechanization programme in Agricultural Engineering. For a number of reasons already mentioned in my paper of Post-graduate Education this course has not found favour with either by students or by potential employers. It served to cause much confusion at considerable expense of effort and funds.

VI. JOB OPPORTUNITIES FOR AGRICULTURAL ENGINEERS.

6. 1. The obvious question that comes to the mind, in view of the large programme in Agricultural Engineering which has already developed in India and the plans underway for futur e development is whether there is likely to be sufficient job opportunities for all at various levels of training. In a study of the technical manpower availability and requirements ( ) the breakdown of the number of various types of graduates for 1961 showed that there were 57,509 engineers, 36,800 scientists, 14,000 agricultural scientists and 5,000 veterinary doctors in the country. During our Third Plan, 1961-1966, whereas as for the most other items our targets were not reached in a Mid-Term Appraisal, it was amazing to find that in all fields of education the targets were far exceeded. In the case of diplomas in technical engineering training the target was exceeded by 27%, whereas for professional degree level education, the target was exceeded by 20%. Whereas, most official targets in Plans of developing countries tend to be over -ambitious, here was a case of gross underestimation. Industrial and agricultural production enterprises obviously demanded many more competent hands.

6. 2. A developing country in the modern world, with a highly competitive world market, and a very rapid rate of technological advancement is greatly dependent on the adequacy of technical manpower both in quality and numbers to ensure a desirable rate of economic growth. Particularly at the initial stages, scarce human capital of technical manpower is a primary limitation to rapid development. Further, modern technology demands an increasingly greater proportion of higher scientific as compared to technicians. It became obvious therefore, to our planners that the lack of higher education in the sciences and technology was a major limiting factor for overall economic development of the country. By the end of 1964, plans were stepped up therefore, to take in over 23, 130 engineering students and increase the number of colleges to 117. For the Fourth Plan 1966-1971 (but now delayed by one year), estimates planned an increased output of 67,578 engineers in the country within five years, as against our Fourth Plan demand estimates of 75,000 additional engineers. Of these 5,000 to 7,000 students were expected to be provided for advanced post-graduate engineering education.

6. 3. Unfortunately, our planners were not much aware then that agricultural production and the creation of the infrastructure and housing for rural living also demanded engineers by the thousands to serve the 72% of our population engaged in agricultural and related production. Whereas, there were plans to provide 75,000 engineers to serve 20% of our total population living in urban settlements. However, no manpower requirements for making a viable modern system of agricultural production and for improving the primitive condition in which 80% of our population lives. Our distinguished former President Dr. Radha Krishnan in 1948 was perhaps, the first to focus the attention of the Government to the inadequacies of higher Agricultural Education under the traditional systems of Education in Universities. The University Education Commission then headed by Dr. Padhs Krushnan recomended the establishment of rural and agricultural universities which took almost a decade for giving rise to the first agricultural university at Pantnagar.

6. 4. In the Indian Society of Agricultural Engineers meetings in December, 1965, the problem of estimating job opportunities and placement for agricultural engineers was considered in detail on a national basis, perhaps for the first time. The estimates arrived at were undoubtedly on the conservative side as appreciation of such

problems comes slowly in a large developing country. The basis for these estimates were to provide for extremely paltry facilities of modern farming to farmers who then had virtually none before, such as to provide one tractor to 150,000 farmers and to provide a set of simple agricultural implements to 20% of the farmers by the end of the Fourth Plan and 600 undergraduates. Whereas, it was estimated that there would be a need for 2,400 professional agricultural engineers in the Fifth Plan and 300 post-graduates. However, already the demands of the country have more than doubled the planned output of professional engineers by 1971 as compared to these conservative estimates. However, the estimated demand for post-graduates with advanced training in specializations in farm machinery and power, soil and water engineering, food processing and agricultural industries and farm structures and rural planning of 200 postgraduates by 1971 may just be met with the new intake at the IARI, the Punjab Agricultural University and the Uttar Pradesh Agricultural University.

6.5. With a country increasing the area of its land under irrigation at the rate of more than two million hectares annually, obviously, efficient water use planning, design and layout of farm irrigation and drainage systems, land levelling and development for the purpose and providing for better methods of application of irrigation would in itself require 1,000 agricultural engineers annually if each engineer was to plan and execute jobs for 2,000 hectares annually.

The Working Group for formulation of Fourth Five Year Plan proposals on Minor Irrigation indicates that while only Re 85 crores were spent on irrigation projects for the first plan increasing the area under irrigation by almost 4 million hectares in 5 years by the third plan 61-66. 3.56 billion rupees were spent to irrigate over 5 million additional hectares. For the Fourth Plan to end by 1971, 6.3 billion rupees were budgeted in order to bring an additional 5.5 million hectares under irrigation. An important factor is the increased accent on ground-water development as compared to major and medium diversion works. During the second plan 33% of the total irrigation works were minor, whereas during the Third Plan 51.6% of the total works were minor irrigation which rose to an average of 66% in the Third Plan period. This brings the agricultural engineers more into the picture for executing of irrigation projects, particularly in view of the fact that the average size of the Indian farm is small and much detailed planning and execution has to be done at the descentralized rural level. A great deal of research in ground water exploration, hydrology, water resources development, field conveyance, application and more efficient water use methods and systems would alone require hundreds of postgraduate engineers in the field of irrigation and drainage whereas thousands of professional agricultural engineers are required for execution of field projects involving construction of low dams and reservoirs for storage irrigation systems, installation of lift irrigation systems, conveyance and distribution of irrigation at the farm level and effective drainage works and antisea water intrusion works.

Similarly, the Central Soil Conservation Board which was set up in 1953 to undertake terracing, land grading, shaping on a watershed management basis has expanded from 280,000 hectares in the First Plan through 1,000,000 hectares of terracing in the Second Plan to 4,300,000 hectares in the Third Plan. Comprehensive watershed management projects, particularly in river valley systems involving afforestation of steep slopes, revegetation of more moderate slopes and terracing of gentle slopes with provision for safe conduct of runoff from the entire watershed to an extent of 8 million hectares has been planned for being undertaken by 1971.

Upstream detension and storage reservoirs, sedimentation and gully control structures and water spreading and ground water recharging systems need to be designed and executed, under professional guidance, for even a minimally adequate level of technological planning, design and supervision for execution would demand over 500 agricultural engineers to take care of field works in the area of soil and water conservation engineering. Besides, advanced research on reclamation of saline and alkaline soils, waterlogging and acidity, the hydrology of small watersheds, deterministic and simulated methods for obtaining rainfall, runoff and hydrographic data, the finding and adoption of coefficients for the universal soil-loss formula to apply to watershed management systems on a more quantitative and scientific basis, to staff the 8 soil conservation research stations already started and more to develop later, would demand hundreds of postgraduates in this vital field for enabling a permanent agriculture to develop in a country where the area of land per capita keeps reducing considerably from decade to decade.

In the field of farm machinery and power 40,000,000 pairs of bullocks that now contribute 66% of the total power available on the farm has to be rapidly replaced by small to medium well adapted power units somewhat along the lines of excellent developments that have transformed Japanese agriculture. An equal number of animal drawn mould board and disc ploughs, and complete sets of harrows, cultivators, seed and fertilizer drills and spreaders, and land levelling and farming equipment need to be developed and manufactures to bring the benefits of modern technology to alleviate the heavy burden of laboursome inefficient work of an estimated 100,000,000 agricultural labourers. Besides millions of women and children are drawn into the drudgery of laboursome farm tasks who should be relieved of such burdens so that they also can build up decent and more comfortable homes and obtain a better education.

Stationery heat engines and electric motors have already begun to be used on the farm to a rapidly increasing extent. The mechanization of harvesting, threshing and processing to save millions of man years of labour all require professional agricultural engineers who have an orientation towards farm power and machinery. There are also great requirements for materials handling and transport of various inputs and agricultural products to and from the farm, besides much power and equipment required for operating lift irrigation systems for the manufacture of such machinery and execution of farm mechanization projects, thousands of professional agricultural engineers are required. Research in the design of suitable small tractors and power tillers, the design of a complete range of field tillage machinery, seeding and fertilizing equipment, crop protection equipment, harvesting, threshing and processing equipment already demands hundreds of postgraduate agricultural engineers that are just not available to commence the revolution of mechanizing farms in India.

6.6. Agricultural Products Processing.

In the field of agricultural products processing, the processing of fibre crops from field to factory, the processing of crops such as sugarcane, oil crops and cereals and food grains, perishable vegetables and fruits, plantation crops such as tobacco, coffee, tea and spices is vital to the economy of the country. In this field, there is the greatest dearth of professional specialized knowledge that demands hundreds of agricultural engineers for planning, designing, execution and management of processing plants in the country. A great deal of research in this area would demand post-graduates to an extent that cannot be foreseen to be not to the least extent in the coming decade.

6.7. Farm Structures and Rural Planning.

Today, few city bound and oriented architects, planners and electrical engineers plan for the extremely limited communications systems, road networks and rural electrification put to farm use in the country. There is virtually no planning at the rural level for human housing and animal housing has not advanced over the last thousand years. Only recently have agricultural engineers entered the field of designing and constructing storage facilities for 5 million tons of buffer stock of food grains, designing processing plants and some small and scattered projects on the rural zoning, planning and provision of the infrastructure for better fural living. There is virtually an unlimited scope in this area to provide a better ambient for 400 million Indian citizens to live and work in.

While not all these works can or would ever be entrusted to agricultural engineers in the near future, there is certainly the immense need for applying the specialized knowledge of professional agricultural engineering of advanced specialists in those areas of work that falls under the purview and field of work of the agricultural engineer.

There will never be a sufficient number of well trained agricultural engineers within developing countries to undertake the vast array of work involved in the coming two or three decades. On the other hand, developed countries such as the U.S.A., Canada and the United Kingdom, which have an extremely small proportion of the population ranging from 4-10% that are involved in agricultural production, at present, are capable of educating vast numbers of agricultural engineers, almost beyond their immediate needs. There is no field where a rich interchange of education and job opportunities exist for which better international interchange towards the overall development of the world, than in the profession of agricultural engineering. It is hoped that the deliberations of this possibly most international and highest level meeting of professionals held anywhere at any time would recognize and formulate clear guidelines for the development of agricultural engineering education, at both the professional and graduate levels, on an international basis, to establish our profession as one of the most important ones in the world today.

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APPENDIX I

Percentage Discipline-wiss Breakdown of Undergraduate Curricula in Agricultural Engineering of Selected Indian & other Universities

Area of Studies	Punjab Ag. Ludhiana	U. P. Ag. U. Pant-nagar	IIT, Khar-agrur	Alla. Ag. Inst.	U. of Udai-pur	Michigan St. U. E. Lansing	Florida Univ.	Uni. Nac. L. Mol. 64-67	Uni. Nac. de Co-lombia, Medell.
Humanities & Social Sciences	8. 1	7. 0	6. 5	8. 5	3. 0	12-16	17. 0	9. 0	9. 5
Basic Physical Sciences & Mathe-	27. 3	24. 5	23. 5	24. 0	28. 0	18-22	26. 7	20. 0	28. 0
Applied Agricul-tural Sciences	16. 1	14. 0	11. 0	15. 5	11. 0	15-19	5. 2	14. 0	5. 5
Basic Engineering	28. 9	28. 5	37. 0	26. 5	30. 5	30-35	23. 5	27. 0	21. 5
Applied Agricul-tural Engineering including Techni-cal Electives	19. 6	26. 0	22. 0	25. 5	27. 5	22-27	25. 8	36. 0	35. 0

Theme 2.

16. THE DEVELOPMENT OF AGRICULTURAL ENGINEERING by Corrado Ricci, Instituto di Construzioni Rurali, Universitá degli Studi di Bari, Bari, Italia.

1. The teaching of Agricultural Engineering in Europe follows different methods, that is:

i) Post Graduate Education offered by either an Agriculture or Engineering or (rarely) Architecture Faculty (or Schools at university level);
ii) Graduate courses in Agricultural Engineering or related branches offered by National or Specialization Schools, however centralized, to graduates or Senior students of Agriculture or Engineering.
iii) Undergraduate courses leading to B. S. degree in Agricultural Engineering or related fields (Soil & Water Conservation, Agricultural Mechanization, Farm Buildings, Rural Planning, Agricultural Products Processing .

2. The first teaching method (Post Graduate Education offered by either an Agriculture or Engineering Faculty is by far prevailing. It is due to the lack of ductility characterizing the structures of the European university teaching which is still resting on the prevalence, in each Faculty of a group of basic subjects, most of which trace their origin back to 19th century. The immutability of traditional subjects makes very difficult the introduction of new subjects and prevents new and wider courses from being established.

To face the specialization demands required by the technological and scientific progress, the only possible solution is that of resorting to post graduate education. The commoner courses offered by European universities have a duration of 2 or 3 years. They are open to graduates of different origins (i. e. Agriculture, Civil Engineering, Architecture , Mechanical Engineering and lead, as a consequence of it, to the preparation of professionals having very different technical background and professional attitudes as well.

In many cases, they have in common nothing more than their academic title of Agricultural Engineers.

When the post graduate educational course is devoted to the General Agricultural Engineering very unsatisfactory results are achieved. The assimilation of biological or economic subjects from graduates in Engineering as well as the assimilation of mathematical or engineering subjects from graduates in Agriculture is almost always very poor. Only a very good practical training is in a position to give the teaching a better cohesion and sharpness.

When the post graduate educational course aims at getting a well specialized and defined area of Agricultural Engineering and such an area is close to the nature of the courses offered by the Faculty, i. e. when a Faculty of Mechanical Engineering offers a post graduate educational course of Farm Machinery Construction, better results both at professional and scientific research level may be obtained.

In such a case, the agricultural engineer acquires an advanced specialization which is however useful only when the professional's range of action involves industry or scientific research.

Should the agricultural engineer's range of action directly involve a better use of land-both at farm and territorial level-a greater extension of knowledges and a more complete approach of the problem appear desirable.

3. The second method with which agricultural engineers are prepared in Europe relates to national graduate schools whose courses are intended for Agricultural Engineering and for more related and specialized branches.

The number of these schools in Europe is not big, but the existing ones are good examples of teaching efficiency and scientific rigour In addition to it, they have the merit of showing the small countries the way towards the concentration of teaching and research activity. Such a concentration is more and more universally demanded by the increasing cost of studies and by the experimental activity.

The centralized schools have the advantage of utilizing in a better way, the available human patrimony favouring that concentration of brains and experiences to which a prevailing role in the development of scientific research must be recognized.

A good example of the national graduate school is the French "Ecole Nationale du Génie Rural". Its courses have a duration of two years and are open to graduate engineers of the Polytechnic School as well as to Senior students having completed the 3rd year of the National Agronomic Institute.

The first year is devoted to the basic background (Mathematics, Thermodynamics, Electrical Technology, Mechanics of Materials, Building, Topography, General and Applied Hydraulics, Hydrology, etc.)

The second year is a technical forming year with a more specialized range of action in Agricultural Engineering. It allows the student to choose one of the following options: (1) Rural territory equipment (2) Farm Mechanization (3) Hydrology.

The curriculum of studies adopted by the School is shown in appendix 2.

In comparison with the above mentioned advantages, the national graduate schools show some disadvantages, that is:

i) the preparation of agricultural engineers requires a long period of time (usually from 6 to 7 years). This period is reduced to 5 years if Senior students having completed the 3rd year of an university course are admitted to the school);

ii) the teaching content tends to crystallize for lack of contest and comparison with other schools;

iii) the assistance to tudents as well as the selection degree of their attitude are in general limited, the number of students being comparatively high;

iv) the School staff has a remarkable teaching load and the time devoted to research is fragmentary and poor.

4. The third method for the preparation of Agricultural Engineers i.e. that adopted by those Faculties offering, according to the USA pattern, undergraduate courses leading to the B.Sc.'s degree- is not well spread and mainly relates, if not exclusively, to the training of personnel in a well defined branch of Agricultural Engineering.

It is generally recognized that this method is very practical as useful especially when it is applied to the preparation of Agricultural Engineers, in a 4-year course, without any further specialization. Yet, it is thought- and many European countries have already prepared detailed plans as to this problem -that the reform of university studies in the field of Agricultural Engineering must tend towards this direction.

However, such projects have difficulty in being carried into effect and the lack of initiative the European university institutions are showing in this field can be attributed to different reasons, some being general and some specific of the study sectors of Agricultural Engineering.

One of the first general causes is the crisis the scientific research bodies, and particularly the University, are passing through. Such a crisis- more or less keen- saves no country however small or big it may be, and it is lived in Europe more traumatically than elsewhere.

For having been in the van in the past, the modern European university institutions meet with bigger difficulties to adapt themselves to the new requirements of Technology and Science.

A second general cause is the necessary consciousness of carrying into effect - together with the economic unification of Europe - the free circulation of technicians. This presupposes not only that academic titles must be equalized, but also that the aim and content of courses leading to the professional qualification must be in harmony with the European level.

Among the main specific causes, the following must be taken into consideration:

i) the progressive importance decline the Agriculture suffered in the recent years in the ambit of the European economic potential;

ii) the lowering of agricultural technicians' remuneration in comparison with that offered by other productive sectors causing a stagnation of candidatures in the field of Agricultural Engineering;

iii) the composite training that most of European countries offers to agronomists putting them in condition - at the end of a good practical training - to carry on a fair work falling within Agricultural Engineering (*).

5. The present status of Agricultural Engineers in many European countries and the methods adopted for their preparation are shown in appendix 1.

It may be noticed that remarkable discrepancies, from country to country, exist in the number of professionals working in Agricultural Engineering as well as in their percentage distribution in the various fields of activity.

It is necessary to remark that the figures mentioned, besides their indicative value, cannot be compared among them. Some national associations include among professionals in Agricultural Engineering all graduates (and sometimes even minor technicians) carrying on their activity in Agricultural Engineering regardless their academic titles. On the contrary, other countries include only technicians holding an academic degree in Agricultural Engineering and, what is more, working in agriculture. In such a case, besides the minor technicians, the agricultural engineers, devoted to teaching and to scientific research are excluded from statistics if these activities do not fall in the province of the Ministry of Agriculture.

As to the percentage distribution of European Agricultural Engineers according to their different range of action, the percentage of people working in industry (from 10 to 35%) and those devoted to farming (from 5 to 10%), with the only exception of West Germany, is surprisingly low.

In addition to it, the percentage of professionals requiring a very specialized preparation (i. e. those working in industry and teaching and research) is always inferior and sometimes considerably lower than that of Agricultural Engineers for whom a wider and more complete preparation (consultantship, free professional activity, extension activity, farm organizations) is more adequate. This circumstance justify in most of European countries the trend towards forming Agricultural Engineers at B. Sc. 's degree level without any further specialization (4-5 year courses) as well as the preparation of more specialized professionals at M. Sc. 's degree level (3-6 semester graduate courses).

6. Taking into account the present status of Agricultural Engineers. In Europe, we may wonder what future is reserved for them, namely what trends will emerge from the solutions which each country is trying

* For instance, in Italy the General course offered in Agricultural Sciences leading to the professional title of agronomist shows that out of a total of 30 basic subjects, 20% of the course time is devoted to six agricultural engineering subjects (Farm Mechanization, Agricultural Hydraulics, Farm Buildings, Surveying, Agricultural Products, Applied Geology) and 13% to the socio-economic subjects. The situation does not greatly differ from other European countries.

to give to the development problem of its rural regions.

In spite of the difficulty due to the lowered economic importance of Agriculture, as it was before mentioned, the fact that many countries consider the supply of Agricultural Engineers inadequate for their needs is an encouraging factor.

The shortage of technical and scientific personnel, trained in the modern engineering techniques applied to agriculture, is likely to increase in the long run as soon as the problems connected with agricultural production and marketing will pour into Europe after going out of the narrow national ambit.

In the whole, the present educational systems are inadequate to face future needs. Nearly all the countries in which such difficulties are met have agreed upon the necessary of reforming the preparation methods for Agricultural Engineers.

Many European countries, such as France, Italy, and Germany, are making efforts to reform their university structures. Paraphrasing J. F. Kennedy we may say that the European University and scientific old world "in approaching the revolution. We do hope to modify its character byt can do nothing to avoid it."

Therefore we realize that it is extremely difficult to outline today models which the new European university institution must cling to.

7. A positive element is emerging from the toils which the European university and scientific world is living in the whole and from the efforts made to unify Europe. This element is the consciousness that the problems connected with the development of teaching and scientific research require a closer coordination of efforts as well as a continuous cooperation at international level.

In fact, this consciousness led to the creation of an international net of Specialized Studies and Research Centers designed for graduates coming from European countries as well as from other nations facing problems of economic development.

These International Centers created in Europe in the last years ground their justification on the fact the European countries, in most cases, are too small to justify the creation of national specialized centers. It is possible through concentration to avoid not only the loss of human capital and initiatives but also to finance wider educational and scientific activities.

One of the Centers working in the field of economic development is the International Centre for Advanced Agronomic Studies, created in 1961 by the Organization for European Economic Cooperation and Development (OCDE). Two Institutes are under the direction of this Center, namely:

Agronomic Mediterranean Institute of Bari (Italy)
Providing a post-graduate education in land use, rural infra-structures and equipment.

Agronomic Mediterranean Institute of Montpellier (France).
Whose course aims at planning rural development.

The course provided by the Agronomic Mediterranean Institute of Bari, as per appendix 3, include many subjects related to Agricultural Engineering. For such a reason, I thought useful to mention this example of international cooperation whose purpose - fixed by the seven European countries creating the Center (*) is that of supplying Agronomists and Engineers with the necessary knowledges to face technical problems connected with a better use of land resources in a well organic and complete way.

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* The Center is managed by a Board of Directors composed of the representatives of the following countries: Spain, France, Greece, Italy, Portugal, Turkey, and Yogoslavia. The treaty was signed on May 21, 1962.

Because of the analogies among the problems of rural development existing in many European and Latin American countries, this example of international cooperation I have mentioned may offer a solution pattern even valid for the problem we are discussing in this seat.

The international pooling of resources to train modern Agricultural Engineers and Planners will undoubtedly help to make up the arrears in the agricultural sector, a sector sometimes regarded by economists as residual and by governments as a constant source of anxiety.

APPENDIX 1

PRESENT STATUS OF AGRICULTURAL ENGINEERS IN EUROPE

AUSTRIA:

Agricultural Engineers in Austria are either graduates of the Technical University or the University of Agriculture. The course of study has the duration of 9 semesters and leads to the degree of Dipl. Ing. in Agricultural Engineering.

There are reported to be about 100 professionals in this field, but it is expected that the number of Agricultural Engineers will increase in the future. Till now, Austria has no specific professional organization. The distribution of Agricultural Engineers is as follows:

- Teaching & Research	30%
- Industry	20%
- Governmental service	10%
- Consulting and other free professional activities	25%
- Farming	5%
- Farm organizations	10%

BELGIUM:

In order to be classified as an Agricultural Engineer (Ingenieur du Genie Rural) it is necessary to have completed 5 years of studies at the Faculty of Agricultural Sciences. A minor degree in the same field (Ingenieur Agronome du Genie Rural) can be achieved with a 3-year course.

The current number of Agricultural Engineers is considered to be adequate and they expect to be able to meet future needs.

CZECHOSLOVAKIA:

An agricultural engineer can be specialized in either the field of "Mechanization of Agricultural Process" or in the field of "Drainage & Irrigation". A 5- year course at the College of Agriculture leads to the degree of Engineer.

The number of professionals in both fields is considered sufficient to the needs of the country, having removed the shortage existing after the second world war. A national organization of Agricultural Engineers represents the profession.

DENMARK:

No undergraduate course of study leading to a degree in Agricultural Engineering is available.

The courses of the National Veterinary and Agriculture College lead to the B.Sc.'s degree in Agriculture.

Two or three year graduate courses with major in some branches of Agricultural Engineering and minor related engineering subjects are provided. These M.Sc. courses are open to students graduated in Mechanical Engineering at the Technical University. It is estimated that there are more than 200 Agricultural Engineers working in extension activities (20%) education and research (40%) and farming (10%)

FINLAND:

So far no undergraduate courses in Agricultural Engineering are provided. Various Agricultural Engineering subjects are being dealt in different B.Sc. courses. Two of these subjects (Farm Machinery and Food Processing), may be included as major in the M.Sc. curriculum in Agriculture. Quite recently, graduate courses in Agricultural Engineering have been organized in the School of Agriculture when two new Institutes (Food Processing, Farm Work and Techniques) were established. The present number of Agricultural Engineers (about 300) is considered to be inadequate for the needs of the country.

The distribution of these professionals in the different sectors of their activity is as follows:

- Education & Extension	35%
- Governmental service	15%
- Consulting & other free professional activities	20%
- Farming	5%
- Agr. and Forestry Organizations	25%

FRANCE:

It is reported that the number of Agricultural Engineers is, at this time, approximately 850 distributed as follows:

- Education & Research	25%
- Industry	20%
- Consulting & overseas technical activities	10%
- Governmental service	15%
- Farming	10%
- Agricultural & professional organizations	20%

Two different Agricultural Engineering degrees (1st- Ingenieur Civil du Genie Rural) (2nd Ingenieur du Genie Rural, Eaux & Forets) may be obtained after a 2-3 year course of study at the National College of Agricultural Engineering and Forestry, Candidates must have previously completed a 3-year course at an Engineering or Agriculture School.

A National Association with 200 members represents the profession.

GERMANY (WEST)

In West Germany, professionals having different levels of technical education may be qualified as Agr. Engineers by one of the following methods:

- Graduates of Technical University (High Level Education)
  - Diplomingenieur (graduates in Machine Construction with specialization in Farm Machinery.
  - Arkitect (graduates in Architecture with specialization in Rural Constructions).
  - Wasserwirtschaftingenieur (Dipl. Ing.) (graduates in Soil and Water Conservation).

Graduates of an Engineering School (middle level education)
- Landmachineningenieur (Farm machinery)
- Ingenieur fur Landbau (Soil & Water Conservation).

Several technical organizations may be considered as representatives of Agricultural Engineering professionals. At this time, more than 850 of these are members of the different organizations.

The distribution of Agr. Engineers may be considered as follows:

- Teaching and Research	20%
- Industry	35%
- Governmental Service	10%
- Consulting & Civil engineering activities	10%
- Farming	10%
- Agricultural organizations	15%

ITALY:

No course of study leading to the degree of Agr. Engineer is now available. Graduates of different fields such as civil or mechanical engineering (5-year course) and agriculture or Forestry (4-year course) are professionally trained in different branches of Agricultural Engineering, i.e. Soil & Water conservation, farm constructions & equipment, farm power, and farm machinery. Training take place both in University Departments and in Agricultural Service Organizations.

The present trend is towards the development of courses of study leading to a degree in agricultural engineering. The current supply of Agr. Engineers is considered to be inadequate for the needs of the country.

It is estimated that the number of Agr. Engineers is about 800, 250 of which are members of a national association. The distribution of these professionals in the differents fields of their activity is as follows:

- Education & Research	40%
- Industry	10%
- Governmental service	5%
- Consulting and free professional activity	15%
- Co-op & Extension service	30%

NETHERLAND:

Undergraduate and graduate courses leading to the final degree of "Ingenieur" are offered by the Agriculture University of Wageningen. It is reported that the number of Agr. Engineers is about 2,000 and approximately distributed as follows:

- Education & Research	25%
- Industry	20%
- Governmental Service	30%
- Consulting & other Professional activity	15%
- Agr. Organizations	10%

NORWAY:

Graduate courses in specialized branches of Agricultural Engineering are provided by the Agriculture College of Norway. The supply of Agr. Engineers is considered to be quite adequate for present needs. No professional organization is available.

POLAND:

No study course leading to the degree in Agr. Engineering is available. Subjects relative to different branches of Agr. Engineering are part of the 5-year course on general agriculture offered by Agriculture Colleges. A 10 semester course in Architecture, with specialization in Rural Planning and Construction, is provided by the Polytechnic School of Warszawa.

Plans have been made for increasing the supply of Agr. Engineers as the present number does not satisfy the current requirements.

PORTUGAL:

Only courses leading to the title of "Engenheiro Agronomo" are available. Different subjects of Agr. Engineering are included in the curriculum of these courses. It seems to exist the need of well trained Agr. Engineers in Water Resources Development, Farm Mechanization, and Agricultural Processing. The present number of agronomist is in fact considered to be inadequate for the future needs of the country.

SPAIN:

No specialized course of study for Agr. Engineer is available. Undergraduate curricula leading to the degree of "Ingeniero Agronomo" are provided by the Agriculture Colleges of the University of Madrid and that of Valencia. Professional experience, research activity, governmental service, and teaching in different branches of Agr. Engineering enable a graduate person of an university to qualify for membership in the National Association of Agr. Engineers. The number of professionals working in Agr. Engineering is generally recognized to be inadequate for the fast growing technical needs of the country. Plans have been made for the development of courses leading to a higher specialization of the present curriculum for "Ingenieros Agronomos".

SWEDEN:

No Faculty or Agriculture College provides courses of study for Agr. Engineers. Persons trained in different fields such as Civil Engineering, Agricultural Sciences, Mechanical Engineering are at this time doing Agr. Engineering work. Programs have been widely discussed for creating a specialized curriculum leading to the B. Sc. 's or M. Sc. 's degree in Agr. Engineering. It is reported that at the end of 1968 approximately 70 people were engaged in Agr. Engineering Research projects and 40 in extension work.

SWITZERLAND:

A study course leading to the degree in Agr. Engineering (Ingenieur du Genie Rural) is provided by the Federal Technical School of Zurich.

It is reported that the number of professionals in Agr. Engineering is more than 1,000 and most of them are gathered in a National Association of Agr. Engineers.

The distribution of these Engineers may be considered as follows:

- Teaching & Research	30%
- Industry	15%
- Governmental service	15%
- Extension	10%
- Farming	10%
- Agr. Organizations	20%

YUGOSLAVIA:

No undergraduate course for Agricultural Engineers is provided. Post-graduate courses at the Faculty of Agriculture as well as research activity in Agr. Engineering enable a person graduate of an university to be qualified in this field. The number of Agr. Engineers is not considered adequate to satisfy the current requirement.

PERCENTAGE DISTRIBUTION OF AGRICULTURAL ENGINEERS ACCORDING TO THEIR FIELD OF ACTIVITY

FIELD OF ACTIVITY	AUSTRIA %	FINLAND %	FRANCE %	GERMANY %	ITALY %	NETHER-LANDS	SWITZER-LAND %
1. Education & Research	30	35	25	20	40	25	30
2. Industry	20	-	20	35	10	20	15
3. Governmental or Public Service	10	15	15	10	5	30	15
4. Consulting & other free professional activity	25	20	10	10	15	15	10
5. Farming	5	5	10	10	-	-	10
6. Agricultural organizations	10	25	20	15	30	10	20

APPENDIX 2

NATIONAL SCHOOL OF AGR. ENGINEERING-PARIS

(France) (Ecole Nationale du Genie Rural- Paris)

Graduate program for M. Sc. in Agricultural Engineering:

FIRST YEAR:

	Class courses (hrs.)	Field or Lab. applications (no.)
- Complements of Mathematics (*)	23	10
- Agronomy	30	12
- Strength of Materials	31	8
- General Hydraulics	36	19
- Applied Hydraulics	24	11
- Surveying	23	16
- Electrical Engineering (fundamental)	15	10
- Electrical Engineering (application)	10	9
- General Geology	16	7
- Applied Geology	24	7
- Thermodynamics	8	5
- Metallurgy I	16	2
- Wood Technology	6	4

* Not required for students graduated at the polytechnic School.

	Class Courses	Field or Lab. applications
- Materials & Building Technique	19	10
- Architecture & Technical Drawing	6	10
- Concrete construction	9	3
- Rural Roads & Land levelling	16	4
- Rural and Administrative law	22	1

SECOND YEAR:

A) Common study period (1st semester);

- Water supply and disposal	13	2
- Water analysis	4	1
- Farm Machinery	27	13
- Heat engines	15	6
- Machine design I	11	16
- Mechanism Technology I	15	2
- Farm Structures	12	4
- Farm management	6	-

B) Differentiated study period(2nd semester):

B. 1. Option: Rural territory equipment:

- River Hydraulics	15	1
- Land consolidation	8	1
- Heat & Mass transfer	24	4
- Refrigerant technology	9	6
- Cold storage principles for vegetal & animal produce	10	1
- Cooling system design	18	2
- Environmental control for cold storage	7	7
- Agricultural products processing plants	27	7
- Agr. Engineering service legislation	12	-
-Administrative practice	10	-

B. 2. Option: Agricultural Mechanization:

- Metallurgy II	14	3
- Mechanism Technology II	14	5
- Machine design	11	25
- Strength of materials applied to Farm Machinery	10	1
- Use & repair of farm machinery	-	10

B. 3. Option: Hydrology:

- River hydraulics	15	1
- Heat & Mass transfer	24	4
- Applied hydrology in arid, semi-arid & tropical regions	8	-
- Geology in arid,semi-arid& tropical regions	-	4
- Agricultural Engineering Service legislation	12	-
- Administrative practice	10	-

INTERNATIONAL CENTER FOR ADVANCED MEDITERRANEAN AGRONOMIC STUDIES

MEDITERRANEAN AGRONOMIC INSTITUTE OF BARI_ITALY

Graduate Curriculum for training of "Land Use, Rural Infra-structures & Equipment".

	Lectures (Hrs.)	Field or Lab. application (No.)
1. Preparatory cycle (12 weeks)		
(a) Features of the Mediterranean Agriculture	18	-
(b) Modern trends of agricultural production	22	6
(c) Basic training		
- Fundamentals of applied hydraulics	20	14
- Cartography & photo-interpretation	12	6
- Applied economics & linear programming	22	15
- Applied statistics	15	8
- Climatology & rainfall analysis	13	10
- Water-soil-plant relationship	16	12
2. Fundamental cycle (16 weeks)		
(a) Department: Soil Reclamation & Conservation.		
- Erosion control & soil conservation	10	4
-Watershed protection	12	5
-Land reclamation & drainage	16	6
- Saline soil correction & use	8	2
- Land reclamation or soil conservation project	-	1
(b) Department: Irrigation.		
- Planning water utilization	6	1
- Irrigation water requirements	10	4
- Irrigation water supply	8	3
- Methods of irrigation	12	4
- Irrigation structures design	16	6
- Irrigation equipment	10	4
- Organization of collective irrigation	8	6
- Farm irrigation design	-	1
(c) Department: Rural equipment.		
Planned Rural Settlement	12	2
- Improvement of existing settlements	4	1
- Service & community centers	8	2
- Rural territory infrastructures	14	2
- Farm buildings & equipment	10	4
- Agr. machinery service centers	8	2
- Farm power requirements	6	-
- Planning facilities for packing & storing agricultural products	6	2
- Cold storages for fruit & vegetables	10	-
- Rural settlement design	-	1
(d) Department: Coordination and Planning.		
- Regional planning	14	6
- Physical plans coordination	6	2

	Lectures (hrs.)	Field or Lab. application (No.)
- Development bodies & cooperation	10	-
- Intellectual investments for Agr. development	6	2

3. Application cycle (18 weeks)

- Study and preparation of a thesis on a subject to be chosen by the candidate.

Theme 2:

17. THE DEVELOPMENT OF AGRICULTURAL ENGINEERING IN THE UNITED KINGDOM by P. C. J. Payne, Principal National College of Agricultural Engineering, Silsoe, Bedford, England.

Early Endeavours.

As in most other countries, the first step in what we would now call Agricultural Engineering were made by farmers endeavoring to achieve more with a given amount of physical effort. These men would certainly not have described themselves as Agricultural Engineers and yet they discovered many of the basic mechanisms we now use. It is impossible to say when all this started, but one of the most dramatic steps forward was taken by Jethro Tull when he published his book "Horse Hoeing Husbandry" in 1733, in which he described both the wide hopper drill more or less as we now know it, and the technique of dragging L and A blades down the space between crop rows in such a way that most of the weed control could be achieved with infinitesimal effort compared with the hand weeding that had previously been necessary.

This development paved the way to being able to fatten beasts during the season when they would otherwise have been slaughtered for want of maintenance rations and many would say that without the increase of winter food production this made possible the British industrial revolution, which had so many repercussions throughout the world, could not have taken place.

Preserved on the author's family farm is a wooden drill with both seed and fertilizer box in all essentials similar to the modern combine drill. This implement cannot be dated correctly, but it is not less than 100 years old and the fertilizer used was wood-ash.

In a paper presented to the American Association for the Advancement of Science last December, Dr. Roy Bainer pointed out that Moore's combine harvester was available in Michigan only five years after McCormick had introduced his repaer in 1831. It is forgivable to feel that nothing really new is ever invented, but only re-invented.

Development of an Industry.

Though invented by farmers, most of these early machines were of course made by local blacksmiths, wheelwrights and carpenters. The first organizations that could be properly described as "manufacturers" of farm machinery, started in the early 1800's in the U.K. Ransomes Sims & Jefferies Ltd. and John Fowler Ltd. probably represent the best-known of these companies still in business. Robert Ransome founded his company with his invention in 1803 of the chilled cast iron ploughshare. The cylinder and shear plate principle of mowing grass is also attributed to this company. By the middle of the century, John Fowler had developed the steel hawser, still known as the plough-rope, to the point where he could use a pair of steam engines to haul a plough from one end of a field to the other and back again.

In Britain today there are about 300 Agricultural Engineering companies, many of them dating back a century or more, though it was not until the end of the second world war that the industry developed to a point where it could make a significant contribution to exports. Tractors exported from Britain now exceed those of any other country and much of the credit for this must be given to Harry Ferguson, an Irishman, whose inventive genius, business skill and world-embracing outlook gave rise to the three-point linkage with hydraulic draft control, and brought about the formation of the Massey-Ferguson Company.

Up to the beginning of the second world war the title "agricultural engineer" was only applied to farm machinery dealers and maintenance engineers, most of whose business had derived from blacksmiths' and wheelwrights' shops. Since then the term has changed its use to be applied to manufacturers of farm machinery who now employ a total labour force approaching 60,000. Very few (probably about 1%) of those employed in the industry would yet describe themselves as agricultural engineers.

Concept of a Profession.

The history of professional engineering institutions in Britain has been one of good springing out of bigotry. The Institution of Mechanical Engineers is reputed to have been formed as a break-away group because the Institution of Civil Engineers could not see their way to accept James Watt, of steam engine fame, as a qualified engineer. The Institution of Electrical Engineers is reputed to have been formed because the Mechanicals could not see Faraday as a qualified engineer. Likewise, the Institution of Agricultural Engineers was founded in 1938 by Col. Philip Johnson, Director of tank research during the first world war, because he could not obtain adequate support from the senior institutions for a separate group to deal with the problems of agriculture. The U.S.A. has always been quicker than the U.K. to recognize new technologies as "respectable" and Agricultural Engineering is no exception. The American Society of Agricultural Engineers was founded as early as 1907.

It is not surprising that during the war years the Institution of Agricultural Engineers could do little more than maintain its identity, but since 1945 it has gained strength rapidly and in 1961 was granted the status of an Incorporated Company, limited by guarantee. In Britain this is the first step along the road to respectability, but even today it has not been granted the fully chartered status of the older institutions- Mechanical, Civil, etc.

If it is any comfort to Peruvian agricultural engineers, let it be said that difficulties breed vigour and the I. Agr. E. in Britain more than makes up for its youthfulness and lack of official status, by its drive and single-mindedness. At present it has a total membership of 2,500 , some 25% of whom are full corporate members.

It is necessary to understand that in the U.K. an important distinction is drawn between theoretical training and professional qualification. A university degree is an appropriate branch of engineering is normally taken to meet the theoretical requirements for corporate membership of the professional engineering institutions, and such graduates can obtain the status of "Graduate" within the institution. This classification of member is outside the corporate grouping, but generally- though not always- denotes a man who is on his way to fulfilling his requirements for corporate membership. Most institutions including the I. Agr. E. require two years further training in a probationary grade in industry and the programme which the employer must fulfill for his Graduate Apprentice, as he is called, is carefully laid down. After this, he requires a further minimum period of 2 years in a position of junior responsibility in order to be accepted as a full corporate member, denoted by the title "Member", or for engineers usually well into their 40's and near the top of their profession, "Fellow". It is not until the status of Member is achieved that the engineer can properly describe himself as a professional engineer.

While the precise requirements used in Britain would probably be inapplicable in Peru, in the author's view, it is important to distinguish between the raw graduate and the engineer who has had at least 4 years suitable experience of the work he is to undertake as a professional during the rest of his life.

Research and Testing.

Undoubtedly, the most important influence in developing Agricultural Engineering into a co-ordinated discipline, was the foundation in 1924 of what was then known as The Institute for Research in Agricultural Engineering and is now better known as the National Institute of Agricultural Engineering. In its early days this organization consisted of a small group of enthusiasts who laid the foundation stones upon which much of modern British Agricultural Engineering is based. The Institute had to put on somewhat different clothes during the war when it was moved to Yorkshire, and concentrated upon the testing of machines for the allocation of priorities and the education and training of a new army of farm workers, mostly women.

Since the war it has been moved to its permanent home at Silsoe, in Bedforshire, and has grown until it now has a staff of about 400 and concentrates upon longer-term investigations of engineering problems in agriculture and horticulture, though still retaining a role as an official testing station.

The N.I.A.E. also have a branch in Scotland to deal with the special problems of different conditions in the extremities of the country.

Incidentally, it may be interesting to note that one of the criteria used in choosing Silsoe as the site for the N.I.A.E.'s headquarters was that there are at least four contrasting soil types available within three miles, and a sandy loam and a clay juxtaposed within its grounds.

Specialist Educational Facilities.

University degrees in Agriculture were first offered in Britain during the 19th century and quite early on, most programmes included a subject termed "Agricultural Engineering" though today we should describe this designation as a misnomer since it really involved farm mechanization. Until the 1940's, most syllabuses included what now sounds like an uninspired approach. That is, words to the effect - "construction, adjustment and choice of farm machinery."

Little attempt was made to integrate this knowledge with the teaching of the husbandries and there was a strong tendency for lectures to consist of a catalogue of points to be considered under classifications such as tractors, cultivation machinery, harvesting machinery. Now-a-days, the pattern has changed so that the mechanization teaching takes place under better-integrated headings such as, crop production, stock production and mechanization feasibility analysis. These programmes are only concerned, however, with assisting Agriculturalists in understanding enough about machinery and mechanization to apply it efficiently, and are not concerned with turning out specialist Agricultural Engineers.

It was not until 1947 that the first attempt to provide specialist courses in Agricultural Engineering was made with the setting up of a Graduate School at King's College, Newcastle. At that time, Kings College was part of the University of Durham, but now has its own Royal Charter and is known as The University of Newcastle. This programme led to the degree of Master of Science and was available in two forms; the one planned to provide an engineering knowledge for Agriculturalists, and the other to provide an agricultural knowledge for Engineers.

The courses were of two years duration and represented one of the earliest departures in British education, in that they included a considerable component of taught work, whereas before that, almost all Master's degrees had been awarded as the result of the submission of a thesis following two years of full-time research work.

Credit for setting the pattern of British specialist Agricultural Engineering education must go to Newcastle, though numbers have remained very small- 7 to 10 per annum, and the spectrum covered did not include much outside the field of Power and Machinery. In spite of the small size of the Department, Newcastle's reputation for its research in the field of soil/terrain/ vehicle mechanics is world-wide, and it has made some notable contributions in the field of grain drying.

The British educational system has always drawn a greater distinction between levels of technical education than is common in most other parts of the world. These levels are generally now-a-days defined as technologist or graduate level, technician or diplomate level, craftsman level. Nescastle having made provision for an elite few at the technologist level, I. Agr. E. realized that there was a need for a much larger number at technician level and in 1950 sponsored courses leading to a qualification known as The National Diploma in Agricultural Engineering. Numbers taking these courses have grown consistently- from 8 or 10 in the early years, to the mid-30's four or five years ago, and the high 40's today.

Still later, the City and Guilds of London Institute, who sponsor most craft and junior technician level courses in Britain, realized that the service industries in particular required special training for farm machinery, and in 1955 inaugurated courses for operators, mechanics and fitters. Currently, between 600 and 700 take the mechanics course and almost 200 carry on to the highest level on these courses.

Having sampled men with specialist training, the industry began to press for greater numbers of technologists, and by 1960 it persuaded the Government to establish the National College of Agricultural Engineering. This College was built at Silsoe to be near the N.I.A.E.* and currently enrolls about 50 candidates per annum for the Bachelor of Science in Agricultural Engineering, and 25 to 30 per annum for graduate qualifications. It is the first educational establishment in Britain to provide courses in the full spectrum of Agricultural Engineering as defined on a world-wide scale. It embraces four Departments, viz:

Machine Design (Power and Machinery)
Field Engineering (Soil and Water)
Environmental Control (Structures and Processing)
and Mechanization (The Economic and Technical application of machinery in agriculture and horticulture).

Graduates from this College, plus a smaller number from Newcastle, now form a steady stream of top level professional engineers for the industry both at home and abroad. They already hold some really senior positions and are doing much to establish the image of agricultural engineering as being equally important as, though smaller numerically than, the long-established branches of Mechanical, Civil and Electrical Engineering.

Recommendation.

That some professional Body, appropriate to Peruvian conditions, be set up both to provide a means of accrediting courses and to lay down criteria for accepting graduates of these courses into the profession when they have completed a period of practical training in their chosen area. These criteria would have to be much more flexible in a developing country than in highly industrialized countries.

* National Institute of Agricultural Engineering.

Theme 3. THE SCOPE OF AGRICULTURAL ENGINEERING PROGRAMMES TO SERVE LATIN AMERICA.

18. THE POTENTIAL OF UNDP80- GRADUATE STUDY IN AGRICULTURAL ENGINEERING TO SERVE LATIN AMERICA

by H.M. Lapp, Local Programme Head, UNDP 80, Project , Agrarian University, La Molina, Lima-Peru.

1. INTRODUCTION.

Agricultural Engineering is the application of Engineering Science to solve problems related to Agricultural production, and improving rural living standards. Agricultural products are used to produce food, feed and fibre for all mankind. The profession has the purpose of serving the agricultural industry and in fulfillment of this worthy objective involves engagement in the related specializations of Soil and Water; Farm Power and Machinery; Farm Structures and Rural Planning; and Agricultural Products Processing.

The National Agrarian University in La Molina recognized the need for training Agricultural Engineers at the beginning of the current decade. A corner stone was laid in 1960 when the Institute of Agricultural Engineering became a Faculty of Agricultural Engineering. The developments through the sixties have been notable. In 1961, the United Nation's Special Fund, with the Food and Agricultural Organization as executing agent, UNDP 40 gave assistance to the National Agrarian University over a 5 year period. This assistance provided was utilized for engagement of International Professional Staff and consultants to purchase teaching equipment, to buy books and to sponsor fellowships in a staff training programme.

The University with assistance from additional Agencies embarked on an institutional building programme which resulted in the planning and construction of a new University Campus at La Molina. The new campus is in various stages of completion which provides adequate and modern laboratory and office accommodation for agricultural engineering totalling 7600 square meters of area. Physical accommodations provided would be much appreciated by agricultural engineers anywhere and is probably unsurpassed in its class throughout Latin America.

Student enrollment in the programme advanced from 87 in 1962, to over 500 in 1968, while academic staff grew from 15 to near 50 in the same interval. A commendable staff training plan to prepare staff members for graduate level work has been adopted and is being implemented. A number of staff members have returned to the Programme holding advanced degrees from abroad and seventeen academic staff members are currently away from La Molina studying in pursuit of advanced degrees.

The National Agrarian University made available approximately one million dollars fro staff salaries, facilities and equipment while the United Nations Special Fund provided finances totalling approximately 3/4 million dollars to assist with the 5 year development programme.

2. UNITED NATIONS DEVELOPMENT PROGRAMME/ SPECIAL FUND 80.

As the undergraduate project began to develop, a programme to initiate and develop Graduate Level Agricultural Engineering Education and Associated Research within the National Agrarian University at La Molina was undertaken by the Inter-American Institute of the Organization of American States. The project is part of the Institute's programme to develop and strengthen Institutes offering Graduate Level Education in Latin America.

The United Nations Special Fund for development joined with the Institute in 1963 to assist with the Development Programme. The Food and Agricultural Organization was appointed as the executing agent on behalf of the Special Fund and the programme was identified as the UNDP/SF 80.

The Andean Zone Programme of UNDP 80, to initiate and develop Graduate Agricultural Engineering Education and Associated Research has an operating term extending through December 31, 1970.

The Special Fund contribution of approximately 1/2 million dollars, is designated to engage professional personnel and consultants, to purchase books and equipment and to make a limited number of staff training fellowships available. Four fellows from the staff of the programme have been selected in recent months and it is expected that they will begin graduate study programmes away from La Molina by or previous to the beginning of September.

The two International Organizations and the National Agrarian University are joint sponsors of the development. Objectives of the project are:

1. To initiate and develop Graduate Education and Research in Agricultural Engineering within the National Agrarian University of Peru in La Molina.

2. To conduct the programme to serve the Latin American Region in co-operation with the Inter-American Institute of Agricultural Sciences.

3. To assist the Institute (IICA), in its efforts to strengthen programmes of graduate teaching and Research throughout Latin America.

3. ELEMENTS OF THE PROGRAMME AND PROGRESS TOWARDS THEIR ATTAINMENT.

Graduate study and research in Agricultural Engineering as in other professional disciplines includes the availability and utilization of qualified teaching and research staff; graduate level courses; classroom and laboratory space; teaching and research equipment; library facilities complete with reference books; students and financial resources.

Staff.

La Molina has engaged in a commendable programme to upgrade the academic level of its teaching personnel. A complement of 46 professors, 39 full time and 7 part time are engaged in academic work.

A number of members in position hold advanced degrees, 17 members are currently engaged in advanced study and 4 additional members sponsored by UNDP 80 Fellowships are scheduled to leave this month in pursuit of advanced degrees, and one will study in Colombia. This potential availability of graduate training in Agricultural Engineering within Latin America marks tangible progress in the profession of Agricultural Engineering on the continent. The acquisition of qualified staff is a major requirement in the advance toward graduate level teaching.

Graduate Level Courses.

Require prerequisite knowledge in the subject area in order that more intensive study and applications of science to the solution of problems can be engaged. Courses in this category must be carefully selected and developed to meet the needs of students and the region with unnecessary duplication in a programme.

Space.

The availability of classrooms and laboratory space is essential for the advance of Agricultural Engineering. La Molina is fortunate to have approximately 6000 square meters devoted to laboratory accommodation with space allocated to the four specializations of Power and Machinery, Soil and Water, Farm Structures and Rural Planning and Agricultural Products Processing. An additional 1600 square meters have been provided for staff accommodation. The estimated cost to provide this space is $380,000.00 based on a unit of $50.00 per square meter.

Classroom accommodation is presently inadequate, however, the need will be met in space which has been provided for in the new campus development.

Equipment.

UNDP 80 will assist the programme with funds totalling $75,000.00 to purchase laboratory and field research equipment in approximately equal proportions.

Library and Books.

The National Agrarian University has erected a fine new library with capacity for an excess of 500,000 reference volumes. UNDP 80 will contribute $10,000 dollars to purchase reference books and periodicals for Agricultural Engineering.

Financial Resources.

Attention has been drawn to some of the costs in providing elements for Graduate Study Programmes, first to illustrate the large capital expenditures required, and secondly to indicate the investment in staff training, physical facilities and equipment which has been placed into Agricultural Engineering at La Molina. From 1961 to present financial resources from all sources in excess of 2 million dollars have been made available to support the development of Agricultural Engineering in the Agrarian University.

4. IMPLEMENTATION OF THE PROGRAMME.

4.1. The Graduate School Division in the National Agrarian University requires that students complete 36 semester credit hours; 30 in the major and 6 in complimentary study to qualify for the Master's degree. Of the 30 credits in the major field, 6 are allocated to research, one to language translation, one to thesis examination and 22 to courses selected in the programme of studies.

Personnel engaged in the UNDP 80 programme are satisfied that a good Master's degree in Agricultural Engineering can be within the framework of the Graduate School Regulations of the National Agrarian University and within the complement of graduate credit requirements.

4.2. Programme Consultants which includes Dr. C.W. Hall, as General Education Consultant, have been engaged. Dr. C.W. Hall, Dr. R.G. Yeck, Prof. J.E. Christiansen and Prof. Ricci visited the project in 1968. They are present now on a return visit and are joined by Professors R. Bainer, E.W. Wiser and H.F. McColly. All these gentlemen have or will be participating in this panel and will continue following to complete their consultantships.

4.3. Graduate study programmes must be designed with flexibility to meet the desires and needs of individual students and at the same time include course content which will assist in finding solutions to regional problems of concern to individual students.

4.4. Programmes such as UNDP 80 which are designated to assist developing regions must emphasize applied research. Problems selected, in so far as possible, should engage field studies outside of the laboratory.

Students should also be encouraged to select problems which will have applications in the region of their prospective employment.

4.5. Normally students aspiring to graduate study advance from a recognized undergraduate study programme in the same study field. A problem, of major concern, exists in Latin America in that only Peru and Colombia have study programmes leading to the bachelor degree in Agricultural Engineering. Many students from the region outside of the programmes in Peru and Colombia may wish to enter the graduate programme in La Molina. The critical concern is that such students do not have the basic engineering training which is normally expected of students desiring to enter graduate study in Agricultural Engineering. Pre-requisite requirements which may be specified for such students may readily add one extra year or more to the time required for a student's programme to lead to the Master's degree. Graduates from engineering schools may be deficient in biological sciences and may also be required to complete additional pre-requisites. It is probable that engineering graduates will normally require less pre-requisite training in view of having completed a greater complement of basic engineering.

Attention must be directed during the development of all graduate training programmes to the admission requirements to ensure that the Master's Graduate will receive training to the desired level of proficiency.

4.6. This panel sponsored by UNDP 80 in co-operation with the National Agrarian University is one activity to fulfill the Institute's objective to strengthen programmes of Graduate Study and Research throughout Latin America .Highly qualified professionals in the field of Agricultural Engineering from many countries have been assembled here in company with colleagues from Latin America to devote serious attention to agricultural engineering needs in the region. It is our charge now to examine thoroughly ways and means in which Agricultural Engineering can serve the development of Agricultural Engineering throughout Latin America. Evolution of recommendations which can be feasibly implemented to increase agricultural production and to improve rural living standards will be a satisfying reward for the efforts and expenditure on behalf of the sponsors.

4.7. There is a desire that students from many countries in the region will avail themselves of the opportunity to utilize the course offerings available in La Molina together with the physical accommodation and equipment which has been made available to the programme. Student fellowships are needed which will permit students from all areas of the region to study in La Molina. Countires in the continent might well consider the sponsorship of such fellowships and the services of the Inter-American Institute of Agricultural Sciences is available to assist in the realization of this objective. The institute currently has a limited number of such fellowships available.

4.8. Research funds are also desired to stimulate students interest, initiative and innovation to seek meaningful solution to problems of the region.

5. THE POTENTIAL.

5.1. Basic to man's search for methods of improving his living standards is first the need to maintain and increase the amount of food being produced from any given land area and, second to seek ways and means of increasing the area available to produce food.

It is a one to one correspondence that as population increases the demand for food increases. An agricultural engineer is concemed, as are many other professionals as to how this relationship is to be maintained. The means of improving living standards through agricultural production must be examined.

5.1.1. Educational advance is perhaps the most important improvement to be made. The most immediate results in better production throughout the world are being obtained by the establishment and improvement of agricultural extension services. The first task is to disseminate any degree of knowledge at our disposal to the people who actually grow crops and raise livestock. It is important to emphasize that extension is a 2-way communication and in this cycle production problems are referenced to the research worker presenting the challenge to seek new solutions.

5.1.2. Water. All plant and animal regimes could not exist without water. The order of importance of water control is dictated by climatic factors and controls of the region. Control activities include irrigation schemes, soil conservation, water conservation and land drainage. Priorities must be set parallel to the needs of the region.

5.1.3. Fertilizers must be given high priority in maintaining and increasing agricultural production from low fertility level soils.

5.1.4. Efficient processing methods together with adequate distribution and marketing facilities must be available to avoid limitations to the quantity or to the quality of products. Feed processing plants, rice mills, jute plants, fertilizer manufactures, seed cleaning plants and many others are necessary.

5.1.5. Land settlement and development schemes frequently open up new areas for development and reclaim abandoned regions. Such schemes frequently include provision or improvement of roads, water supply, sanitation, electric power, planning, and holdings in general.

5.1.6. Mechanization plays a part to a varying degree in one or all of the other means of improving production. It may be the only means of establishing production in a new area and can be used to increase production in a well established area.

Agricultural engineering has a place to serve all general methods available to improve agricultural production. The potential of agricultural engineering is only limited by the availability of trained professional manpower, financial resources and the problems presented.

5.2. The Programme in La Molina can become a center where students from many countries can come. Sponsoring agents should think in terms of Latin America and the world, during the development of the programme. In commencement stages various countries in the region cannot singly afford, with or without OAS-IICA and UN-FAO assistance, to provide physical facilities, train staff, purchase equipment, provide a library and make available course offerings from outside of the engineering sphere, in the short run. The development of a programme, centered in La Molina, to serve the Latin American region is sound, it should be encouraged and supported in order to realize its potential benefit to the region.

5.3. Availability of graduate study in La Molina offers a potential for students from region countries to engage in higher study without, first, overcoming the formidable barrier of mastering a foreign language to understand the teaching offered in an institution.

5.4. Improvement of Agriculture in a developing region offers many opportunities for service by agricultural engineering, including: Soil and Water; Mechanization; reduction of hazards; use of chemical for insect and weed control storage; processing and retention of farm product quality; improved sanitation; and promoting a more enjoyable and satisfying life.

5.5. Agricultural Engineering developed to maturity involves extension activity, undergraduate and graduate teaching and research. It can serve urban and rural communities which in all can play an important part in advancing living standards in the entire Latin American Continent.

6. SUMMARY.

The initiation of a programme to engage undergraduate and graduate teaching and research in all areas of Agricultural Engineering at La Molina to serve the Latin American Region has been undertaken. The concept, development and support of this bold and purposeful venture is to be commended. Sponsorship by two International Organizations and one National Institution is testimony to the importance and urgency with which the project has been launched.

Commendable progress has been made in acquiring staff facilities and equipment for the programme. A number of staff members have returned to the programme after receiving training abroad, 17 are currently away engaged in higher studies and 4 will begin study fellowships this months. New laboratory area of first class quality totalling 6,000 square meters has been allocated to the programme. This accommodation is without doubt the most superior of its type in Latin America. A good beginning has been made to stock the laboratories with modern teaching and research equipment.

Technical officers have been engaged to work under the co-ordinating office of a Local Programme Head with the objective of advancing the aims of the programme in co-operation with the academic members of the programme.

There is a need for ways and means of sponsoring students into the programme. Regional governments may consider the feasibility of providing such fellowships to avail themselves of the facilities and training offered at La Molina. Efforts should be made to detail programmes of study which will satisfy the individual interests of students and at the same time the needs of their concerned regions.

Agricultural Engineering plays an important role in all methods of improving agricultural production. A unique opportunity has been offered to the National Agrarian University in La Molina to develop graduate study in the profession. Institutions in the region can avail themselves of the potential to utilize staff, facilities and equipment to obtain optimum return for the high capital expenditure already placed in the programme. A challenge of magnitude has been offered. Co-operation, hard work and dedication are required to realize success for the worthy objectives of IICA-UNDP 80, U.A. programme in promoting Agricultural Engineering to serve Agricultural Development in Latin America.

Theme 3:

19. INSTITUTIONAL REQUIREMENTS IN ATTAINING THE CAPACITY TO OFFER PROGRAMS IN AGRICULTURAL ENGINEERING by Roy Bainer, University of California, Davis, California, U.S.A.

Agricultural engineers apply engineering principles to problems of food and fiber production, storage and processing animal and plant environment; agricultural wastes management; soil and water control and conservation; and other phases of agriculture and related industries. Agricultural engineering is unique in that it requires a general understanding and application of the biological, soil-management and environmental aspects of agriculture in addition to a thorough knowledge of basic and applied engineering.

The first requisite for an agricultural engineer is that he have a strong basic education in engineering. Secondly, he must have an understanding of and be able to deal with biological variables.

Institutions offering professional programs in agricultural engineering should have strong offerings in the areas of physical and biological sciences, social sciences and humanities as well as basic courses on which to build a solid engineering foundation.

In addition to the normal courses taken in high school, the student electing to enter a university for a program in agricultural engineering should have courses in algebra, plane geometry, trigonometry, chemistry, physics and mechanical drawing. These subjects are prerequisite to certain courses offered in the first year of an agricultural engineering program.

Experience has shown that university courses in chemistry , mathematics and physics normally offered to students majoring in these areas are suitable for engineering students. Occasionally an advanced course in mathematics for engineers is needed to prepare for basic engineering courses at about the third year level.

The first problem in regard to developing a program in agricultural engineering is an Agrarian University is the lack of staff to teach courses in basic engineering. At La Molina, for example, it was necessary to enlist assistance from the University of Engineering. The courses in question are: statics, dynamics, fluid mechanics, electrical circuits, properties and strength of materials, thermodynamics, and heat and mass transfer. The second problem is developing the staff in agricultural engineering to utilize the knowledge acquired by the students after completing the basic courses. Unless the instruction in machinery can utilize the knowledge the student has acquired in statics and dynamics, there would be no reason for him to take the preparatory courses. The same thing holds true in farm power. The student should be able to utilize what he has learned in thermodynamics. Likewise, in structural courses, the student should apply principles learned in statics and strength of materials. This deficit in teaching ability at La Molina, for example, was corrected to a great extent through a fellowship program that permitted the faculty to study abroad. This , of course, took time. However, during the first five years of FAO-UNSF 40 project, great progress was made at La Molina. There are still a number of staff studying abroad with the result that the staff will be able to present outstanding undergraduate and graduate programs. In this respect, I want to compliment the faculty at La Molina for their determined effort of self-improvement.

Another factor at La Molina was the close cooperation between experts assigned to the project and the counterparts appointed by the University. Furthermore, some of the counterparts had had professional training. The amazing thing to me was the determined effort of the entire staff at La Molina to inform themselves and literally lift themselves by their bootstraps to develop the knowhow to give a high level professional program. Had this not happened, we would not be here today in an effort to develop a graduate program.

One of the chief concerns at an Agrarian University is that courses in the basic physical sciences and mathematics are not taught at a professional level. In other words, there are no majors in these areas. This means that a bridging course in mathematics is necessary. Certain portions of the physics can be augmented with courses in statics and electrical circuits.

Keeping in mind that a professional program in agricultural engineering is basically engineering in nature, typical courses needed during the first two years (lower division) are:

Subject	Semester hours
General chemistry	10
General physics	12
Analytic geometry	2
Calculus	6
Linear algebra	2
Differential equations	2
Vector analysis	2
Introduction to engineering systems	2
Engineering application of computers	2
Statics	3
Surveying	3
Technical drawing	3
Properties of materials	3
Language	3
Public speaking	2
Biology	3
Humanities and social studies	6
Total	66

The above program assumes that the entering student has had high school courses in advanced algebra, trigonometry, chemistry and physics.

The program of the third year (beginning of upper-division) should include basic engineering courses as follows:

Subject	Semester hours
Mathematics for engineers	3
Electric circuits and laboratory	4
Dynamics	3
Fluid mechanics	3
Strength of materials	3
Thermodynamics	4
Heat and mass transfer	4
Engineering principles laboratory	4
Humanities and social studies	6
Total	34

During the final two years, certain required courses are needed to round out the program. The balance should be elective in nature to permit the student to specialize in a field of his interest. Suggested required courses are:

Subject	Semester hours
Farm power	4
Farm machinery	4
Irrigation and drainage	4
Farm structures	4
Agricultural processing	4

Engineering economics	3
Machine design	4
Soils	4
Field crops	3
Technical electives	26
Humanities and social studies	6
Total	66

Suggested technical electives

Advanced surveying	3
Geology	3
Hydrology	3
Water-soil-plant relations	3
Soil conservation	3
Irrigation systems design	3
Rural electrification	3
Rural design	6
Reinforced concrete	3
Rural sanitation	3
Structural analysis	3
Materials handling	3
Refrigeration	3
Dehydration	3
Machinery design	3
Soil mechanics	3
Instrumentation	3
Agricultural meteorology	3
Pest control equipment	3
Rural law	3

A student completing the above program is in an excellent position to enter a career in agricultural engineering. Those having a high scholastic record can continue their education here or abroad if they should choose.

It would appear that it would be impossible for an Agrarian University to develop a high level professional agricultural engineering program in five years. Yet, La Molina succeeded in doing this.

Students desiring to enter a graduate program must have completed, as a minimum, the program outlined above. Otherwise, it will be necessary for them to take a remedial program before doing advanced work. The necessary undergraduate preparatory courses are available at La Molina. It should be pointed out that graduates in chemical, civil, electrical or mechanical engineering at other institutions should be permitted to enter a graduate program in agricultural engineering. Remedial work for them would be at a minimum.

In developing a Master's level program, many institutions in the United States permit the student to include up to 40 or 50% upper- division undergraduate courses. Other suggested courses suitable for a graduate program are:

Developing and evaluating farm machines
Engineering properties of agricultural materials
Soil-machine relations in tillage and traction
Advanced agricultural structures design
Advanced unit operations in agricultural processing
Agricultural waste management
Environmental engineering in agriculture

Water resources engineering
Prestressed concrete
Ground water flow and seepage
Mechanics of open channel flow
Mechanical vibrations
Dynamics of mechanisms
Kinetics of mechanisms
Advanced machine design
Thesis research

The foregoing material covering a program in agricultural engineering is necessary as a base to work from. It is immediately evident that such a program can be best given in a general University that has colleges of Letters and Sciences, Agriculture and Engineering.

Offerings in the College of Letters and Sciences include: Chemistry, botany, mathematics, physics, language, social and humanistic studies.

The College of Engineering is prepared to offer basic engineering courses in statics, dynamics, electric circuits, fluid mechanics, thermodynamics, heat and mass transfer, strength of materials, stress analysis, etc.

Basic courses in agriculture, such as soils, farm crops, livestock production, etc. are offerings available in the College of Agriculture.

The curriculum in agricultural engineering may be administered by either the College of Engineering or the College of Agriculture. In many of the United States instances, the program is the joint responsibility of both colleges. In the author's opinion, the ideal arrangement is for the College of Engineering to administer the academic program and leave the research responsibility to the College of Agriculture. This gives the student the feeling that he is receiving an engineering education. It ensures that the student follows the basic core of courses taken by other engineering students. On the other hand, the location of the research responsibility in the Agricultural Experiment Station of the College of Agriculture gives the staff the feeling of belonging with the group in agricultural research. This is where the problems to be solved by agricultural engineers are located.

Arrangements mentioned above introduce certain problems in most Latin American countries because of existing agricultural structures. For example, universities have the responsibility for teaching whereas research and extension are handled by the Minister of Agriculture. To be most effective, coordination of effort between the University and Ministry is essential. To maintain an up-to-date live program it is desirable to introduce research findings into the instructional program. This can best be done by involving the faculty in a part-time research program.

The structural organization of a university starts at the top with a Governing Board (Board of Regents or Executive Committee) which is fully responsible for the general operation. Actinv under the Board is the Chief Campus Officer (Rector, President or Provost). His council is usually made up of the Deans of the various colleges. Under the Deans come the various department chairmen, and finally the faculty and their supporting staff.

The initiation of a strong program in agricultural engineering depends upon having a strong faculty with a basic engineering education. Lacking this, provision should be made for their further education. This will take time. However, it is essential to the development of an outstanding program.

Laboratory facilities are necessary for handling some subjects. Facilities available to engineering students in connection with courses in electrical circuits, fluid mechanics and strength of materials, etc. are the type needed also by the student in agricultural engineering. In addition, laboratories are needed for courses in farm power, farm machinery and farm structures. A field laboratory is also desirable for operating tractors and machinery during instructional periods.

The development of proper laboratory facilities is quite costly. One way around this might be taken from the experience at the University of California. During the first 25 years of operation of a program in agricultural engineering at Davis, the students spent their first three years in the Engineering College on the Berkeley campus, 70 miles away. Only the fourth year and a graduate program were offered at Davis. When the students arrived at Davis, they had their basic science training including the core of basic engineering courses. The specialization in agricultural engineering plus basic courses in agriculture was limited to the fourth year and to graduate work taken by a limited number of students. Graduates from this program were competitive with students graduating from other institutions. Furthermore, the B.S. graduate from Davis was readily accepted for graduate studies in other institutions.

Accrediting of engineering programs in the United States is done by the Engineering Council for Professional Development (ECDP), under the auspices of the American Society for Engineering Education. When accreditation started in 1934, there were only three programs in agricultural engineering approved. One of these was at the University of California. At the present time, there are around 40 agricultural engineering programs in the U.S. that are accredited. This gives some idea of the strengthening of programs to meet ECDP standards during the past 35 years. This improvement included improved quality of the program as well as the faculty.

As professional programs in agricultural engineering develop in Latin America, consideration should be given to organizing a professional society. The society could sponsor annual meetings for the exchange of ideas and research results. Eventually, the Society might become strong enough to publish a Journal that would be of great value to its membership.

In closing, I would like to state that the most important engineer in the world of the future will be the agricultural engineer. I say this because food production will be the number one problem. As a country develops, more and more of the problems in agriculture have engineering implications. It has been stated that 80% of the agricultural problems in the United States are in this category.

Theme 3.

20. EXPERIENCES IN THE DEVELOPMENT OF AN ACCREDITATION SYSTEM IN THE INSTITUTIONS OF SUPERIOR AGRICULTURAL EDUCATION IN LATIN AMERICA by Carlos Garcés O., Director, Program of Studies for Graduates National University- I.C.A., Bogotá, Colombia.

Background.

The Faculties of Agronomy of Latin-America have been taking interest in a joint action, during this last decade, to raise their administrative and academic level, and have taken a special interest in establishing a system that might enable them to operate within a frame of minimum quality conditions. Since 1958, in which year the First Latin-American Conference of Superior Agricultural Education was held in Santiago, Chile, the Deans of said Faculties have indicated the necessity of having available some mechanism to establish these minimum standards of quality. In later conferences, special importance was given to this project and, when the Latin-American Association of Faculties (ALEAS) was formed, the "establishment of standards and criterions framed within a common system of evaluation and accreditation of a periodical nature at the Institutions of Superior Agricultural Education, in order to stimulate their improvement" was included in the statutes as one of their ends.

It was the duty of the Education Program of the Andean Zone of the IICA, to promote the establishment of the system of institutional accreditation desired, for which it started by supplying to the interested institutions complete information about the same. This was necessary due to the lack of knowledge about the objectives, standards and procedures of the system, in the greater part of the Latin-American countries.

It was our duty therefore, to prepare some of the informative documents that were presented at the Piracicaba Conference (1966) and in later meetings at regional and national levels. More recently, in the national meetings of the Faculties of Superior Agricultural Education held in Peru (1967), Venezuela and Colombia (1969), more complete documents of orientation and procedure of the accreditation have been presented (1).

The System.

The Accreditation is a typically North-American system, developed because of the fact that the Federal Government does not have the responsibility of controlling the education and it therefore corresponds to each state of the union to assume this responsibility. The diversity of educational programs and the notorious differences in their quality, that existed in the United States at the beginning of this century, led distinguished educators of that country to try to put some order in the chaos, and out of their effort arose the first associations of schools and universities, the establishment of the entry examination and, lastly, the accreditation. Basically, the accreditation is a system to check on the academic standards and prevent their degradation. It identifies the institutions that offer programs of high quality and promotes the continuous improvement of the same. Another, not less important purpose, is that of serving as a force of equilibrium between the many pressures being applied continuously against the educational institutions.

According to Selden, "the strongest and most respected institutions turned to accreditation, the American way of control over the academical standards, as a means of ensuring a better education for the people and to protect themselves against the pretentious, impostor and even fraudulent institutions that often called themselves schools or universities". (2)

The accreditation having been established, however, its adoption by the educational institutions was not as general and enthusiastic as might have been thought. It was criticised and fought, as is demonstrated by the case of the schools and universities of New England, where since 1920 it was attempted to establish it, but this was only possible in 1952, against the stubborn opposition of the presidents of some of the most important universities.

From 1930 on, a clamour of resistance arose against the accreditation agencies and the system. John Tigert, President of the University of Florida, criticised the Agencies of Accreditation "because they are too numerous; they invade the rights of the institutions and destroy the institutional liberty; they estimulate uniformity and restrict

* Garcés, C. 1969. Basis and Procedures for the Accreditation of the Superior Agricultural Education in the Andean Zone of IICA, Lima-Perú.

experimentation; they imply excessive costs; they demand too much duplication of efforts; sometimes they take into consideration matters that are foreign to the accreditation and they foster a system of brotherhood or an attitude of syndicate" (Selden- page 72).

This controversy culminated in 1948 with the decision by the American Association of Universities, of ending administrating the accreditation. We will see further on, how in Latin-America the accreditation has encountered criticisms with aspects similar to the ones set forth.

Even today, in the United States, there is confusion, misunderstanding and controversy regarding the system of accreditation. Nevertheless, since 1960, about 80% of the Colleges and Universities were accredited by the duly acknowledged offices of accreditation. These institutions now include over 600 Junior Colleges; 800 Colleges with four-year programs; 450 institutions that offer Master grade and several professional grades or degrees, and more than 200 universities that grant the Doctorate in Philosophy (Ph. D.) in Medicine and other professions.

The basis of the accreditation are the criterions or standards that are established to warrant the quality of the educational program. As this depends on factors such as the capability of the staff of teachers, the administrative system of the institution and its financial capacity, the resources of libraries, the appropriateness of the laboratories, the student services, etc., these factors must be evaluated on the basis of their respective influence upon the quality of the general educational program.

The system starts with the preparation of an exhaustive study of the present conditions of the institution, undertaken by its personnel of teachers and administrators and that covers the examination of its human and material resources, of the objectives pursued, and the strong and weak aspects of the institutions.

This self-study must be made with absolute honesty and with an objective criterion of diagnosis, in order to bring to light the failures in the educational system.

As a result of the self-study, the institution works out a special report, in which are detailed its functioning , administration, educational and financial resources, the student aspect, etc. This report is sent to the Regional Association of Institutions, which sends a group of experts that visit the institutions and evaluate its educational conditions. This group, that has had the opportunity of studying the self-study report, forms an opinion about the adjustment of the same to the conditions of the institution and renders a report to the accreditational entity, that uses it as a basis for determining if it grants the accreditation or not.

Administration.

The administration of the accreditation is undertaken by voluntary organizations, of regional or national character, which do not have legal control over the educational institutions. These accrediting organizations only establish standards of quality or criterions of institutional excellence and approve or admit the requests from institutions that fulfill these standards; the only power that they have is that of making publicly known the lists of the institutions that they have accredited. The inclusion of an institution in the approbatory lists of an accrediting organization, nationally acknowledged, is generally considered as the most significant indication possible about the quality of that institution (3).

These lists serve as guides to the students in choosing the institution where they wish to enter; to the universities and colleges, for the acknowledgement of the transfer courses. For the teachers it is equally important, as the greater part of them wish to work in accredited institutions. Finally, in many professions, the offices (state offices) that grant license for the professional exercise, generally only grant them to persons graduated from institutions whose programs are accredited.

Accreditation of Professional Programs.

Besides the institutional accreditation, there exists in the United States the accreditation of profession-

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(2) Selden, W.K. Accreditation. Harper and Brothers. N.Y. 138 pp.

(3) National Commission on Accrediting Maintenance of Academic Standards Through Accreditation in the U.S.

al programs, administrated by the respective professional organizations. This type of accreditation was established as a means of protecting the public against the professional incompetence. The American Medical Association initiated it in 1906, and at present it comprises around 30 fields of professional activity. This accreditation, as the institutional one, is voluntary and follows the same procedure standards. It has had a great influence in the improvement of the professional careers and in the development of investigation.

Nevertheless, it has also been one of the most discussed practices, due to the influence it can reach for the benefit of some institutions and in prejudice of others.

On the other hand, the accreditation of Programs, separately from the institutional accreditation, has been strengthened because in one and the same institution may be found programs with very different standards.

The Accreditation in other Countries.

With relation to the adoption of the accreditation in other countries, Selden points out that after the Second World War, by influence of the United States, Japan and the Philippines introduced the system in their universities, not without there arising criticisms about the convenience of transplanting a typically Northamerican activity to countries whose cultural heritage and traditions were so notoriously different from those of the United States.

In Latin-America, only the Technological Institute of Monterrey, Mexico, has introduced it, having associated to the Southern Association of Colleges and Universities of the United States. It exists also, in some schools of secondary education in several Southamerican countries, where the children of North-American embassy executives and special organizations study.

In Colombia, a mission contracted to study the university situation and prepare a basic plan for the superior Colombian education, presented in its report to the Colombian Association of Universities, recommendations for the establishment at the National University, of the system of accreditation as an instrument for the improvement of the superior education in the country (4).

The recommendations cover not only the institutional accreditation, but also the accreditation of professional programs. The document was studied by several persons from the various universities of the country , and received frankly unfavorable comments, many of which are notoriously similar to those made in the United States. We indicate some examples:

"The word introduced to the Colombian universitary structure, accreditation makes us think of a variation of inspection and vigilance".

"The unification of texts, programs, nomenclature, etc, is advocated, that is to say, the educational standardization analogous to that which has given "so very fine results" in the Baccalaureate".

"All the universities (Colombian) , by the sole fact of existing, fighting against everything and everyone, must wait with resignation for a visiting commission to order them if they are to continue or not and how they will continue to do it".

" The system of accreditation seriously injures universitary principles, it is obligatory, it is unique, it removes all capacity of election within the compulsion, it is extrauniversitary, it vulnerates autonomy (5)".

This adverse reaction to the accreditation is due, in our opinion, to the lack of previous information in the country about the true nature of the system and about its administration. On the other hand, the mentioned report unfortunately does not present in the best way the philosophy of the accreditation, nor does it explain sufficiently the process of administration.

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(4) Felix, G.C. 1967, Normas y Acreditación, Bogotá, Colombia.

(5) National University of Colombia. Basic Plan of Superior Education. "Critical Analysis". Jan. 21, 1969.

The Accreditation of Institutions of Superior Agricultural Education in Latin America.

The Program of Superior Agricultural Education of the Andean Zone of the IICA, has been promoting among the Faculties of Superior Agricultural Education, in Colombia as well as in the other countries of the Andean Zone, the adoption of the accreditation as an efficient instrument for the constant improvement of the institutions.

In these countries, in the last years, several Faculties of Agronomy have been established, whose resources in teachers, laboratories and physical facilities are notoriously scarce. These deficiencies have carried with them, as a consequence, a disparity in the academic level of the programs and in their orientation. The competence to present attractive programs is leading to the spreading of offers of study plans for the development of which, in most cases, the necessary resources are not available. The interest of the institutions to search for the collaboration among them is little apparent, and every day it is more necessary to adopt measures tending to look for a stable organization in the agricultural education and to remedy the institutional deficiencies.

We are, as can be seen, in conditions similar to those that led to the establishment of the accreditation in the United States, without the way in sight in which the agencies external to the same institutions may intervene in order to modify the existing conditions and satisfy the demands of the superior agricultural education.

It corresponds, therefore, to the institutions themselves to establish a stable cooperation and search within themselves for the resources and the experience that are needed to fulfill the objectives and purposes. The institutional accreditation appears as the most indicated system for achieving the necessary changes and this is the reason for the promotion that the IICA has done, for our institutions to adopt them. As an initial measure, and as it is necessary for the accreditation to function in a joint action, it was necessary to promote the creation of national associations of the institutions of superior agricultural education. This initiative has had acceptable success, there already existing duly organized associations in Peru, Ecuador, Colombia and Venezuela.

It corresponds to the National Associations to establish the standards of quality, based on a just appreciation of the existing human and material resources and on the objective definition of the educational levels which it is desired to reach. The setting of the academic standards is one of the critical points in the establishment of the accreditation in our Latin-American countries. The great difference between the national institutions, in their states of organization and development as well as in resources and facilities, makes it necessary to have a high dose of spirit of collaboration and of collective interest for the common development, and the elimination of many distrusts and misgivings, natural if it is taken into account that the most common among our institutions is the egocentrism and the isolationism.

The Self-Study.

The self-study that, as was pointed out, is the first step in the accreditation, is being undertaken by the Faculties of Superior Agricultural Education of the Andean Zone (Colombia, Peru, Ecuador and Venezuela).

In Bolivia the accreditation has received less attention, possibly because until a short time ago there was only one Faculty of Agronomy. Recently, another Faculty of Agronomy and Forestry Engineering has been established, but it can be expected that several years will pass before any interest for the accreditation is seen in these institutions.

The Education Program of the IICA has put special interest in promoting the self-study of the faculty of agronomy. It is considered very important that these institutions analyze carefully the conditions in which they are operating and that they realize their limitations and possibilities. They can thus reevaluate their objectives and use their resources adequately. For this, the Program has prepared a document that will serve them as guide or manual and that has been turned over to them recently. This manual has been elaborated according to the standards and procedures of the Southern Association of Colleges and Universities of the United States, with some necessary modifications.

The associations of Colombia and Venezuela have received the project with interest and have set for the coming month of August, the date of termination of the self-study of their respective faculties. Once this stage has been fulfilled, they will proceed to study the implantation of the accreditation, establishing the standards of quality and procedures to administrate the system.

Problems for the Accreditation in Latin-America.

a) The Autonomy.

When the first informative document about the accreditation system was presented in Piracicaba (1966) at the Third Meeting of Superior Agricultural Education of Latin-America, it could be seen that there was an attitude of resistance on the part of several deans, based on the concept that it would interfere with the universitary autonomy. The concept of autonomy is very deeply set in the universitary spirit and it is defended zealously, despite the reality of its existence being discussed. The practice of the periodical visits to the institutions, by visiting committees to evaluate the resources of the same and the quality of their educational programs, was considered as a violation of that autonomy.

It is possible that in some institutions this attitude is only a defensive reaction to avoid having to show before strangers the deficiencies and prpblems derived from a deficient administration or the fear that the precarious conditions of the institution be made known.

To vanish these fears and obtain that the institutions accept voluntarily the critical examination of their situation, is one of the initial tasks that must be undertaken to bring along the accreditation.

b) The Inexperience in Evaluation.

When the system of accreditation is initiated in Latin-America, one stumbles upon the lack of experience in the evaluation of the institutional characteristics. In the United States, until a short time ago, this evaluation was based on a quantitative system, that has been replaced by the qualitative one.

The evaluation, quantitative as well as qualitative, is conceptual and therefore subject to error. Therefore, when there is no experience among the educators in determining differences in levels of institutional quality, a numerical basis gives a better orientation to the evaluator and enables the setting of an evaluation pattern sooner. For these reasons, it has been recommended in our institutions to adopt initially the quantitative pattern, pointing out that once the accreditation is under way, and when a considerable group of educators with experience in evaluation has been prepared, the quantitative criterion be changed for the qualitative one.

The evaluating equipment is another of the key aspects of the accreditation, and therefore, one of the most discussed. Considerable experience in the handling of educational institutions and programs is needed, aside the developed capacity for analysis and lack of prejudices, in order to do just evaluation. Besides, the relatively short time available to the visiting committee to undertake the evaluation and the difference of individual criterions, increase the possibilities of error.

It is easy to verify, doing a small poll among educators that have not had previous experience in the evaluation of institutions and programs, the difference of criterions in assigning values to the different institutional aspects. Therefore when the accreditation is established in our countries, it will be necessary to give special attention to this phase of the system, preparing previously, and in accordance with a training program carefully thought out, the greatest possible number of evaluators, selected in the different national institutions. Nevertheless, it should not be tried to create an hom.. group for the production of standardized evaluations. This would be as harmful as the disparity of concepts between them.

c) The Standards of Quality.

The institutions that because of their recent creation or because of the lack of human or material resources have not yet been able to organize programs that can compete without disadvantage with those of the faculties of greater prestige, are afraid that the establishment of the standards of quality will lend itself to maneuvers to place them in a disadvantageous situation. The establishment of standards is at such a high level that these institutions cannot keep up with them, or attain them, even within a moderate period of time could not be achieved. This attitude of misgiving must be eliminated as it destroys the confidence in the system. In the documents of informative nature, that have been delivered to the faculties about accreditation, it has been stressed that one of the principal objectives pursued by it, is the promotion of the improvement of the institutions and their programs and that it cannot be used as a coercive instrument against the weak institutions. It has been made clear also, that the accreditation leads to the elimination only when the institutions make no efforts to improve, in which case they perish due to their own incapacity to progress.

d) The Administration of the Accreditation.

It corresponds to the National Associations of Superior Agricultural Education, to establish in each country the necessary mechanisms to administer the accreditation. This eliminates the fear of interference in the university autonomy and strenghens the link between the institutions. This is the policy adopted by the faculties of agronomy of the Andean Zone and should be the general pattern in Latin America. The extrauniversitary administration would awaken strong resistances and would change the purpose of mutual aid, that is pursued with the association.

e) Perspectives of the Accreditation in Latin-America.

Without doubt the establishment of the system of accreditation in the faculties of Superior Agricultural Education in Latin America will encounter initial difficulties.

There does not yet exist an appropriate climate for the immediate adoption of a procedure that demands the voluntary cooperation and the collective interest. The usual attitudes of the educational institutions is that of isolation and selfsufficiency, to which are added a spirit of competence and rivalry developed as a consequence of the fight for survival. This spirit of rivalry, nevertheless, has been useful for many of them in order to improve, and from this point of view is desirable. But the lack of communication between the faculties gives rise to the development of unconnected initiatives that bring as a result the disorganization of the national educational system. Therefore it is desirable and convenient to introduce the accreditation, that will offer the opportunity of reaching an agreement about the integration of programs and to discuss about the common problems.

To obtain the adoption of the system, it will be necessary to first take to directors, administrators and teachers of the universities and faculties, the most ample information about the meaning of the accreditation and about its influence in the individual and collective improvement of the institutions.

It will also be necessary to introduce in the system, those changes in procedure suggested by experience. Many of the failures in the adoption of educational systems that we have had in our countries, have been due to the rigid copying of the philosophy and the procedures of the same, without taking into account the difference of our educational system and our idiosyncrasy.

Finally, though not less important, the administration of the accreditation will have to be observed carefully, and constant vigilance maintained to prevent that it turns into a coercive force that, driven by forces foreign to the university, or that originate within it, favour interests of groups or private persons, to the prejudice of some of the institutions.

The program of Superior Agricultural Education of the IICA, that has been undertaken an intensive promotional campaign for the accreditation, must continue its activities, giving counsel to the interested faculties and gathering information about the way in which the adoption progresses in the various countries to extend the knowledge of these experiences to all the Latin American institutions.

Theme 3.

21. EXPERIENCE IN THE DEVELOPMENT OF ACCREDITATING SYSTEMS FOR AGRICULTURAL ENGINEERING IN THE UNITED STATES by F.J. Hassler,

The accreditation of engineering curricula in the United States began after the formation in 1932 of the Engineers Council for Professional Development (ECPD), a federation of various professional engineering societies.

Initially, accreditation of undergraduate curricula was an to the system of licensing for the practice of the profession; later with the build-up in graduate education, accreditation has also served as a criterion for admission to graduate schools. This is signified by the statement in practically all graduate catalogs, under requirements for admission, which generally reads as follows: "A B.S. degree from an accredited curriculum or its equivalent". Without some common basis of evaluation each school would be obliged to set up its own rating of other schools from which students might transfer.

The first activity of the ECPD related to the accreditation of engineering curricula and this continues to retain its original importance. The first engineering curriculum was accredited in 1936. The basic relationship of the ECPD to the education of the young engineer is clearly spelled out in a statement relating to the purpose of ECPD:

a) To promote and advance all phases of engineering education with a view to the promotion of the public welfare through the development of the better educated engineer and engineering technician.

b) To carry out a program of guidance of pre-college students; to formulate and maintain high educational standards for colleges of engineering and engineering technology. To assist such colleges in planning and carrying out their educational programs at all levels, to cooperate with state licensing agencies, and to promote the intellectual development of the young engineer and engineering technicians.

The main objectives of the accreditation program of the ECPD, carried out through its Engineering Education and Accreditation Committee, are as follows:

a) To identify to the public, prospective students, educational institutions, professional societies, potential employers, governmental agencies, and state boards of examiners, the institutions and specific programs that meet minimum criteria for accreditation.

b) To provide guidance for the improvement of the existing educational programs in engineering and for the development of future programs.

c) To stimulate the improvement of engineering education in the United States.

In the field of engineering education there are two kinds of accreditation: (1) Academic Accreditation of institutions by regional associations. The regional associations generally approve an institution as a unit; approving their financial and administrative structure the functional operating standards, and the general level of academic endeavor, but they do not accredit specific programs for their disciplinary content. The second kind in Professional accreditation by ECPD, in this instance, of undergraduate curricula leading to first engineering degrees. It should be noted that one of the basic prerequisites for an ECPD, evaluation of an engineering program is that the institution must have the accreditation of its relevant regional association. Without this, the ECPD will not review a program.

The basis for accrediting engineering curricula rests upon written information supplied by the institution as well as an onsite visit by a visiting team of evaluators selected from an annually certified list of representatives from the appropriate professional engineering societies. The visiting team will spend approximately two days at the campus; holding discussions with appropriate faculty and administrative officials and, in general, gathering as much information and feel for the program as is possible. The individual team members will prepare a written report on their specific findings and their accreditation recommendations to the team chairman who, in turn, will prepare this own summarization and recommendation to the Engineering Education Accreditation Committee. Finaly, it is the recommendation of the full EE&A Committee (20-24 members) that is transmitted to the Board of Directors of the ECPD for final action and transmittal to the university accompanying the information on the terms of accreditation that is transmitted tothe institution will be a "statement" delineating the specific findings of strength and weakness by the visiting team.

Full accreditation is for six years, conditional terms may be for 2 or 4 years, of course no accreditation may be ruled.

During their visit, and in reviewing the information supplied by the institutions, the evaluators place particular emphasis upon the manner of fulfillment, the degree of fulfillment, and the prognosis for continuing to fulfill the qualitative and quantitative criteria that ECPD uses for establishing accredibility. The principal qualitative criterios is "The extent to which a curriculum develops the ability to apply pertinent knowledge to the identification and solution of practical engineering problems".

Particularly important among the ECPD's presently cited quantitative criteria are those that relate to curriculum content. Briefly summarized these are:

(1) 2 1/2 years of mathematics, basic sciences and engineering sciences, including integration into a meaningful engineering experience.
(2) 1/2 to 1 year of Humanities and Social Sciences.

The American Society of Agricultural Engineers was officially organized in 1907. It joined the ECPD in mid-1930's as an affiliate member, gaining full membership status in the early 1960's when ASAE attained the minimum requirement of 5000 corporate members. The curricula of three Agricultural Engineering Departments were accredited by 198. Ten additional Departments were accredited by 1950; today our accredited list includes over 35 departments.

During the 1950's and into de 1960's the ASAE, through its committee on courses and cirriculum, conducted a within Society accrediting procedure by which departmental curricula were evaluated against a set of minimum criteria. This did, as intended, motivate Agricultural Engineering Departments to qualify for accreditation by ECPD. After fulfilling its purpose this ASAE activity was terminated.

The first engineering curriculum was accredited in 1936. Since that time engineering education has shifted from training in technical skills to education in engineering science and in the synthesis of engineering systems.

Accreditation by ECPD has played an important role in this trend in engineering education by serving in effect, as a national forum for discussion, experimentation and innovation.

It has been a tremendous responsibility and a challenge to the ECPD to insure the optimum progress of the profession and at the same time responding to the ever changing challenges and needs of society and technology. For these reasons engineering education has been improved and stimulated by a series of distinguished reports and recommendations. The Wickended study of 1923-29 emphasized the importance of training in economics and management, and the need for rounding out the engineers technical knowledge with social and humanistic studies. The Hammond reports of 1940 and 1944 placed even greater emphasis on this matter of broad general knowledge and suggested that a large aprt of the student's specialized technical education should be postponed to the senior year or even beyond. The Grinter study of 1952-55 pointed up the necessity of a strong base in mathematics and the sciences. Somewhat at variance with the intentions of ECPD, implementation of the results of the studies resulted in undue rigidity in the criteria for meeting minimum standards for accreditation. This has posed an especially difficult problem for Agricultural Engineering, which integrates the principles of other engineering specialties and the life sciences. However, the 1968 report of the Goals of Engineering Education, which represents the culmination of a 5-year study, calls attention to the need for greater flexibility in engineering curricula and the increasing importance of graduate study. Accreditation of curricula in the future must be re-examined in light of the need for flexibility and diversity among institutions and programs . Standardization beyond a marginal limit of acceptability will retard rather than enhance the quality and effectiveness of engineering education. Today each professional society has the responsibility for establishing guidelines for its accredited curriculum based on the extent to which the curriculum relates and integrates the mathematics, physical and bio-sciences, and the engineering sciences into a meaningful engineering educational programs or the extent to which the curriculum develops the ability to apply pertinent knowledge to the identification and solution of practical engineering problems so this and ASAE's Committees on Curriculum and Course content and on Professional Development has under preparation a "Guide for Agricultural Engineering visitors on ECPD Accreditation Teams".

Theme 4. EDUCATION AND CURRICULUM OF THE AGRICULTURAL ENGINEER AND ITS RELATION TO THE "AGRONOMO".

22. THE EDUCATION OF THE AGRICULTURAL ENGINEER AND THAT OF THE "INGENIERO AGRONOMO" by J. D. Berlijn, FAO Reg. Agricultural Engineer, Latin American Regional Office, Santiago, Chile.

I. INTRODUCTION.

1. I have been asked to deal with a subject on which various opinions are being expressed; many of these relate to differences in the interpretations of the objectives of the profession of the "ingeniero agrónomo" (agronomist) versus those of the profession of the "ingeniero agrícola" (agricultural engineer).

2. The profession of the agronomist, and consequently the way in which he is to be educated, is well-known in Latin America. There exist excellent schools of agriculture in the region; and there is no doubt that in the past the agronomists have contributed greatly to the development of Latin America's agriculture.

3. However, and in respect to the differences between the two professions, there are various thoughts. There is even doubt as to whether it is desirable to consider agricultural engineering as a specialization within the university programmes. Some are afraid that this new professional may well turn out to be an inconvenient competitor in respect to future employment possibilities for agronomists. And due to a certain conservatism, there is also resistance to accept the necessary changes; and this in turn slows down the required development of agricultural engineering programmes.

4. As a result of these and many other reasons, there are, up to the present, few places in Latin America where a true professional programme in agricultural engineering has been organized, that is academically comparable with those developed during the last half century in other parts of the world. More particularly, the lack of a clear concept of tasks and objectives of the agricultural engineering profession has caused in this continent the creation of educational programmes, that appear to have very little relation with the agricultural engineering profession; as for instance the so called orientation programmes in agricultural engineering and postgraduate courses in the subject for agronomists.

5. Consequently, it is important that this panel gives us the opportunity to study the mentioned problems more deeply; although I realize well that it is at the same time a rather difficult subject to deal with.

II. AGRONOMY AND AGRICULTURAL ENGINEERING.

6. Before embarking upon an analysis of the education programmes in agronomy and in agricultural engineering, it will be necessary to determine in the first place the principal objectives of these professions in order to have a basis for an adequate discussion of the subject. Because it is a matter of fact that agronomy and agricultural engineering have to a certain extent opposite interests, and this is to be taken duly into account in discussing the education programmes for these professionals.

7. It is known that agronomy embodies a profession which is oriented towards the solution of numerous problems facing the rural society. It has at its disposal two main tools: natural sciences and agro-socio-economic sciences. With these the agronomist tries to make the best possible use of the physical resources of the country, such as crops, animals, soil and water, and climate, paying due regard to agro-socio-economic aspects, as well as to natural sciences, because farming is work with natural as well as human resources (campesino). Therefore, the agronomist considers principally nature and farm-workers as basic elements for agricultural production.

8. On the other hand, agricultural engineering is a profession that pretends to improve agro-socio-economic conditions by means of the application and ample, effective use of engineering resources in agriculture, with the objective of conditioning adverse characteristics of nature, such as pests, drought, inconvenient temperatures, excesses of water, limitations inherent to power development by draft animals and others; and of facilitating and augmenting the production of the farm worker, removing the drudgery from the daily farming tasks and raising farm efficiency; resulting in improved rural living conditions and general economy.

9. Consequently, what distinguishes the two professions is that the agronomist is mainly concerned with obtained the best possible use of natural resources, and his task is to combine in an efficient way the valuable elements of nature, applying for that purpose his technical knowledge, biology, physics, chemistry and agro-economy, whereas the machine-minded agricultural engineer is concerned with conditioning and changing the elements of nature, by applying his knowledge of engineering, electronics, mechanics and hydraulics.

10. With respect to the training of these professionals, it is obvious that the agronomist needs profound knowledge of all aspects of nature, to be used in achieving the best possible use of natural resources; whereas the agricultural engineer needs profound knowledge in conditioning nature to facilitate, humanize and improve farm work.

11. There is , therefore, an essencial difference in mentality , task and basic knowledge. Table 1 presents a general picture of this difference.

12. The principal objective of the agricultural engineering profession is a specific one, and implies the development of an industrialized or technified agricultural production system, in which capital instruments are being applied to natural, biological and human resources. It is unfortunate that still mainly natural and human resources only are being used in agricultural production, whereas this production could be increased significantly by making a more extensive and better use of engineering means and modern techniques; which is the objective of agricultural engineering.

13. It implies the substitution of the traditional agricultural production system by an advanced, modern and efficiently technified agriculture, in which adverse elements of nature are being eliminated, providing the rural society with the technical means to perform their basic tasks efficiently and more conveniently; at the same time paying due regard to local conditions as well.

TABLE 1

Resources	Natural Resources	Human Resources	Engineering Resources
applying	soils, water, climate, plants, animals		Machines, installations, silos, infra-structures, rural roads, irrigation, drainage, farm power, processing machinery
SCIENCES: with the OBJECTIVE:	Applying Agricultural Sciences		Applying Engineering Sciences
	1. to make the best possible use of favorable elements of nature.		1. provide rural society with the technical means, adapted to local conditions, and 2. conditioning adverse elements of nature in a technical manner, with the purpose of:
		enabling the rural society to make a more extensive and skillful use of available natural resources	
	2. using these favorable elements more extensively and skillfully applying engineering means and eliminating adverse elements of nature		

3 to obtain maximum production at less costs, with greater benefits, to have:

greater possibilities for improved living conditions | greater possibilities to acquire capital instruments

APPLYING SOCIAL SCIENCES, AGRARIAN; REFORM, HOME ECONOMICS EDUCATION
to obtain

A GOOD STANDARD OF LIVING

IS THE TASK OF:

THE AGRONOMY SPECIALIST

THE AGRICULTURAL ENGINEER

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14. In spite of the mentioned possibilities for drastic improvements there is still much of conservatism and fear that resist a rapid acceptance of these new techniques, methods or machines, found not only amongst farmers, but also amongst officials. Many Latin American countries show a tremendous vision in aspects such as architecture culture, urbanization and construction of new cities like Brasilia. But the majority of these do not show much of a vision in respect to the necessary technical changes in agriculture; maintaining a traditional production system, and agricultural education programmes that do not pay due regard to engineering and capital resources. This is particularly unfortunate because these schools are at present training young professionals that will be the future agricultural leaders of Latin America. In order that they will be able to perform their task adequately, it is urgent to develop now the required forward looking mentality and ability.

III. ENGINEERS AND INGENIEROS.

15. The efficiency of training programmes for agricultural engineers andagronomist depends greatly upon the clarity of professional concept that is applied in these programmes. The "ingeniero agrícola" is an engineer, and the "ingeniero agrónomo" is an agronomist. and not an engineer. The word "ingeniero" is frequently used in two senses; as a title and as a profession. This has resulted in a certain confusion, to which has contributed also the fact that some schools of agriculture in the continent were named "escuela de ingeniería agronómica" (in english: school of agronomic engineering); schools that have nothing in common with engineering or with agricultural engineering. Also, the fact that the words "agrónomo" and "agrícola" show much similarity, has added to the confusion.

16. In Continental Europe and in Latin America, universities usually grant the title "ingeniero" or "ingenieru" to those graduates who have presented a thesis. This title does not indicate the profession of the graduate. As a matter of fact. "ingeniería agrícola" has more in common with mechanical and civil engineering, than with agronomy, as will be shown later.

17. In Anglo-American countries the title "ingeniero" or "ingenieur" is not in use. Professional engineers are engineers (maquinistas). The "Ingeniero Agrícola" is the agricultural engineer, whereas the "Ingeniero Agrónomo" is an agronomist. To do justice to the "Ingeniero Agrícola", in Latin America, it is necessary to call him "Ingeniero en Ingeniería Agrícola" or "Ingeniero en Ingeniería Rural". However, that would be inconvenient in daily use, and for that reason it is recommended to use "Ingeniero Rural" and "Ingeniería Rural" instead, to make at least a fair reference of the profession, and to avoid confussion.

Table 2

Spanish		English	
Title	Profession	Grade	Profession
ingeniero	agronomo	B. Sc., M. Sc.	agronomist
ingeniero	ingeniería agrícola	B. Sc., M. Sc.	agricultural engineering
ingeniero	ingeniería mecánica	B. Sc., M. Sc.	mechanical engineering
ingeniero	ingeniería civil	B. Sc., M. Sc.	civil engineering

IV. BASIC PRINCIPLES IN TRAINING AGRICULTURAL ENGINEERS AND AGRONOMISTS.

18. Due to the specific difference between agronomists and agricultural engineers with regard to their respective mentality or philosophy, tasks and basic knowledge, it is logical that their education programmes ought to reflect similar differences in order that their training be efficient. These differences are of such a magnitude, that it would be a fundamental error if schools try to produce an agronomist that possesses at the same time sufficient knowledge of agricultural engineering.

19. Various schools of agriculture, though, try to reserve an ever-increasing part of their original agronomy curriculum for the purpose of teaching agricultural engineering subjects, under the pretext that agricultural engineering is a subject belonging to the responsibility of the agronomist. In this way the schools create the so called orientation programme in agricultural engineering for agronomists. It is obvious that this implies a considerable reduction of the true agronomy programme, and that these schools, in fact, are producing an agronomist who on the one hand knows less of agronomy, and on the other is neither an agricultural engineer.

20. Some European Universities follow the same system, and offer a programme in agriculture, with a specialization in agricultural engineering. This requires a prolonged study, up to an average of seven to eight years, of intensive study, with three semesters each year. Consequently, the system is expensive, and the results are not always significant because of the duality of the training. In general, the graduate of such an extended programme is not better prepared than the agronomist trained in a five year agronomy programme, and neither does he reach the level of those agricultural engineers who followed a four or five year training programme, exclusively dedicated to the especialization, as for instance, in the United States.

21. A programme designed for training agronomists cannot normally offer either sufficient grounding in mathematical or physical sciences, nor the specialized teaching or facilities that are needed for the training of a man who is, in effect, an engineer with an agricultural orientation. Although these programmes offer a range of courses as surveying, elementary hydraulics, irrigation and farm buildings, these are normally taught by civil engineers, while courses in farm mechanization are generally offered by agronomists. Neither can be expected to give the specific technical orientation that is needed for the training of agricultural engineers; nor is it reasonable for a school of agriculture to possess specialized laboratories and installations such as materials testing, hydraulic, electrical, farm power and processing laboratories and workshops, required for an agricultural engineering programme.

22. However, the foregoing does not suggest that the agronomy programme and the agricultural engineering programme ought necessarily to be separated completely. It is not suggested either that agronomists are being trained without any knowledge related to the application of engineering techniques, or that the agricultural engineering programme should ignore fundamental aspects of agriculture. To the contrary, such an extreme would be equally wrong.

23. In framing adequate programmes, in agronomy as well as in agricultural engineering, it is necessary to take into account the special requirements for modern agricultural development in Latin America. These demand that in future the countries have at their disposal the following types of professionals:

a) Agricultural Engineers, concerned with the design and application of engineering resources and capital instruments such as:
- agricultural mechanization and automatization
- soil and water engineering
- farm structures and rural planning
- process engineering

with the objective of providing the rural society with the technical means-adapted to local conditions- and of conditioning the adverse elements of nature, to permit that society makes a more appropriate and extensive use of natural resources, with less strain and with better results.

b) Agronomists, concerned with the use of natural and human resources for agricultural production, including soils and water, plants and animals, and climate, with the task of achieving the best possible use of favorable elements of nature, taking full advantage of agricultural engineering techniques and eliminating adverse influences of nature.

24. It will only be possible to substitute traditional and limited agricultural production systems by an advanced and technified agriculture if these professionals become available in future in sufficient numbers. Such an agriculture, in turn, will produce more at less cost, facilitating the acquisition of more capital instruments, and improving rural living conditions.

25. The implantation of the relevant programmes, in true accordance with future agricultural development, requires the inclusion of the following requisites:

Table 3

Professional	Training	Orientation
Agronomist	specialized in agricultural sciences	oriented towards economic and efficient use of modern techniques
Agricultural Engineer	specialized in agricultural engineering as a technique	oriented towards agriculture as the ambient for application of modern techniques

V. ACADEMIC PROGRAMMES.

26. The Second Latin American Conference on Higher Agricultural Education, held in Medellin , Colombia, in 1962, and the First Round Table Conference of Agronomy Faculties in Central America, recommended the following distribution of subject matters for an adequate preparation of agronomists in future:

Table 4

Programme of studies		Number of credits		
		Second conference		Round table
basic cycle				
basic sciences:	mathematics	12		
	physics	8	50	60

Programme of studies		Number of credits		
	chemistry	12		
	biology	18	50	60
agronomy cycle				
sciences:socio-econo-		12		
mic agriculture:	ecology, soils,	16		
	plant production	30		
	animal production	16	90	127
rural techniques				
orientation				
technical electives		20		
free electives		20	40	20
total credits:			180	207

27. That re-distribution of the agronomy programme implies a most important step forward towards the elaboration of a reorganized plan of studies, with sufficient flexibility to introduce into these programmes technical inventives or specializations which may develop in future in relation to the various disciplines of agricultural sciences. Moreover, the 16 credits reserved for rural techniques with the 20 credits in free electives assure sufficient possibilities for interested agronomy students to orient themselves in the economic and efficient use of agricultural engineering techniques. In this way the programme offers between 30 and 40 credits for a sound and practical orientation of agronomists in agricultural engineering techniques, without interfering too much with the fundamental objectives of the existing agronomy programme.

28. The orientation of the agronomist in these techniques could eventually include the following course offerings (evidently with emphasis upon their application and economic use):

Table 5

Course offerings for orientation of agronomists in agricultural engineering techniques (30-40 credits)	
irrigation systems	drainage systems
applied hydraulics	soil-water-plant relationships
water administration	agricultural mechanization
farm machinery	tractors and engines
rural electrification	rural sanitation
conservation of products	processing of products

29. In offering these courses for agronomists, the emphasis must be necessarily upon practical. efficient and economic use of techniques, and not upon engineering; because the agronomists are the consumers of techniques, not the initiators.

30. On the other hand, the training of professionals in agricultural engineering demands an academic programme which is basically different, with a machine-minded mentality, and with other objectives. Such a programme could be initiated as follows:

a) parallel with an agronomy programme, so that use can be made of a part of the agronomy programme, to orient the students towards agriculture, or
b) parallel with an engineering programme, for instance with a polytechnical school or engineering faculty, so that use is made of part of the engineering programme in offering basic en-

gineering subjects to the agricultural engineering students, or
c) parallel with an agronomy programme and an engineering programme in those universities that have both programmes available. In that way full use can be made of these two programmes, both to orient the student towards agriculture, and to offer him basic engineering, without duplication of efforts and investments.

31. Following the first alternative, the Agrarian University of La Molina in Peru, initiated in January 1962 a project of the United Nations Development Programme (Special Fund), executed by FAO, whereby this university could establish a complete agricultural engineering programme parallel with its agronomy programme, as follows:

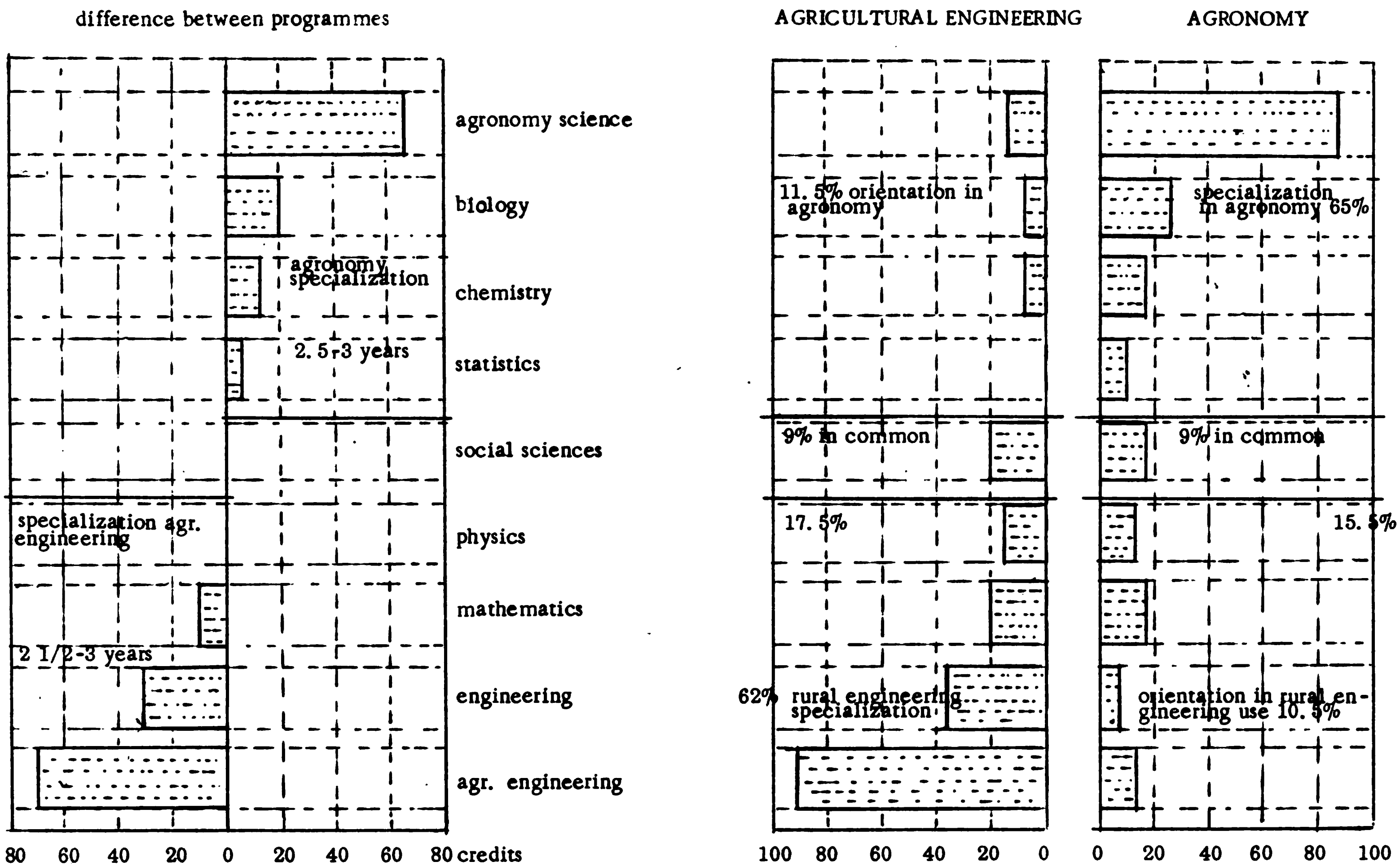
Table 6

Subjects	Agronomy curriculum		Agricultural engineering	
Biology	general biology	4	general biology	4
	animal husbandry	4		
	botany	4		
	microbiology	4		
	plant physiology	4		
	general genetics	4		
		24		4
Chemistry	general chemistry	4	general chemistry	4
	biochemistry	4		
	analytical chemistry	4		
	agricultural chemistry	4		
		16		4
Physics	physics I and II	8	physics I and II	8
	meteorology	4	meteorology	4
	geology	3	geology	3
		15		15
Mathematics	algebra	4	algebra	4
	calculus I, II, III	12	calculus I, II and III	12
		16		16
Statistics	general statistics	4	algebra	4
	statistical methods	4		
		8		0
Engineering	topography I	3	topography I	3
	drawing	3	technical drawing	2
			descriptive geometry	3
			statics	4
			dynamics	4
			topography II	3
			strength of materials	4
			engineering economy	3
			fluid mechanics	3
			machine elements	3
		6	thermodynamics I, II	6
				38

Subjects	Agronomy curriculum		Agricultural engineering	
Social Sciences	language art	2	language art	2
	technical reporting	2	technical reporting	2
	economy	4	economy	4
	sociology	4	sociology	4
	humanities	3	humanities	3
	accounting	3	rural laws	3
		18		18
Agricultural Sciences	soils	4	soils	4
	general agriculture	4	general agriculture	4
	soil fertility	2	crop husbandry	3
	soil management	3	animal husbandry	4
	crop husbandry	9		
	pasture, fodder crops	3		
	viticulture	2		
	fruits	4		
	entomology	7		
	phytopathology	7		
	phytotechniques	7		
	plant propagation	2		
	animal husbandry	4		
		58		15
Agricultural Engineering	rural constructions	4	materials for construction	3
	irrigation systems	4	electricity	4
	rural mechanics	7	construction methods	3
			structures	4
			farm power	4
			applied hydraulics	3
			rural design	3
			farm machinery	4
			irrigation, drainage	4
			process engineering	4
			rural planning	2
		15		38
Orientation	technical electives	20	technical electives	38
	free electives	4	free electives	10
		24		48
Total credits		200		200

32. The electives in the agricultural engineering programme of La Molina include approximately 39 course offerings, with a total of 122 credits. Consequently, the programme offers a total of 274 credits, of which 72 are university credits or credits of the agronomy programme. The agricultural engineering programme, in turn, offers courses with a total of 21 credits to the agronomy programme.

Table 7. Comparison between programme of course in agronomy and in agricultural engineering



33. An analysis of these programmes of La Molina shows the following distribution of subjects:

Table 8

Sciences	Agronomy	Agricultural Engineering
Social Sciences	9%	9%
Agricultural Sciences, including: biology chemistry statistics	65%	11.5%
Physics, mathematics	15.5%	17.5%
Agricultural Engineering	10.5%	62%

34. The above table reflects almost perfectly the earlier mentioned requisites for the training of agronomists as specialists in agriculture with orientation towards the use of rural techniques, as well as those set forth for the training of agricultural engineers as specialists in agricultural engineering with an orientation in agriculture.

35. The other alternative in creating an agricultural engineering programme includes the use of facilities available in schools of engineering or polytechnical schools. For instance, a study made by FAO in the National Polytechnical School in Quito, Ecuador, showed that the following courses of the Faculty of Engineering of that School could eventually be used in the establishment of an agricultural engineering curriculum.

Table 9

Subject	Courses	No. of comparable credits
Chemistry	general and inorganic chemistry	4
Physics	physics I and II	8
	engineering geology	3
Mathematics	analytic geometry, algebra	4
	calculus I, II and III	12
	advanced mathematics I	4
Engineering	topography and topographical drawing	6
	technical drawing	2
	descriptive geometry	3
	statics I and II	4
	dynamics	4
	strength of materials	4
	fluid mechanics	3
	applied mechanics	3
	thermodynamics I and II	6
		70

Social Sciences	language (English)	2
		2
Agricultural Engineering	construction materials	3
	general electronics	4
	constructions	3
	structures	4
	applied hydraulics	3
	process engineering	2
		19
Electives	processing I, II and III	9
	unit operations I, II and III	9
	plant design	3
	refrigeration	3
	electric machines	3
	hydrology	3
	agriculture hydraulics	3
	soil mechanics	4
	sanitary engineering	4
	hydraulic structures	3
	basic electronics	3
		47
Total credits available for agricultural engineering programme		138

36. In order to make a more complete comparison between the two earlier mentioned alternatives- using facilities of an agronomy programme or using the facilities available in an engineering school- the available courses can be brought into groups as follows:

Table 10

	course offerings in agricultural engineering	courses available in agronomy programme	courses available in school of engineering
basic sciences	81 cr	39 cr	70 cr
social sciences	18 cr	18 cr	2 cr
agricultural sciences	15 cr	15 cr	- cr
agricultural engineering	38 cr	- cr	19 cr
technical electives	122 cr	- cr	47 cr
total credits:	274 cr	72 cr	138 cr
	100%	26%	50%

37. The foregoing table shows clearly the duality in the agricultural engineering profession, with emphasis upon engineering, and with an orientation towards agriculture. Agricultural engineering is therefore to be considered as a discipline of engineering. As a result of being al-

ready a specialization, in itself , of engineering, it is not recommendable to permit further specializations within the agricultural engineering curriculum below the graduate level. The slight orientation by means of technical electives must merely help the student to decide in which direction to specialize afterwards; for instance in:

- soil and water engineering
- farm power and machinery
- farm structures and rural planning
- process engineering

38. In that way it is ensured that all students receive a uniform and adequate basic education in the specialization with only an orientation in one of the disciplines of agricultural engineering. This approach is of particular importance in Latin America, which is a continent in the state of development, and where agricultural engineering is still rather new.

39. The foregoing table raises the question whether it would not be better to create new agricultural engineering programmes along with existint engineering schools instead of with agronomy programmes. This appears to be more advantageous due to the fact that such schools can provide already 50% of the required course offerings, but in the case of Latin America it is certainly more convenient to build up such agricultural engineering programmes within schools of agriculture for the following reasons:

a) it is of special importance in Latin America that the young agricultural engineers receive their education within an agricultural environment, together with agronomists, and with those who will be the future consumers of agricultural engineering techniques.

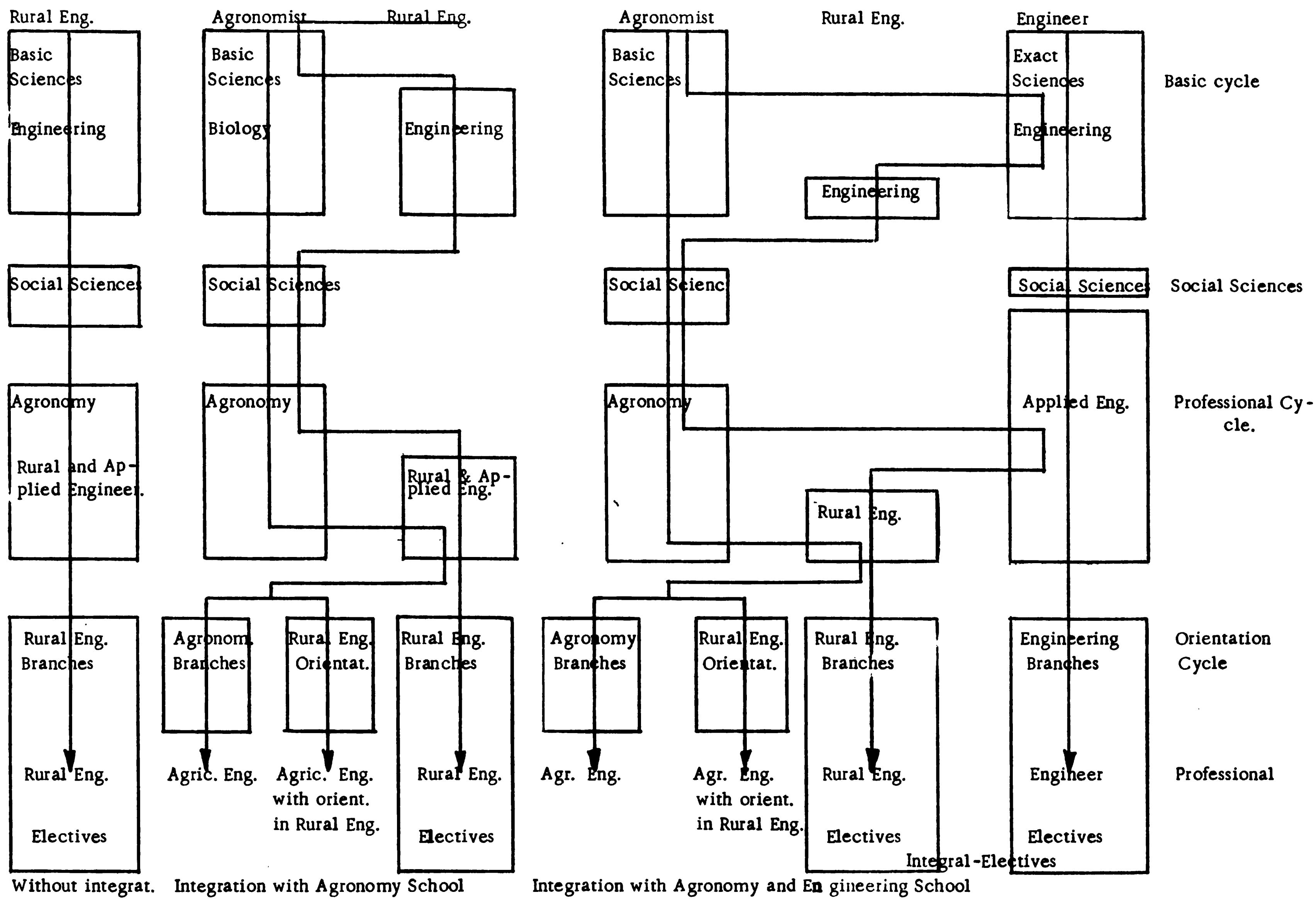
b) in such an environment there exist plenty of opportunities for the agricultural engineering student to familiarize himself with actual agricultural problems.

c) and, on the other hand, the programme of agricultural engineering can offer service courses for agronomy students up to a total of 21 credits; and these agronomists can familiarize themselves with new techniques as well.

40. It is, of course, evident that the most adequate environment for the training of agricultural engineers- due to the duality of the profession- will be found within universities that offer programmes in both engineering and agriculture. In those cases approximately 174 credit courses will be available, which represent almost 63% of all courses required for an agricultural engineering curriculum.

41. Table 11 shows finally the way in which full use can be made of existing programmes in agronomy and in engineering in creating an agricultural engineering curriculum, without duplication of efforts and investments. This requires, however, that much of attention is being paid to university integration. At first sight this appears to be somewhat contradictory to the desire for specialization, but such integration, in effect, is precisely a vital pre-requisite to achieve an efficient, specialized programme in agricultural engineering, that at the same time will be economical and of good academic standing.

Table No. 11. Scheme of the career of Rural Engineering and Universitary Integration.



Theme 4.

23. AGRICULTURAL ENGINEERING EDUCATION IN COLOMBIA by Fabio Bustamante, I.A., M.S.

I. INTRODUCTION.

Agricultural Engineering teaching in Latin America has began its improvement and development period, in order to have a technical agricultural industry. For this a good exposition of the necessities related to this discipline that each country has been necessary in order to prepare a program in agreement with them and to obtain qualified personnel that with their general knowledge of the profession provide the necessary basis for the correct integration of the elements related with the complex of the Agricultural Engineering industry.

The Agricultural Engineering Program of the National University of Colombia-Medellín, the second one organized in Latin America is operating for an integral preparation of Agricultural Engineers and although in any new program there are a series of troubles, it presents an attractive balance in aspects related to the courses, physical facilities, staff members, students and the other aspects involved in the program.

This paper tries to include all and each of the elements that allow the operation of a program for Agricultural Engineering, showing the use of the facilities and elements that exist in order to obtain optimal results for the profession that is to be developed.

II. HISTORICAL BACKGROUND.

The Agricultural Engineering program in Colombia, as in other Latin American countries, up to 1965 has been offered by the Agronomy Faculties in their Agricultural Engineering section where they have been teaching courses in Surveying, Hydraulics, Irrigation, Rural Construction, and in some of them Farm Machinery has been included.

In order to reach the minimum requirements in requisites for the Agricultural Engineering courses, the Faculties had prepared the students in Mathematics and Physics. From this point of view, teaching of Agricultural Engineering has been a vocational type rather than a professional type with a notorious deficit in basic Engineering courses difficulting further advances in those disciplines.

Considering that in spite of its rapid industrial expansion, Colombia is fundamentally an agricultural country, 75% of its export income comes from agricultural products, therefore a high expansion and efficiency of this industry are necessary for the general progress of the country; and estimating that 5% annual increase on food and other agricultural products demand due to population increase, improvement of living standards, increase of exportations, etc, the Government estimated necessary to sponsor the increase of agricultural production and realistic projects were started being in charge of the Agricultural Ministry, Instituto Colombiano Agropecuario (ICA), Instituto Colombiano de Reforma Agraria (INCORA), Instituto de Mercadeo Agrícola (IDEMA), and other related institutions.

The University, as a mean to prepare qualified personnel to facilitate the operation of such projects with efficiency, considered that it was time to prepare a professional with vision to utilize the necessary elements from Engineering and Agronomy to solve the complex problems that the agricultural industry presented; in 1956 the Agronomy Faculty of the National University- Medellin, made an assistance contract with Michigan State University for the purpose of improving the courses related with Agricultural Engineering, especially Farm Machinery, Irrigation and Drainage. Using the conclusions from this contract, the first program to prepare Agricultural Engineers was submitted. In 1960 with assistance from OAS and Michigan State University, another program including the Agricultural Faculty and the Engineering Faculty in Medellin was submitted to the University Board, and was approved in 196[illegible], its development started in 1965. In the same year preparation of the staff members began in foreign countries, especially in the United States, returning in 1967 when the students were starting the especialized courses in Agricultural Engineering.

In 1966 another contract with the University of Nebraska was started. Its staff members and the Colombian specialized staff jointly studied the Agricultural Engineering curriculum; they made the necessary changes, looking for having the requisites in Mathematics and Physics, and the basic engineering courses balanced with the biological courses, to provide the basic training that every agricultural engineer needs in order to understand the relation between the engineer and biological sciences. With this last curriculum, the National University is working in the preparation of Agricultural Engineers and the first students with a Bachelor's degree in Agricultural Engineering will graduate in December of this year.

III. PRESENT SITUATION OF THE AGRICULTURAL ENGINEERING PROGRAM IN COLOMBIA.

The importance of Agricultural Engineering for an efficient development of the agricultural industry in Colombia has been recognized by the Universities, making use of their agronomy and engineering facilities respectevely. This program is in the second semester, not having yet any specific courses in Engineering. It is in the phase of preparing staff members and is located in the Cauca Valley zone.

At the National University campus in Bogota, another curriculum for the preparation of Agricultural Engineers has been planned to begin during the second semester of the present year, as a reciprocal colaboration between Engineering and Agronomy Faculties.

The other Agronomy Faculties that exist in the country, having in consideration the programs that the Government has prepared with institutions mentioned before, are preparing courses to intensify the programs related to Agricultural Engineering, so in some of such schools, for example, programs have been established to allow a specialization at undergraduate level in irrigation or in processing, trying to show the importance that Agricultural Engineering has.

IV. AGRICULTURAL ENGINEERING PROGRAM, NATIONAL UNIVERSITY- MEDELLIN ZONE.

1. Organization of the National University at Medellin.

For a better understanding of how the program is structured, it seems important to have a brief explanation of the organization of the National University at Medellin. Three Faculties, Faculty of Mines (Engineering) Faculty of Agricultural Sciences, and Faculty of Architecture form the University. These three Faculties administrate the professional curricula related with the three fields of work: housing, industrialization and food.

The following table is a summary of the curricula offered in Medellin by the three Faculties with their semestral duration:

FACULTY	PROFESSIONAL CURRICULUM	No. SEMESTER
ARCHITECTURE	Architecture	11
	Construction	11
	Graduate Study in Planning	04
AGRICULTURAL SCIENCES	Agronomy	10
	Agricultural Engineering	10
	Forestry Engineering	10
	Agricultural Economics	10

	Animal Husbandry	10
MINES (ENGINEERING)	Civil Engineering	11
	Administrative Engineering	11
	Petrologist Engineering	11
	Industrial Engineering	11
	Metalurgical Engineering	11
	Geological Engineering	11
	Chemical Engineering	11
	Electrical Engineering	11
	Mechanical Engineering	11
	Graduate Study in Engineering (Structures, Roads, Hydraulics Systems)	04
	Graduate Study in Applied Mathematics	04

The Faculties are the fundamental academic and administrative units of the University. Each one is divided into Departments that are the operative units for developing the activities related to teaching and research in the topics of the field in which each Faculty works. The professional formation of curricula is under vigilance of the Faculty but the total configuration of a curriculum is due to the cooperation of various Departments where the general courses or professional courses are offered.

2) Organization of the Agricultural Engineering Curriculum:

From the following table it is easy to deduca the participation that different University's dependances have in the program. It has facilitated the organization, reducing the investments in equipment and human materials, staff members, etc. basic Engineering couses necessary for the Agricultural Engineering program when the budgets are limited.

Academic participation of the different Departments expressed in percentage of offered courses for the Agricultural Engineering curriculum:

FACULTY	DEPARTMENT	PERCENTAGE	
AGRICULTURAL SCIENCES	Agricultural Engineering	31.2	
	Agronomy	3.4	
	Chemistry and Biology	13.0	
			47.6
MINES (ENGINEERING)	Administration and Prog.	3.8	
	Mathematics and Physics	26.4	
	Engineering	14.6	
	Mineral Resources	2.0	
			46.8
ARCHITECTURE	Arts	1.0	
	Humanities	4.6	
			5.6
		GRAND TOTAL	100.0

It is well known that Agricultural Engineering was created to fill the necessity of giving a greater emphasis for the Physics and Mathematical Sciences to develop a technical agricultural industry that depends more on mechanization to make use of the techniques and scientific discoveries to obtain high yields using correct agronomic techniques.

The more advanced countries in the Agricultural Engineering field had divided their programs in the following four areas of application:

FARM MACHINERY	IRRIGATION AND DRAINAGE
RURAL CONSTRUCTIONS	PROCESSING OF AGRICULTURAL PRODUCTS

Under these four divisions, the Agricultural Engineering program in Medellin has been structured, in order to have a correct planning of investments, staff members preparation, and a balance between the courses that the student has to receive for his integral preparation.

With the understanding of Agricultural Engineering philosophy and with a knowledge about the government projects for a better Agricultural Industry in the country, the present curriculum was prepared, so it permits to give a real and adjusted preparation to the Colombian necessities where experience in these areas is poor or does not exist. The general information given by the curriculum to the future Agricultural Engineer provides him a general knowledge in the profession, and permits an easy adjustment to graduate programs. Also, the program was prepared in such a way to meet the requisites for every Engineering curriculum, with the approval of the Engineering Council of Professional Development (ECPD) of the United States and that of the Engineering Committee of the National Association of Universities in Colombia. This permits students to pursue graduate programs in the United States.

The program or curriculum has observed the requisites and the pre-requisites that the University demands to every student that wants to study in it, and has been organized in the following form:

COURSE	HOURS/WEEK	CREDITS
LEVEL 01		
Mathematical Analysis I	4	4
Trigonometry	3	0
Practical Complement	3	0
Chemistry I (General)	7	5
Biology	6	4
English I	4	0
Drawing I	3	1
LEVEL 02		
Mathematical Analysis II	4	4
Geometry	4	4
Practical Complement II	3	3
Chemistry III (Organic)	6	5
General Physics	4	4
English II	4	0
Humanities (Language)	2	2
LEVEL 03		
Mathematical Analysis III	4	4
Physics I	6	5

Chemistry IV (Biochemistry)	6	4
Technical Drawing	4	2
Botany I (General)	6	4
Humanities II (Use Library)	2	2
LEVEL 04		
Mathematical Analysis IV	4	4
Physics II	6	5
Implements and Materials used in Engineering	2	1
Topography I	4	4
Practices Topography I	3	1
Humanities III (Tech. writing)	1	1
Humanities IV (Political-Economic Doctrines)	1	1
LEVEL 05		
Mathematical Analysis V	4	4
Physics III	6	5
Fluid Mechanics	4	4
Plant Physiology	6	5
Soils I (General)	5	4
Humanities V (Sociology)	1	1
LEVEL 06		
Thermodynamics and Heat (Physics V)	4	4
Statistics I (Bio-statistics)	5	4
Soil Mechanics (Soils II)	5	4
Strength of Materials	4	4
Computers and Programming	6	5
Humanities VI (Rural Sociol.)	1	1
LEVEL 07		
Agricultural Systems I	6	5
Applied Hydraulics	6	5
Economy I (General)	4	4
Irrigation I (Relation water-soil-plant)	3	3
Principles of Farm Machinery	3	3
Elective	5	4
Humanities	1	1
LEVEL 08		
Hydrology and Climatology	4	3
Sources of Rural Power	5	4
Agricultural Systems II	3	3
Process of Agricul. Prod. I	3	3
Irrigation II (Design of Irrigation Systems)	5	4
Elective	5	4
Humanities	1	1

LEVEL 09		
Process of Agricul. Prod. II	5	4
Rural Electrification	5	4
Cultives or Crops	3	3
Analytical Methods	5	4
Elective	5	4
Research I	5	3
LEVEL 10		
Drainage and Erosion Control	6	5
Engineering of Rural Environment	4	3
Elective	5	4
Research II	5	3
Seminar	1	1

The curriculum is divided in the following ways: General basic courses, Humanities courses, Basic Engineering courses, Agricultural courses, and Agricultural Engineering courses. The content of courses for each one of them is as follows:

A) GENERAL BASIC COURSES: This group includes courses necessary to the primary formation of an engineer and for a later understanding for the basic engineering courses.

a) Mathematics and Physics courses group:

Mathematical Analysis I	4	
Mathematical Analysis II	4	
Practical Complement I	0	
Practical Complement II	3	
Analytic Geometry	4	
Mathematical Analysis III	4	
Mathematical Analysis IV	4	
Mathematical Analysis V	4	
		31

b) Biological and Chemical Courses group:

Biology	4	
General Botany	4	
General Chemistry	5	
Organic Chemistry	5	
		18

B) HUMANITIES COURSES: This group includes the courses that give the students a formation in general culture and are requisites for the University.

Language	2
English I	0
English II	0
Use of Library	2
Technical Writing	1
Political-Economical Doctrines	1

General Sociology	1
Rural Sociology	1
2 Elective courses in Humanities	2
General Economy	4-------
	14

C) BASIC ENGINEERING COURSES: This group includes the courses that give the student the necessary basis in Engineering to understand the applied courses.

Drawing I	1
Technical Drawing	2
Physics I	5
Physics II	5
Physics III	5
Hydrology and Climatology	3
Soil Mechanics	4
Topography	6
Geology	4
Fluid Mechanics	4
Applied Hydraulics	4
Strength of Materials	4
Computers and Programming	5--------
	52

D) BASIC AGRICULTURAL COURSES: This group includes the necessary courses to fill the total agricultural formation:

Plant Physiology	5
Biostatistics	4
Crops	3
General Soils	4
Biochemistry	4---------
	20

E) AGRICULTURAL ENGINEERING COURSES: This group includes the specific agricultural engineering courses and they are divided into the four divisions above mentioned. The number of courses in each of the divisions is more or less the same, in order to obtain an Agricultural Engineer with a general knowledge of the profession. It was not considered an especialization in a given area, for any specific field is limited because the profession is new in the country and it is necessary to provide organized work areas to get to specialization.

a) Irrigation and Drainage courses:

Relation water-soil-plant	3
Design of irrigation systems	4
Drainage and erosion control	5---------
	12

b) Farm Machinery:

Implements and materials	1
Principles of farm machinery	3
Sources of rural power	4
Analytical methods	4---------
	12

c) Agricultural Construction:

Agricultural Systems I	5
Agricultural Systems II	3
Rural Electrification	4
Engineering of the Rural Environment	3
	15

d) Processing of Agricultural Products:

Thermodynamics	4
Processing Agricultural Products I	3
Processing Agricultural Products II	4
	11

F) ELECTIVE COURSES: Each semester, one or more elective courses are offered in equal number in each of the above divisions, these courses are different from the regular courses in the curriculum.

This system gives the students an opportunity to select courses in which they are interested in order to have a better knowledge in the field of their selection, instead of having a real specialization. Some elective courses are: Administration and Operation of Irrigation Districts, Air Conditioning and Refrigeration, Advanced Machinery, etc. It is not necessary for elective courses to be strictly Agricultural Engineering courses, the student can take courses from another Department in the University, by having the authorization from his advisor. The total credit value required is 16; these generally, are divided in the last four semesters.

G) RESEARCH AND SEMINAR: In the last two semesters the student has to register in research. This effort tries to create an interest in research and to develop a special problem that permits a familiarization with the techniques for research and to analize a specific project. The research gives the student the capacity for a better performance in his work or to have a higher efficiency in graduate school research. The number of credits for research is 6. A list of the research themes that are being processed in the present year is shown in Appendix 1.

During the last semester each student has to present a Seminar. The theme is of free selection. The number of credits for Seminar is 1.

H) CREDITS: The credit value for each course is calculated by computing 1 credit for one theoretical class hour per week, and one for two laboratory class per week. It is difficult for a student to carry more than 25 credits per semester and therefore each student has to submit to his advisor the program prior to the registration time. The student can select courses from any semester, depending on the requisites and his advisor.

In the following table the resume of the distribution of courses with the credit value expressed in percentage is presented.

a) Syllabus or Program resume for Agricultural Engineering courses:

Appendix 2 contains the resume of the courses that are offered for Agricultural Engineering. The text books are included; some of them do not have a text book because the professor prepares class notes for the students.

COURSES	CREDITS		PERCENTAGE
	Partial	Total	
General basic courses:			
Physics and Mathematics	31		

COURSES	CREDITS Partial	Total	PERCENTAGE
Chemistry and Biology	18	49	23.6
Humanities courses		14	6.7
Basic Engineering courses		52	25.0
Agronomy Courses		20	9.6
Agricultural Engineering Courses			
Irrigation and Drainage	12		
Farm Machinery	12		
Agricultural Construction	15		
Process Agric. Prod.	11	50	24.0
Electives		16	7.7
Research and Seminar		7	3.4
		208	100.0

V. STAFF MEMBERS.

Since the initiation of the program the main aim has been the preparation of teachers for specific Agricultural Engineering courses. The labor has been difficult because the profession is new and the few Agricultural Engineers that exist are employed in different institutions and are not attracted by teaching for many different reasons, among them the problem of low salaries in comparison to other institutions.

The preparation of staff members is a program that consists in having Agronomist Engineers (Ingeniero Agrónomo) or Civil Engineers in the Graduate School level, as long as they are interested in Agricultural Engineering studies. The best results have been obtained with Agronomist Engineers because they understand easily the Agricultural Engineering Philosophy.

The first step for this program is that every staff member gets the M.S. degree, this objective is expected to be achieved by the first semester of 1971. The program for the obtention of the Ph.D. level will start during the year of 1970 for some members of the staff.

The Agricultural Engineering staff members are 15; 13 of them depending on National University and the other 2 are University of Nebraska Mission's staff members. Also, there are two other Nebraska staff members that periodically fly from Bogota to help in some courses related to their specialization. The division of the 13 staff members into the Agricultural Engineering areas is:

Irrigation and Drainage	3 professors
Farm Machinery	3 professors
Agricultural Construction	2 professors
Processing Agricultural Prod.	4 professors
Pursuing graduate studies	3 professors
	15 professors

One of the professors has his Ph. D. degree , three have the Master's degree, one has graduate studies but without any title, and the others have their University title.

Our objective is to have 5 professors as a minimum in each one of the four areas; some of the first graduates will be the future professors of the program.

VI. STUDENTS.

The Agricultural Engineering students are submitted to the same registration process as all National University students; a student can register in any curriculum but he has the opportunity to change from one to another according to the knowledge that about a specific field he gets during the first year in the University.

The following table shows the increase (by accumulative total) of the number of students per semester. The program was initiated in 1965.

YEAR	FIRST SEMESTER	SECOND SEMESTER
1965	29	29
1966	47	59
1967	70	90
1968	105	124
1969	141	163

The flexibility of the program permits the student to select courses from different semesters, in accordance to his advisor, credits and requisites. The advisor's labor for this program is considered very important, because as this is a new program in the country, the students sometimes do not understand the importance of the different courses for the general composition of the program. The most notorious labor has been made with the students that are about to finish, because with them different trials were made in order to obtain the correct program.

VII. ASSISTANCE FROM OTHER INSTITUTIONS.

The assistance from other institutions with the experience in activities related to the profession that are initiating their own development is of capital importance. To obtain the objective the National University and Colombian Agricultural Institute (ICA) made a contract in which the ICA gives assistance to the University to improve the teaching and research activities. In this particular program the Agricultural Engineering has been considered of primary importance. In order to obtain the objectives for such program, ICA signed a contract with the Mid-American States Universities Association (MASUA) for which the University of Nebraska is the entitled manager.

The above programs and contracts have permitted Agricultural Engineering to receive excellent benefits from staff and counselors which with all their interest spend their time in establishing adequately the program, as it is running now. Two of the Nebraska staff members are in Medellin, their specializations are respectively: Rural Construction, Farm Machinery and Soil and Water. In Bogota there are two other Nebraska Members, they give assistance as advisors and sometimes as professors. ICA has organized a program to provide laboratories and lecture facilities.

There is reciprocal assistance with Public Institutions and with private companies related with Agricultural Industry.

VIII. PHYSICAL FACILITIES.

The physical facilities include all kinds of equipment, space and other necessary elements for teaching and research. The nature of the Agricultural Engineering courses requires a complex laboratory for strength of materials, hydraulics, agricultural processing, irrigation and drainage and mechanics, drawing and carpenter shops. All this equipment is expensive and needs qualified personnel.

Although part of this equipment is new for the Engineering and Agronomy Faculties, both have some of it, and this reduces costs due to the cooperation that the program receives from such Faculties. This situation occurs in Medellin and favors the program by reducing the need for purchasing equipment.

The following are the laboratories that exist in both Faculties in which the program is based:

AGRONOMY FACULTY:

Soils laboratories
Biology laboratories
Physiology laboratories
Chemistry laboratories
Farm Machinery laboratories
Irrigation and drainage laboratories

ENGINEERING FACULTY:

Physics laboratories
Strength of materials laboratories
Hydraulics laboratories
Soils physics laboratories
Mechanics laboratories

For Agricultural Engineering courses, the Farm Machinery, Irrigation and Drainage laboratories have been improved. New equipment has been obtained for Rural Construction, Rural Electrification and Processing laboratories.

A computer center, equiped with IBM 1620 can be used for the Agricultural Engineering program and in it the students make the laboratories of the programming courses and are able to process research data.

IX. LIBRARY.

The Agricultural and Engineering Faculties have a good library, in which both staff and students are able to obtain more or less complete information required for the courses. A new file system is being organized to attend Agricultural Engineering; it consists in re-equipping and reclassification of the titles.

X. GRADUATES.

In December of this year the first students will be graduating. This group initiated the program in 1965 and it is hoped that they will open the way to have a good application of all the topics related with Agricultural Engineering, showing the errors and the necessary corrections to obtain good results in the application of Engineering to the Agricultural Industry. The job opportunities are very wide and some of them plan to go to graduate school.

Theme 4.

24. AN UNDERGRADUATED LEVEL CURRICULUM PROJECT FOR AGRICULTURAL ENGINEERING IN PERU by Jorge Quiroz, Herbert M. Lapp, Shunil E. Roy, Alberto Arnillas.

1. The Philosophy.
2. Comparative study.
3. The needs.
4. Recommendations.

1. THE PHILOSOPHY.

Stablishing the Agricultural Engineering Philosophy, one of the speakers has said:

"Agricultural Engineering has as a base the following mathematical sciences: Physics, Chemistry, Sociology, Biology, and also needs Engineering knowledges, that are applied to agricultural problems; it is not engineering applied to agriculture, it is Engineering and Agriculture, being more important the first one, for it presents new work philosophies and new methods. Agronomy seeks solving biological problems; and other Engineering branches such as: Civil, Mechanics, Electrical, etc. are different from Agricultural Engineering because their professions do not cover natural sciences nor deal with agricultural problems.

Agricultural Engineering studies agricultural problems and solutions, in areas such as: rural physical planning, farm machinery uses to increase production, studies storage problems, water and its conduction, storing and market processing food products for an effective conservation technique; has designs for rural housing problems and of so many topics that the list to number them would be endless. Agricultural Engineering solves infra-structure problems. Seeks that man belonging to the rural area or wanting to belong, or the indian andean culture man that wants to remain forever in his land, be technically grouped and to assure him facilities and services. Agricultural Engineering will provoke an orderly integration of men forming comunities, this is done previous to the social, economic and agricultural studies."

Later, the underwritters agree in the following point:

Industrialization and technification is the aim of agricultural engineering profession. Integrating capital resources with natural and human resources. In the case of sub-developed countries, agricultural production is linked to the use of natural, biological and labor resources. In the developed countries the integration also takes into account the use of capital and modern techniques adapted to local conditions.

From the first Symposium of Agricultural Engineering, important conclusions were given, despite the fact that at the start some divergent points of view were expressed, due to well defined concepts, the conclusions were set as guides for the Undergraduate Study Plan. It was stablished the need of a broad base program in Agricultural Engineering, graduates should have only a vias rather than a specialization in any of the departments. Hence a speaker said:

"The University has to teach all fundamental humanistic topics. The students should have all necessary knowledge with a strong methodological base, so they would develop a creative mind to solve totally their problems. It was concluded that knowledge should not further be divided towards a sophisticated development. An opposition was expressed towards unilateral specialization. It was demonstrated too that a true universitarian teaching is that of solving society and world questions. In regard of specialization courses, it mentions of being of high quality the content and should deal with the reality.

Phrasing what a graduate student from Agricultural Engineering said:

"More agronomic knowledge was lacking of the different plant varieties we have under production and whose operation we want to mechanize" furthermore, he said "... It is known that the University prepares highly specialized professionals, neither the government nor the private enterprises have but a limited capacity to hire them, and we have graduates that work in a different area of their specializations" (referring to departamentalization).

The final UNSF-40 Report Project gives the basic philosophy to be followed: the necessity of a broad base program in Agricultural Engineering. This point of view has been accepted by Northamerican and by European experts after visiting our Program. Besides, Departmental Heads spoke in favor of having a broad base undergraduate program for Agricultural Engineering, seeking specialization at a higher level of education. These points clarified after a series of discussions carry, the following appreciations: Agricultural Engineering is a branch of Engineering just as: Mechanical Electronic, Civil, etc. are, and hence it is already a specialization within Engineering. Agricultural Engineering comes to be a young profession related to the other branches.

The great difference with other Engineering professions is that Agricultural Engineering deals with rural population interests, tries to improve productive means, implementing and improving infra-structures, and brings to the farmer modern technology. This is an important fact, since 2/3 of the world population has a rural habitat, and works in agriculture. To improve standards of living, then it is necessary to distinguish and to reinforce the professional principles of Agricultural Engineering. This is true in developing countries that are the ones with bigger rural populations. These countries are the ones that need most Agricultural Engineering to implement their environment by means of industrialization and infra-structural works. Consequently, Agricultural Engineering students need social and economical studies, biological sciences, basic engineering, and specialization sciences; related to agricultural production and to live in the rural areas, this preparation seeks professionals capable of doing their jobs.

It is a necessity of giving more basic engineering to the students, in this way the graduate will have a better ground for his professional work; in our countries we have broad applications for them. In the other hand, a deeper specialization comes through professional experience or through post-graduated studies. This specialization is important, but is not the task for an undergraduate curriculum.

2. COMPARATIVE STUDY.

A table has been prepared to stablish some valid conclusions from the experience gained in different Universities, the table presents information from: National Agrarian University of Peru, National University of Colombia, Udaipur University of India, and the Universities of Florida and Illinois in the U. S. A. The table has the 1963 and the 1964-7 programs of National Agrarian University, also the recommended program done by Dr. C. W. Hall, Education Consultant of UNDP-80. Finally the program recommended in this paper is also presented.

In regard of the National Agrarian University, the following can be established:

The study plan is of the highest academic technical level, the student can arrive prematurely to specialization, without an integral formation of Humanities and of the environment. This is because of the flexible possibilities the program offers. It is important to diminish the elective load and adding instead more Humanities and basic sciences.

The change has to be accompanied of some course content modifications, seeking a more general formation in Agricultural Engineering.

It is important to note that the program development has permitted the integration of graduated courses.

	Proposed Program in this Report	Dr. C. W. Hall Recommendations	Colombia's National University	Udaipur India	Florida U. S. A.	NAU Prog. 1964-7	NAU Progm. 1963	Univers. Illinois U. S. A.
Humanities and Social Sciences	14.0	8.5	9.5	3.0	17.0	9	9	19
Basic Sciences	24.0	25.0	28.0	28.0	26.7	18	20	20.5
Basic Engineering	29.0	30.0	21.5	30.5	23.5	26	27	22.0
Applied Agricultural Sciences	9.0	9.0	5.5	11.0	5.2	11	14	10.5
Agricultural Engineering	14.5	18.0	28.0	21.0	15.0	12	11	11.9
Electives	9.5	9.5	7.5	6.5	10.8	24	19	16.1

From the table the following thoughts can be derived:

Illinois University offers 16.1% in elective courses, and the National Agrarian University by comparison offers 24%, but the program suggested by Dr. Hall and by us calls for 9.5%.

Specialization courses in Illinois reach 20% in Florida 25.8%, in India 27.5%, in Colombia 35.5% and in our proposal 24%. In the Colombian case there is a smaller need of humanities and a basic engineering.

The lowest percentage of basic sciences are taken in Peru, and in Humanities the lowest percentage is presented at Udaipur.

In applied sciences Florida and the Colombian Universities offer the lowest percentages: 5.2% and 5.5%

Considering the great specialization in the United States Universities is important to point to Latin American Universities to look for a well balanced program, reducing courses of over specialization.

3. THE NEEDS.

Professional education in its earlier stages, gives a general basic education. Later professional education is given by means of applied knowledges. Therefore, Agricultural Engineering Programs should follow this line. The first stage would present courses in Humanities, Mathematics, Basic and Applied Agricultural Sciences; later, Engineering applied to agriculture. Flexibility has always to be taken into consideration so that specialization courses could be chosen within one of the four program areas.

The Bachelor's degree equips the students for immediate work and also prepare him for higher studies. The Bachelor's degree should not mean an overspecialization, the graduate should know well fundamental principles and know to apply them; nevertheless, the Program should be flexible enough so the student can take some courses in areas he likes according to his vocation and future plans. Specialization comes after graduation, by courses or by constant work in a same line.

Morever, it has to be considered that graduates switch works when they start their professional activities in Agricultural Engineering.

Emphasis should be given to the teaching of the fundamental principles of the Agricultural Engineering profession. This means a heavier load of courses in Humanities, Mathematics, Physics, Chemistry, Biological Sciences, etc. then basic Engineering knowledge should be given, such as: Statics, Thermodynamics, Fluid Mechanics, Electricity, etc., and Agricultural Engineering courses as: Plant Design, Irrigation System Design, Farm Machinery, Rural Design, etc. All Agricultural Engineering courses should include agricultural and habitat applications. Dosification, in the other hand, is important, velocity of technological changes is o great that we are not capable of giving students last hour improvements. One has said that it would take 25 years for a student to take all University materials in one branch. Likewise Universities tend to subdivide the applicative course number, we will not permit this event in Agricultural Engineering.

G. W. Giles in his work titled "A Frame Work for the Development and Improvement of Teaching and Training Agricultural Engineering in India", has said the following concepts.

"Science and Technology are necessary for Agricultural Engineering, they are very well interrelated; we first must learn and then we must know how to apply our knowledge to practical problems; at the end, we must have something that will serve agriculture or else we are not really Engineers.

The only element that differentiates Agricultural Engineering from other Engineering technologies is that the first one is applied to biological and organic material. Most of the things Agricultural Engineers do, directly or indirectly, influence plants and animals, or their products and processes: seeding, adecuate fertilizers, irrigation with correct amount of water, crop development, processes, market and manufacture are a part in the quality and quantity of the final product. We are working in Engineering as it were a system of raw biological production, but we are not concerned in educating and training young people to do a better job in the future than the one we did in the past.

We should also be concerned with the mechanism of these biological materials, such as we are concerned with external production systems. What happens inside plants and animals can be explained, regulated or changed by scientific laws and engineering laws; that is why we need to know more about the internal mechanisms.

Bio-engineering systems are the most complicated things on earth because organic matter is restless and changes constantly from birth till death. In the other side, our educational system should develop the necessary aptitudes and to impart all teaching materials to prepare students in this new Engineering profession. We need basic and fundamental points from the biological sciences such as: plant and animal physiology".

Education really is solving problems with thinking tools. It is not only pure and applied sciences the resolutive elements for a decision taking man; they are also humanities; the points for Agricultural Engineering that links man and land.

Higher mathematics are studied for two reasons, the first one is because it is the only way to express relations precisely and universally; and the second reason, is because it is a way of educating the mind to think in a more ordenate and efficient way.

Technicians use less the mathematical tools than the scientifics. But he has to study them as well for the mentioned reasons, and besides for the necessity to have a better understanding of scientific advances and to apply them to the new technical methods.

Science and technology are used and applied in Agricultural Engineering. Science is the knowledge that governs general truths and the applicative laws that have been obtained through experiments and scientific methods. Science is also the discovering of new thoughts that are valid and up to date, technology in the other hand applies scientific and derived knowledge.

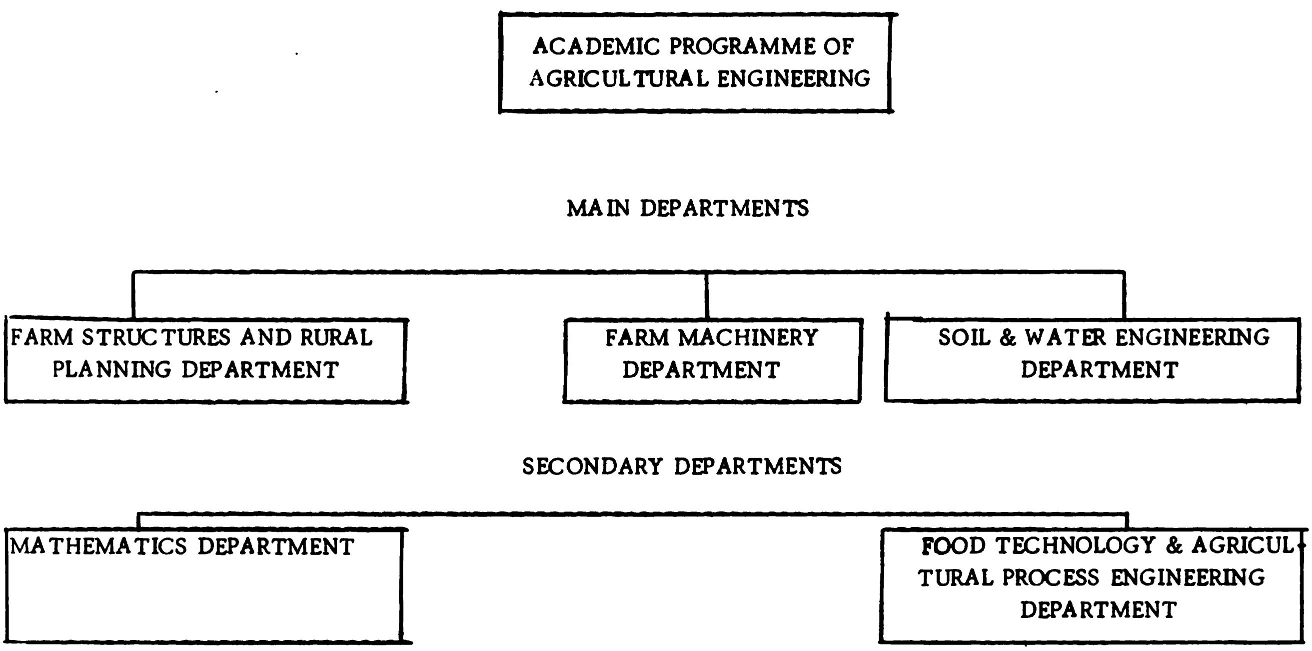
In regard of the Staff of a Higher Education Center, we can remember the concepts of philosopher Vossier and of Nobel Prize Winner Haussay, they have said: "Professors that only teach and never do research could be well called school teachers, and within the hierarchy of a University could be properly called sargents". If a higher education institution forgets research, the institution should not be called a University. But if a technical school practices research it has the University category".

4. RECOMMENDATIONS.

From the detailed Curriculum of Studies review, and in accordance with the Experts recommendations, there is a necessity of incrementing studies in: Chemistry, Statistics, Electronics, Physical Principles of Biological Materials and Humanities.

The Program to be proposed has all these topics, with the exception of Physical Principles of Biological Materials, that is recommended as an elective course to be taken as one of the more important for the Bachelor's degree students. Preparing the curriculum, the new University law was taken into account. The law establishes departmental organization for all National Universities, but for our case this is not something new, the new law gives the name of Academic Programs to what our Faculties used to be.

The curricular structure of certain Academic Departments determine the Academic Program of Agricultural Engineering. The Program is under a director and presently it is formed as follows:



The main Departments have a wider participation in the Program. Having a greater representation and interest for the professional formation.

To obtain the Bachelor's degree in Agricultural Engineering the student has to approve 200 unit cre that are divided in the following way:

80 units of general studies
120 units of professional studies

The general basci cycle is for all universitary students, this is a formative period, giving the students a balanced plan of scientific and humanistic courses. The system is flexible and grants, after completing the 80 units a diploma.

UNDERGRADUATE CURRICULUM

(Bs. in Agricultural Engineering)

Basic two-year general study period.

FIRST YEAR.

General Biology	4	Microbiology	4
Mathematics I	4	Mathematics II	4
General Inorganic Chem.	3	Physics I	4
Introduction to Biology	4	Evolution of Universal Cult.	3
Spanish	2	Principles of Economy I	3
Introduction to Philosophy	3		
	20		21

SECOND YEAR.

Mathematics III	4	Spanish Writing	2
Physics II	4	Meteorology Hydrology	3
Organic Chemistry	3	Evolution of Peruvian Cult.	3
Principles of Economy II	3	Statistics Fundamentals	
General Anthropology	3	Electives	7
Electives	3		
	20		19

Suggested courses for Agricultural Engineering:

Mathematics IV	4
Geology	3
Descriptive Geometry	3
	10

Three year professional program.

THIRD YEAR

Edafology	4	Crop Sciences	4
Mathematics for Engineers	3	Strength of Materials	4
Surveying I	1	Surveying II	3
Statics	4	Dynamics	4
Materials Science & Building Construction	3	Animal Sciences	4
Technical Drawing	2	Manufacturing Process	2
	19		21

FOURTH YEAR

Thermodynamics	3	Heat & Mass Transfer	3
Structures	4	Machine Design	4
Theory of Machines	3	Heat Engines	3
Electrical Engineering	3	Electronics	3
Fluid Mechanics	4	Rural & Industrial Laws	2
Electives	3	Applied Hydraulics	3
		Electives	3
	20		21

FIFTH YEAR

Rural Design I	3	Engineering Economics	3
Soil and Water Conservation		Rural Planning	2
Engineering	3	Farm Machinery	3
Farm Power	3	Irrigation and Drainage	3
Process Engineering	3	Design of Processing Plants	3
Electives	8	Electives	5
	20		19

CONTENT

ANALYSIS OF THE PROGRAM

A. HUMANITIES AND SOCIAL SCIENCES.

	Cred	Percent	
Principles of Economics I	3		
Principles of Economics II	3		
Introduction to Sociology	4		
General Enthropology	3		
Evolution of Universal Culture	3		
Evolution of Peruvian Culture	3		
Spanish	2		
Introduction to Philosophy	3		
Spanish Redaction	2		
Rural and Industrial Laws	2		
	28	14%	
B. BASIC SCIENCES AND STATISTICS			
BIOLOGICAL SCIENCES:			
General Biology	4		
Microbiology	4		
	8	4%	
PHYSICAL AND CHEMICAL SCIENCES:			
General Chemistry and Inorganic	3		
Inorganic Chemistry	3		
Organic Chemistry	3		
Physics I	4		
Physics II	4		
	17	8.5%	
	25		12.5%
MATHEMATICS AND STATISTICS:			
Mathematics I	4		
Mathematics II	4		
Mathematics III	4		
Mathematics IV	4		
Mathematics for Engineers	3		
[illegible]tics Fundamentals	4		
	23		11.5%

C. APPLIED SCIENCES.

	Cred.	Percent
Geology	3	
Edafology	4	
Crop Science	4	
Animal Science	4	
Meteorology and Hydrology	3	
	18	9%

D. BASIC ENGINEERING

Descriptive Geometry	3	
Technical Drawing	2	
Surveying I	3	
Surveying II	3	
Statics	4	
Dynamics	4	
Structures	4	
Strength of Materials	4	
Materials Sciences and building Construction	3	
Fluid Mechanics	4	
Thermodynamics	3	
Heat Engines	3	
Theory of Machines	3	
Machine Design	4	
Heat and Mass Transfer	3	
Electrical Engineering	3	
Electronics	3	
Manufacturing Process	2	
	58	29%

E. AGRICULTURAL ENGINEERING

Rural Design I	3	
Rural Planning	2	
Soil and Water Conservation Engineering	3	
Applied Hydraulics	3	
Irrigation and Drainage	3	
Farm Power	3	
Farm Machinery	3	
Process Engineering	3	
Design of Processing Plants	3	
Engineering Economics	3	
	29	14. 5%

F. ELECTIVES	19	9. 5%
Total:	200	100. %

This Curriculum and analysis is offered for consideration in the development of the most appropriate and suitable program in Agricultural Engineering to serve the best interests of Peru and the Latin American Region.

ELECTIVES.

A. From the University Departments.

Biological Sciences:
Botany, Zoology, Plant Physiology, Animal Physiology, Genetics, etc.

Physical Sciences:
Inorganic Chemistry II, Organic Chemistry II, Special Bio-chemistry, Instrumental Analysis I, Physical Chemistry, Chemical Technology, Advanced Physics, etc.

Applied Sciences:
Climatology, Soil Physics, Soil-water-plant Relationships, Soil Chemistry, Agrometeorology I, Hydrometeorology, Geography of Development, Use of Forest Lands, Wood Technology.

Mathematics & Statistics:
Computer Programming, Nomography, Dimensional Analysis, Matrices, Differential Equations, Statistical Mathematics I, Advanced Statistics, Statistics for Engineers.

Social Sciences & Humanities:
Rural Sociology, Rural Administration, Development Economics, Development Planification, Agricultural Economics, Principles of Business Management, Econometry.

Food Technology & Agricultural Products Processing:
Unit Operations, Principles of Processing Engineering, Processing Plant Design, Materials Handling and Transport Energy Computation for Handling and Processing Equipment Distribution, Machine Design.

B. From Departments within Program of Studies.

General Agricultural Engineering.
Research Methods in Agricultural Engineering, Instrumentation for Agricultural Engineering, Energy Conversion Systems, Physical Principles of Plant Environment, Physical Properties of Biological Materials.

Soil & Water Engineering.
Hydrology, Flow through Porus Media, Hydraulic Machinery, Turbines and Pumps, Water Resources Development Engineering, Water Shed, Management Systems Design, Photogrammetry and Interpretation, Irrigation Systems Designs, Soil and Water Engineering Structures, Administration and Operation of Land and Water Resources, Erosion and Transport of Sediments, etc.

Farm Structures and Rural Planning.
Soil Mechanics, Reinforced Concrete, Advanced Structural Analysis, Rural Sanitation, Environment Control Engineering, Rural Planning Design II, Rural Electrification, Animal Housing Design, Design of Storage Structures.

Farm Machinery.
Harvesting Machinery, Harvesting Machine Design, Farm Machinery Applications, Earth-moving and Land Forming Machinery, Optimization of Engineering Systems, etc.

Theme 5 : GRADUATE EDUCATION IN AGRICULTURAL ENGINEERING IN LATIN AMERICA

25.. REQUIREMENTS FOR GRADUATE STUDY IN AGRICULTURAL ENGINEERING by Robert G. Yeck, Consultant FAO.

A graduate study program in Agricultural Engineering requires consideration of: (1) The reasons for which graduate training is being provided; (2) the standards to be maintained and the resources to be provided by a university in fulfilling this need; (3) the preparation of the students prior to entering a graduate program; and (4) the needed promotion and support of graduate training. These requirements for graduate training programs are the same throughout the world. However, when one looks within each of these considerations, Latin America is shown to have its own specific requirements. These requirements also differ among countries and regions within Latin America.

Why Graduate Training ?

The need for training agricultural engineers to meet the challenge of progress in Latin American countries has been well established. But, why does Latin America need graduate training ? Graduate training, of course, provides an opportunity for a student to increase his proficiency. But, what does this mean? Increased proficiency may mean specialization in a relatively narrow area to fit a highly specialized technical assignment in teaching, research, agricultural advisory work or industry. On the other extreme, it may mean broad training to meet requirements of some teaching and advisory jobs, some industrial assignments, and most administrative duties. Some students will know who they will work for and what they will be expected to do upon graduation. Others simply will be seeking to improve their job opportunities. The latter will probably make choices according to their personal preferences and their confidence that opportunities will be available upon graduation.

Job opportunities will most likely align with traditional subdivisions of agricultural engineering such as farm power and machinery, soil and water management, electric power and processing, and rural structures and planning. Rapidly changing social and technological developments are adding to these basic subdivisions. Bio-engineering and forest engineering are examples. The terms we use to categorize special study areas are useful and important in establishing administrative control and communication. Of much greater importance, however, are the problems that need to be solved and where they occur. Too many times emphasis is placed on graduate study as a means for advancement in an academic institution or to help establish a reputation as a researcher. Indeed, graduate study serves these purposes but the overall goal is solving the problems of people -- society. These problems vary widely. Andean problems differ from those of the jungle. Small farms require different solutions than large farms (both need attention). There are differences in social patterns, customs and government. The variety of problems points to the need for flexibility in graduate programs.

Adequate supplies of food and fiber are the usual goals for agricultural technological improvements. Thought must be given toward the needs of tomorrow as well as today. The consumer's needs for kinds, quantity and quality must also be considered.

The sale of agricultural products is an important aspect of the national economy for many nations. Therefore, technology must be progressively improved to maintain a competitive position.

Another aspect of people's needs is the maintenance of income for farm families and rural communities. Just as a nation depends on products sold in international trade for procuring its import needs, so does an individual community. Last year, I visited one small community in the Andes that consumed 82% of its agricultural production. Practically all of its manpower efforts were required for that production. Little purchasing power was left for improvements that would greatly enhance community welfare. Helping these people improve their income as well as reduce the cost in obtaining improvements (sanitation, water supply, electricity, housing, etc.) requires engineering inputs.

Today, great emphasis is put on improving the quality of the environment. Agricultural operations, crops, livestock, and the people who engage in agriculture may be adversely affected by pollution and the lack of conservation. In addition, those outside agriculture may be affected by impairment of the environment brought about by agricultural operations. Here again agricultural engineers have a major role.

The preceding discussion of the many facets of the problems is given to emphasize that our agricultural engineering graduate students must think and study with goals beyond engineering design calculations. They must have a knowledge of each system as a whole. They must be able to understand and cooperate with specialists of other disciplines. Those who lead programs involving farm machinery design must think not only of the adequacy and efficiency of the mechanical design but also the characteristics of soil, climatic conditions, the soil environment, plant requirements, availability and skill of labor, marketing, financing, and the requirements for harvest.

So far I have stressed the immediate application of training. This has been deliberate. Basic research efforts to advance science knowledge certainly are important. However, the immediate problems in South America seem so pressing that the preparation of students for pure scientific effort should take a secondary role to meeting the immediate needs of society-- namely, applied, research, development and education.

What is Required of the Institution?

Colleges or universities have requirements that they must meet to provide an adequate graduate training program. They must provide: An environment that will attract outstanding faculty and students for scholarly study and research; a well-qualified faculty; adequate facilities and resources for research and study; financial resources; and adequate curricula.

The nature and content of curricula for graduate training is the topic of the next speaker. They should be developed to provide students with knowledge, dexterity in application, and judgement in decision making (as well as to meet standards of acceptance among other colleges). Of course, curricula by themselves do not mean success.

An adequate faculty is essential. This means adequate numbers, training and ability. Adequate numbers are needed to provide a variety of approaches and fully supply the needs of the curriculum. No specific criteria exist for the number of courses one person may instruct; but, certainly two or three qualified faculty could not cover all areas of graduate agricultural engineering training. It would be better to have them limit themselves to relatively narrow areas of specialization. They could identify themselves as a "center of excellence" in that area of specialization and perhaps draw more students than they would by sponsoring a broad program.

Faculty members who lead graduate programs should be trained at least to the degree level being offered their students. It might not be so necessary for courses that are somewhat less related to the area of specialization.

In addition to initial training, opportunities should be provided for continually updating the knowledge and improving the ability of the faculty. Sabatical training, visiting professors, scientific society activities, and inter-university seminars are examples.

At this point I would like to interjet support for the inclusion of training for faculty in methods of instruction and training aids. Many times faculty members have very adequate knowledge but don't adequately communicate it to the students. The ability to teach is often considered an art. It is true that some people have more of this talent than others, but training in communication and diligent effort can greatly improve teaching. Equally important is the need for administrators to adequately reward good teachers. In United States ' universities a tendency exists to base salaries on research accomplishments with little reward given to good teaching. I would hope Latin American universities would do better.

Research should not be disregarded. It provides the opportunity for developing individual initiative, dexterity and judgement in solving problems. Research facilities must be provided for graduate students. These include: A reference library; a place to conduct research; instruments and other resources to measure and analyze results; financial and subprofessional resources; and a means of publishing results. Many think of research laboratories and extensive instrumentation for measuring results when thinking of needed research. Neither may be needed in many of the applied research problems now facing South and Central America. I would encourage field research studies for most of the graduate students during the next several years. In providing research facilities and a curriculum the opportunity to use the resources of other departments, universities, or governmental and industrial laboratories should not be overlooked.

Financial resources are inherent in all requirements but are mentioned as a separate item because graduate training requires substantial support per student.

An attractive environment not only includes pleasant and attractive housing, offices and classrooms but also a friendly and cooperative relationship among and between faculty and students. This cannot be attained by edict but starts with the administrators and filters downward. Friendly approaches to problems, sound and fair administrative policies, and careful selection of new faculty members are needed.

What Must the Student Provide?

In the United States, the first answer would be, money! But assuming that this worldly need has been met, let us look at the prerequisites for entering graduate training. Paramount, of course, is the ability and desire to learn. The student should also know his choice of an area of specialization.

Optimum use should be made of :(1) The student's own time and resources; (2) the faculty's time; and (3) the resources provided by the university. This requires adequate undergraduate preparation to meet the prerequisites of the graduate school and the specific courses in which the student plans to enroll.

Undergraduate programs have been discussed by previous speakers but I would like to speak of the need for flexibility in establishing prerequisites. Since the opportunities for undergraduate degrees for the "Ingeniero Agricola" are very limited in relation to the needs of Latin America, graduate entrance requirements should be established that would permit the entrance of the "Ingeniero Agronomo" who would be willing to perform the extra work needed to attain professional competence in a relatively narrow area of specialization. Such graduates would not have the flexibility of assignment of a broadly trained "Ingeniero Agricola" but I consider such a program necessary to speed the improvement of education and technology in Latin America. Flexibility is also needed to provide agricultural training for other engineers (civil, mechanical, etc.) who wish to attain graduate degrees in agricultural engineering.

Supporting Graduate Training

Financial support to meet the budget of a university is an obvious need. "How much and who provides the money?" is another story. Competition for available money resources is everywhere. Educational institutions seldom can develop and operate on fees charged the students. Other support is necessary. Whether this support comes from local or national taxes, the church, local or national fund drives, or grants and gifts from sources outside the country, they must be solicited and promoted. Such solicitation and promotion requires the combined effort of many people. It would be interesting to list all who have worked toward developing the graduate program at La Molina. Academic, sociological, governmental, professional society, alumni, agricultural, and industrial interests are resources for initiating support for a graduate program.

Once started, other established graduate programs within the university should be encouraged to cooperate. Students and faculty need to be recruited. Those who help initiate a graduate program should realize that they started a program that needs continuous attention on their part. The agricultural and related equipment industries should realize that they can and should provide opportunities for conducting research. These may be in the form of direct monetary support or indirect assistance such as furnishing field or laboratory space, equipment, or services. Of course, the graduate program must demonstrate, through performance, the need for this support. It must produce accomplishments that reflect technological advancements. Advancements in knowledge are important contributions, too. This helps recruit faculty and students but generally does not draw support from industry and economists who make governmental budgetary decisions.

There are other forms of support needed too. Encouragement by the press and public at large, promoting job opportunities and placement of graduates are examples.

Summary

The requirements for graduate study in agricultural engineering have many facets. They begin with an analysis of the reasons for graduate training. They involve considerations of institutional resources, curriculum development, prerequisite training, and outside support and promotion. Latin American needs for highly skilled and trained agricultural engineers are tremendous. The needs for rapid technological development coupled with shortages of trained agricultural engineers suggests that current emphasis should be placed on applied engineering research and that curricula and prerequisites should have flexibility to meet the diverse situations that exist in Latin America.

Theme 5:

26. WHAT SHOULD BE THE NATURE AND CONTENT OF GRADUATE AGRICULTURAL ENGINEERING PROGRAMS IN LATIN AMERICA. by Wesley Hobbs, Project Leader in Agricultural Engineering and Norm Teter, Associate Professor of Agricultural Engineering, University of Nebraska, Mission in Colombia.

The question - "What should be the nature and content of graduate level agricultural engineering programs in Latin America", requires the attention, and sincere consideration of every agricultural engineer and agricultural university administrator in Latin America, and all foreign advisors concerned with agricultural engineering in Latin America. Latin America cannot afford less than this sincere attention and consideration.

Basic Requirement.

The basic requirement of graduate programs in agricultural engineering is that they be "professional in nature". Therefore, they must be based upon a firm foundation of mathematics, physics, and engineering. Any programs not of this nature should, and must be labeled as they truly are "mechanized agriculture or farm mechanics". It is not only academically dishonest to label such programs as "professional agriculture engineering", but is also highly detrimental to the development of the profession of agricultural engineering and as a result to the agricultural development of Latin America. This is not to say that there is no place for the "mechanized agriculture" curriculum in a graduate or undergraduate program. Of course there is. However, it should be "in addition to", rather than "in place of" the professional agricultural engineering curriculum. In a time related development of institutions of research, teaching and extension the profession of agricultural engineering should have priority over "mechanized agriculture", because design, fabrication and engineering studies of the proper machines and equipment must proceed study about their use. Service courses in machinery are, of course, a different question.

Specialization- Depth vs Breadth.

Graduate programs, on the Master of Science level, should not be so narrowly specialized that they do not provide sufficient breadth to enable an understanding of, and cooperative research efforts in, the fringe and overlapping areas of agricultural engineering. The amount of course work and/ or other experiences necessary to attain this breadth will depend upon the amount of specialization on the undergraduate level. However sufficient specialization must be provided to assure reasonable competence in problem solving and in the major field. It is a regrettable situation when, for example, an irrigation and drainage engineer, working on a land development project, has little or no knowledge of the machinery requirements of the development work and of the subsequent farming operation.

Emphasis Upon Problem Solution.

Major emphasis must be upon the techniques of problem solution rather than upon the memorization of more facts and figures. The agricultural engineer must be a specialist in transforming ideas and dreams into reality. He must be a solver of problems, a realist. and a man of action. He must be capable of thinking through the problems currently hindering agricultural development in his country and arriving at solutions that work efficiently. This naturally requires that he have from his undergraduate studies, as well as from certain graduate studies, a sound basic reservoir of basic knowledge and the sources for additional knowledge.

However, more than facts are requered. If an agricultural engineer is information oriented, rather than problems oriented, his effectiveness is generally impaired. He frequently cannot proceed in the absence of sufficient (in his opinion) published information, which he frequently considers the only source of knowledge. He frequently spends excessive time on data gathering. He has too much faith in the infallibility of neat, mathematical solutions and too little faith in trail-and error experimentation. He frequently thinks that there is only one correct answer to a problem.

Graduate students must have training and experiences in the exercising of judgement . We all agree that experience is the best teacher, however, we must remember that experience can be vicarious as well as actual.

Graduate students must have assistance in learning how to cut through extraneous materials to the core of the problem be studied.

Graduate students must have experiences in the gathering and determination of pertinent data and the degree of accuracy needed in the solution of a particular problem. Again the exercising of judgement is needed here.

Because of the general lack of agricultural experience of the vast majority of students, and the general unsatisfactory quality of laboratory experiences of undergraduate students, we in the graduate programs must place greater emphasis upon laboratory teaching in the technical course work. We must utilize, for those experiences, the facilities of our formal teaching and research laboratories, the field, and especially in the area of processing, near-by industrial facilities. We must at the same time, maintain a high standard of quality in the theory part of our classes.

The students general lack of confidence in the application of theory necessitates the organization of our theory and laboratory teaching in such a manner as to provide meaningful and successful experiences of a problem solving nature. Design courses and special design problems are a necessity. This experience is far too important to be left solely to the thesis research problem.

Design problems should, whenever possible, be followed by the construction of the project in the laboratory or in the field. This is probably more necessary in the area of machinery design, but is important in all areas. The construction of prototypes and the field installation of other designs will require that graduate programs have well equipped laboratories, and an adequate number of well-trained sub-professional technicians. Where graduate teaching and research are highly integrated, as I believe they should be, these technicians can be of tremendous assistance in the support of laboratory teaching activities.

Shop mechanics and laboratory technicians working in harmony with graduate students help to furnish further valuable training because they help to bridge the communication gap that sometimes lies between the professional engineer and the farmer or factory worker.

Research and Development.

Research should be based, largely, upon the current and high priority needs of the agricultural producers, product processors, and the machinery and equipment manufacturers. This requires that the graduate program professors must be familiar with these industries. It is not sufficient that graduate professors work on only those problems that are reported to them by these groups. Frequently, and especially in the case of farmers, these people cannot really identify the problems they have.

The development of the agricultural equipment and machinery manufacturing industry should be a high priority project in Latin America. Agricultural Engineers can, and should, play a major role in this endeavor. Even if sufficient foreign exchange currency were not a problem, and it is a serious one, much of the imported equipment is not suitable for tropical and sub-tropical agriculture. For example, the North American potato planter will not function properly in the tropics where whole potatoes must be planted because of disease problems. Where for example, can you buy a yuca harvester, or a kikuyo sod cutter? Why, for example, should Colombia purchase farm machinery, except for the highly sophisticated ones such as the large tractors and combines, when it is self sufficient in steel production, and has the capability to manufacture them? Why, for example, should Colombia continue to pay a license fee for use of certain North American and European designs in order to manufacture them in Colombia when it now has in training agricultural engineers who can make such designs?

The new Latin American regional trade associations such as the Andes Group should, in the very near future, make possible for virtual self sufficiency in farm machinery and equipment manufacturing. The graduate programs in agricultural engineering must, through their teaching and research programs, play a leading role in the rapid development of this critical industry. We cannot afford to let this opportunity pass us by.

Comprehensive Programs.

To comprehend means to have an awareness, and this awareness comes from contact of the senses with the exterior contacted, which represents the actual basis for future problem solving. Therefore graduate students cannot all be trained in a foreign environment and adequately comprehend the one in which they later work.

We must guard against erecting rigid walls of isolation between the areas of soil and water, power and machinery, structures, and processing; or any of the little barriers that groups of professors may want to erect around private areas of endeavor.

A power and machinery engineer, for example, must have a fair knowledge of irrigation, drainage, and conservation engineering, and also of process engineering in order to design machinery for these areas of work.

He must also have the cooperation of engineering specialists in these areas if his design efforts are to the most efficient.

Latin America has, for too many years, had narrowly trained but highly specialized soil and water engineers with little or no understanding of machinery who are working alone on agricultural development projects. While most of these projects have been technologically successful from the irrigation and drainage aspects, they frequently have not been economically feasible as production units. Why? Largely because of the lack of proper consideration in the selection and use of land development and crop production machinery.

Latin America cannot afford this type of segmented approach to its agricultural problems. Let us so organize our graduate level teaching and research so as to maximize the quality of experiences necessary in the comprehension of the interrelated factors needed in a specialized field. While students must be taught to not fear the "trial and error" approach to problem solution, he should, at the same time, be provided with the necessary depth and breadth of training so as to minimize the necessity of excessive use of the "trial and error" approach. Above all we must condition him, through participation in cooperative efforts, so that he is willing to seek advice and assistance in the fringe areas of his work.

Cooperative Efforts.

With the assistance of industry, agricultural engineers design and fabricate machines, systems and facilities for agricultural production and processing. We do not produce basic commodities, for this reason cooperation with the professional staff in the areas of the plant and animal sciences and in agricultural economics is essential. It is our ability to communicate with these people, and to comprehend many of their problems and data, that make us different from civil, mechanical, and architectural engineers. We must encourage this cooperation among our graduate students. We must give them opportunities to participate in meaningful cooperative efforts. They must be made to realize that we depend upon other disciplines for much of the basic agricultural data, as well as judgements, which make our designs functional.

Educational Facilities.

Facilities for teaching and research must be adequate but need not be elaborate. We must guard against sacrificing essential laboratory equipment in order to obtain elaborate buildings. We must impress upon our students, through actual experiences, that the field, the factory , or the processing plant is where the problems arise and must ultimately be the place for many of the final solutions. The formal laboratory is the place to carry out those investigations which cannot be easier carried out in the field, and to provide supporting facilities for those which are carried out in the field.

Any graduate program in Latin America that does not avail itself of the use of nearby industrial facilities is missing a wonderful opportunity for meaningful educational experiences. In Colombia these processing and manufacturing plants, and nearby specialized farms have been a tremendous value to our graduate programs.

Last, but not least, I want to emphasize that Latin American Agricultural Engineering Programs should be designed and conducted in such a manner as to provide solutions to Latin American agricultural problems under the conditions that exist in the various geographical regions, and with the available human, physical, and financial facilaries that exist in each of the countries. They must, furthermore, have the means of perpetuating themselves on the undergraduate and graduate levels. Any program which does not meet these criteria will be, in a large measure, a sterile academic excercise.

Theme 6. FINANCING AND ADMINISTRATION OF AGRICULTURAL ENGINEERING TEACHING AND RESEARCH PROGRAMMES

27. FINANCING AND MANAGEMENT OF AGRICULTURAL ENGINEERING EDUCATION AND RESEARCH PROGRAMS by Arturo Cornejo, National Agrarian University, La Molina, Lima - Peru.

The experience which I shall discuss with you regarding the financing and management of agricultural engineering education and research programs is limited to the case of the National Agrarian University of La Molina, Peru.

I shall discuss the topic emphasizing those points which I feel are important within a complex and dynamic process. For a coherent analysis the following aspects must necessarily be considered:

a) A starting point which is closely related to the history of the development of the University.
b) The internal organization which was established within the guidelines of Peruvian University Laws since ours is a State University.
c) Its relationship with the community it serves and from which it receives the resources and stimuli necessary for its development. In our case: Peru's agriculture and rural environment.

Milestones in the University's History.

1. The present National Agrarian University of La Molina started its activities in 1902 as the National School of Agriculture, being then a division of the Agricultural Bureau of the Peruvian Government. The organization was entrusted to a Belgian mission of 5 professors, most of which remained in the country until they retired from teaching, that is, after 20 to 30 years of professorship. The Belgian mission organized the School within European guidelines and developed a tradition of discipline and dedication to studies.

2. In 1942 the Peruvian Government granted the National School of Agriculture academic and administrative autonomy. This is an important difference with other Faculties of Agriculture of other Latin American countries, which were developed within the structure of a National University. Autonomy made it possible for the School to organize its academic and administrative structure with greater freedom.

3. In 1952, with the sophomore and senior years, a limited attempt was made at giving elective courses which made it possible for the students to follow some given course within the broad field which, at that time, was covered by Agronomy. That year the School entered into agricultural research at a national level when, with the economic aid of the Rockefeller Foundation, it started what today is known as the National Corn Program.

   In 1953, there were 64 professors of which 22 were full time. The 5 years of studies had a total of 430 students. 70% of the University's budget was financed with the production of its farm and income from student tuition.

4. During 1954, to 1958, the elective courses for fourth and fifth year students were increased in number. The following areas were established:
   Agricultural Economics, Agricultural Extension, Fruit Cultivation, Agricultural Engineering, Plant Health, Soils, Tropical Cultivation and Animal Husbandry.
   There were 14 elective courses for the agricultural engineering specialty, among them were, surveying,earth moving and irrigation. Research Programs were increased specially in the areas of soils, animal husbandry, nutrition, grains, cotton and vegetable products.

   In 1958, there were 94 faculty members, of which 48 were full time, and 670 students. 45% of the School's budget was financed with the farm's production and income from student tuition.

5. In 1958, the school underwent an academic and administrative reform process which had the fol-

lowing objectives:

5.1. To organize the courses into more functional academic and administrative units entrusted with education and research, and the Departments started to take form.

5.2. To incorporate full-time professors with more than seven years of service in the university and student representatives into the School's government.

5.3. To change the system of study from rigid curriculums and year-round courses to one of flexible curriculum and semester courses.

5.4. To organize graduate studies.

5.5. To seek the assistance of international agencies, foundations and bilateral aid from governments desiring to cooperate with the School's development plans.

6. In 1960, the Peruvian Government gave a new University Law which changed the status of the School of Agriculture to that of Agrarian University.

6.1. The University was organized into departments which were the academic units entrusted with carrying out educational, research and extension functions. Faculties grouped the Departments important for training in any given profession.

6.2. A system of flexible curriculum was adopted. Academic performance is measured by credits. The flexible curriculum established three types of courses.

6.2.1. University compulsory courses which had to be taken by all students.
6.2.2. Faculty compulsory courses, which had to be taken by all students desiring to obtain the degree granted by the Faculty.
6.2.3. Elective courses, which permit the students to follow some specific studies according to their vocation or preference.

6.3. The number of full time professors increased,85% of faculty members were now full time.

6.4. Professors received training in outstanding foreign universities. From 1962 to date, 15 to 20% of full time professors were abroad studying for advanced degrees every year.

6.5. The Graduate School was created and the Basic Sciences Department were strengthened.

6.6. The adequate physical installations were planned, financed and built.

6.7. Research was promoted by means of faculty member evaluation regulations which emphasized research.

6.8. A magazine "Anales Científicos", where the results of the research carried out by University professors were to be published, was created.

7. In 1964, free education at State's Universities was decreed.

8. In February this year a new University Law was given. It has not been well received by the different sections of the University Corporation and as a result it could not be completely applied in the University.

Peru's Agriculture and Rural Environment.

Peru's Agriculture and Rural Environment have quite varied conditions which can be grouped as follows:

1. Physical Characteristics.

1.1. Varied climatic conditions- Tosi, in the report accompanying Peru's ecological map, comes to the conclusion that under Holdrige's classification 85% of the climates of the world can be found in Peru. Within a 350 kilometer cross section one can go from the dryest desert to the humid tropics crossing highlands of more than 4,000 meters above sea level.

1.2. Rough and abrupt topography. Uneven distribution of soil and water resources. In the coastal region water is the limiting factor. Agricultural soils are scarce in the highlands and run the risk of erosion. In the jungle region, there is abundant water but soils are lateritic, of low productivity and difficult to manage. 65% of Peru's area and 10% of its population lie in the jungle.

2. Social Aspects.

2.1. 51% of the population is dedicated mainly to agriculture.

2.2. Illiteracy is high in the rural areas. 68% of the peasant population is illiterate. The figure for urban areas is 10%.

2.3. At the departments of Huancavelica, Ayacucho, Apurimac, Cuzco and Puno the quechua language predominates over Spanish in the rural areas.

2.4. In Peru's highland some ancient community organization forms which have to be modernized still exist.

2.5. The capital and major cities exert great influence and atraction on the rural population. Young and ambitious elements tend to migrate to Lima and other major cities.

2.6. There is a marked social stratification between groups of different economic, educational or even racial levels.

3. Structural Aspects.

3.1. Existance of latifundia and minifundia (very large and very small landholdings).

3.2. Political and Economic power is concentrated in three pressure groups: the oligarchy, political parties and the army. Generally political parties and the army have been subservient to the economic power. The case of the present military government, of a nationalistic purpose, is an exception.

3.3. Existence of monopolies in the exploitation and marketing of the country's major resources.

3.4. Foreign dependence as regards to international market, capital investment and technological progress. Many of the important decisions are made abroad with no consideration given to the priorities and needs for a harmonious development of the country.

3.5. Defficient Development Plans. In most cases only partial and incomplete plans are available.

3.6. The communication, road and power networks are as yet incomplete to promote cultural integration of the country and a coordinated agricultural and industrial development.

4. Skilled Personnel Aspects.

   4.1. Lack of trained staff for the different levels: Scientific, professional, middle management and skilled workers.

   4.2. Lack of executive personnel. Even at the scientific and professional level, personnel having organizational and executive capabilities is limited. There is great need for managerial staff understanding the importance of well coordinated teamwork.

   4.3. Proliferation of universities and specialized fields. For example, in 1959 there was a single school training agronomical engineers. In 1968 there were 13 faculties of agriculture.

5. State Organizational Aspects.

   5.1. Government activities are centralized in the capital city.

   5.2. Research is not felt to be important for the country's development.

   5.3. Low salaries and limited incentives in public administration.

   5.4. Unstable organization. Continuous reorganization processes. In 25 years the Ministry of Agriculture has suffered 7 reorganizations. The average duration of ministers of agriculture in the last government was seven months.

   5.5. Limited delegation of responsabilities on the part of the executive staff.

   5.6. Rigid and complicated procedural regulations.

How then to organize University Research so that it might be effective and help the country's development?

The Agrarian University has:

1. Highly trained staff for the country's average conditions .
2. Adequate physical facilities and equipment.
3. A degree of prestige because of the research work carried out.

To be effective in the future University actions should be broken into:

INTERNAL ACTIONS.

1. Internal organizational coordination of research carried out to serve the country. Under university autonomy the internal organization falls within its own control and should involve the following aspects:

   1.1. To establish research priorities.

   1.2. Coordination to avoid duplication and dispersion of resources.

   1.3. Appraisal mechanisms to achieve greater effectiveness.

1.4. Development of in-depth research programs.

1.5. That research serve to strengthen education and the university's internal infrastructure as regards to administration, library services and publications.

2. The internal organizational research should be very flexible without going into excessive detail which might handicap dynamic action.

3. The university should undertake all types of research and studies which it is capable of carrying out.

4. Staff training should continue with a view to satisfying the following needs:

4.1. Teacher-administrators. Selecting faculty members and employees having administrative capability and executive capacity for purposes of training them for an efficient university administration.

4.2. Teacher-researchers obtaining a Master's degree from the La Molina Graduate School and being sent to other countries for short periods to receive training in research program management, laboratory techniques, experimental design, courses in extension and communications.

4.3. Teacher-scientists, selected from among the most capable graduate students and sent abroad to obtain Ph.D.'s and thus be capable to carry out and direct scientific research.

5. External Actions.

5.1. To encourage the Ministry to create a National Coordinating Committee of Agricultural Research. This committees shall establish priorities and allocate funds for agricultural research.

5.2. To participate in the preparation of the Ministry's development plans for the agricultural sector.

5.3. To enter into agreements with the Ministry, universities, private sector and descentralized government agencies to carry out research work and studies.

5.4. To request international technical assistance to implement national research plans. This aid should have the following characteristics:

5.4.1. With specific plans.
5.4.2. For a reasonable duration, five years subject to extensions.
5.4.3. A greater proportion of equipment to be included.
5.4.4. Financing of certain local expenses.

In the case of soft loans conditions should be minimal or, even better, have no strings attached.

FINANCING.

In 1968, the University's budget amounted to S/150 million of which S/56 million were allocated to financing research. 90% of the University's funds were provided by the government.

The sources of financing for research were as follows:

1. From the General Budget of the country 56.81%

1.1. Specific budget items	30.74%	
1.2. General University funds	26.07%	
2. Self-financing		22.60%
3. Agreements		3.28%
4. Local donations		2.29%
5. Foreign contributions		15.04%

For purposes of fund allocation certain standards have been established depending on whether research is:

a) Sponsored by the university, and
b) Financed under agreement and contracts.

1.0. University sponsored research.

1.1. Research carried out by graduate students. The Research Bureau allocates funds to the Graduate School which, in turn, distributes them among the professors sponsoring thesis papers.

1.2. Research under a faculty member or members. The Research Bureau has a fund to finance these projects. The fund's functions are: a) to encourage research among professors; and, b) to increase a project file.

1.3. Complementation of projects.- Part of the funds of the Research Bureau are allocated to complementing projects which have not received the necessary funds from the government and other sponsors.

2.0. Research Financed under Agreements and Contracts.

2.1. Indefinite or term agreements with the government to develop programs at a national levell.

2.2. Short term (under three years) agreements with the government or the private sector.

2.3. Contracts to undertake specific studies.

In all of these cases the funds are allocated to the Department, Programme, group of professors or professor responsible for implementing the work. The Research Bureau sees to it that agreements and contracts are fulfilled.

General Standards Which the University Follows in Research Agreements and Study Contracts.

1. Any construction erected or equipment purchased revert to the university to improve education and research.
2. It is usually seen to it that additional staff necessary to implement the agreements and contracts belongs to or is hired by the counterpart.
3. Agreement and Contract Budgets have a 10% overhead to cover administrative expenses.
4. Whenever possible, the agreements and contracts include some given amount of money for the National Library for purposes of preparing Peruvian or foreign references related to the problem.

These general standards were set up to strengthen the University's education, administration and Library services; giving personnel from other institutions and on the job training while, at the same time, the problems derived from having a high percentage of contract personnel for short periods of time are avoided. Lastly, for purposes of obtaining continuous financing for research certain taxes are suggested to the government such as taxes on incremental agricultural production, marketing, use of water and soil resources, etc.

Theme 6:

28. FINANCING AND ADMINISTRATION OF AGRICULTURAL ENGINEERING TEACHING AND RESEARCH PROGRAMMES

by P. C. J. Payne, Principal, National College of Agricultural Engineering, Silsoe, Bedford, England.

ABSTRACT

Financial arrangements in the U.K. for students and for colleges and universities are outlined. Sources of finance for research at British universities are discussed together with confidentiality of results.

Systems of governing British universities and colleges are commented upon in the light of "Academic Freedom" and the arrangements favoured by the author for planning an integrated student programme without creating water-tight divisions between subjects and between departments are given in more detail.

The paper concludes with an outline of types of government to government financial aid from British sources and promises to furnish a more detailed appendix on this subject at a later date.

Without detailed knowledge of the situation in Peru it is only possible for the outsider to describe those aspects of what happens in his own country that he thinks may be of interest elsewhere. In this paper conditions pertaining in Britain will be described, followed by an outline of the types of assistance available from British sources, quoted from memory. It is hoped to be able to follow this up with an appendix giving accurate details, which are to be supplied by the Ministry of Overseas Development.

FINANCE

Teaching.

For the student:

Since the second world war the British Government has accepted the principle that no candidate acceptable to a university for a first degree course should be prevented from attending by lack of funds. A corollary of this, is, of course, that universities should not be permitted to accept students unless they meet a universally acceptable minimum academic standard.

To keep charges on public account to a minimum and because it is much cheaper to maintain a student at school than at university, secondary education has been provided with the means to complete what in many other countries would be the first year of university education. The minimum legal age for children to leave school is 15 years and most stay until they are 16. At this age, the vast majority leave either with the General Certificate of Education or at a slightly lower level, the Certificate of Secondary Education. Those who pass their GCE particularly well are permitted to continue at school for a further two years, after which they sit an examination known as the Advanced Level of the General Certificate of Education and if successful in two or more subjects, they are elegible for university entrance.

Though there are some private fee-paying schools, all children are elegible for the free state schools and the vast majority in fact attend these. By no means all holders of the Advanced Level of the GCE apply to university , but those who do and are succesful have the statutory right to receive a grant from their local education authority. If under 21 years, their parents ' means will be taken into account in assessing this grant. For those in the lower income bracket the public will pay all tuition fees and adequate maintenance grant for a reasonably comfortable life at university. The latter amount is reduced progressively as the parents ' means rise, and the assumption is that the parent will make up the students' allowance to the level given to those receiving a full grant from public funds. In practice, few parents give their children more than this amount and some less, so that it occasionally transpires that university students with wealthier parents in fact have less money to spend than those whose parents ' income prevents any contribution.

Since only those with fairly outstanding school records are allowed to proceed to university, the university failure rate is quite low and academic standard are kept high. While this arrangement may not be politically acceptable to some, it has the merit of minimum costs for the results achieved.

For the college:

Practically all universities and colleges of higher education receive the whole of their revenue from public funds, though part of the capital in frequently provided from private sources and some of the older-established universities are wealthy in their own right. The author's college was founded six years ago and receives its entire revenue grant from the Central Government, but 13% of its capital has been subscribed by industry. This proportion is quite high for a recent foundation.

Research:

Most British universities and colleges are autonomus in the way they allocate their revenue, providing they meet certain national criteria such as salary rates. This means, of course, that establishments vary in the proportion of their income they allocate to research. Universities usually lead the field, polytechnics come a close second and colleges of further education working at a lower academic level but with adult students, rarely carry out any research.

At the author's college, the total sum allocated to research is distributed among projects on the recommendation of a committee of the academic staff, known as The Research Advisory Committee, which also has the responsibility for approving projects .

In the case of student research , a fairly formalized procedure is adopted. The highest calibre of first degree students carry out an honours project and are allowed £50 ($120) per year over two years, for the whole work. Higher degree candidates are allowed £100 ($240) per annum irrespective of whether the work lasts over one, two or three years. In consultation with his supervisor, the student makes his own proposals on the expenditure of this money, which does not have to include purchase of capital equipment provided the college already possesses it. It is considered that the spending of this money is part of the research training. Fortunately, not all students take up their whole allocation and the Research Advisory Committee may allow others to increase their budget.

Some projects require finance of an altogether higher order of magnitude than is quoted above, in which case students and their supervisor or members of the academic staff are encouraged to use their initiative in persuading outside Bodies such as manufacturers, charitable, trusts, etc., to make donations because the project is of particular interest to them. If a manufacturer is interested in a particular piece of work, he can often be persuaded to provide the extra money necessary for the expensive project, though if the college contributes any significant part of the funds, the results must be made public and not the property on the sponsor. In the case of research carried out as part of the requirement for a higher degree, the work must always be published as a thesis and could never be made in any way exclusive to the sponsor.

Occasionally staff undertake research on contract to an outside organization, in which case the sponsor must bear the whole cost, including the entire cost of overheads and the results then become the sponsor's property. In one or two cases the sponsor has met the salary of additional staff, through normally the work is supervised by a permanent member of the academic staff.

ADMINISTRATION

In Britain, academic freedom is maintained by avoiding the situation where government authorities have direct control over educational establishments. For universities this is achieved by appointing a Body know as the University Grants Committee, which receives its funds from the Government, but owes the Government of the day no particular allegiance and is completely autonomous in its allocation of those funds to the various universities. The UGC has, of course, to work within the funds provided by the Government and listens to the Government's point of view on very broad issues such as a suggestion that the emphasis should be changed from postgraduate to undergraduate courses, or the like. The Government, however, cannot order it to do anything except to live within its means.

At the author's college, (although working in the university sector, is not a university in its own right), the same principles are provided for by interposing an organization known as the "Governing Body" between the Government and the college. This intermediary Body consists of distinguished persons prepared to give a little of their time to serve on committees without remuneration, and they decide the broadest issues of principle.

Although the UGC and Governing Body both make decision such as whether or not to grant permission for the founding of a new faculty, the latter would also include slightly more detailed matters in its terms of reference, such as what courses may be run.

Within these broad policies, the academic staff is autonomous and generally acts through committees known by various names, such as, The Senate, Academic Board, etc. At universities, the administration lays down minimum standards of entry within the criteria mentioned in the first section of the paper, and Faculties or Departments may add their own requirements, such as specifying the subject in which candidates must have passed their Advanced level of the General Certificate of Education. Syllabuses or programmes are usually provided by the Faculty Board and approved by the Senate, both of which Bodies consist entirely of academic staff.

A difference often pointed out as existing between a commercial organization and an academic organization is that in the former, projects are initiated from the top and filter down to more junior staff for action. In the academic organization, initiative is nearly always taken at the department level, the highest academic committees only being involved in graning or withholding approval.

Teaching.

Reverting to the relative details of administering an agricultural engineering teaching programme, various points are made below.

In the author's view, one of the most important pitfalls to be avoided is a tendency for staff to become segregated in thought within their departments, so that it is very difficult to keep the programme integrated. Various practical points which may be of value in avoiding this, are as follows:

1. So far as possible, distribute the work among subjects on the basis of objective and not the discipline of individual lecturers. For instance, a course in crop drying could be broken down so that a botanist deals with the structure of grain, stressing aspects of relevance to the passage of moisture. A thermodynamicists could contribute a few lectures on the adibatic saturation processes followed by a more impirical approach to the basic crop drying process. A Power & Machinery man could describe the various mechanisms that are employed to achieve crop drying on the farm. A systems engineer could contribute a few lecturers on the integration of the drying processes with the harvesting and storing processes, and finally, an economist could sum up the whole situation in terms of return to the farmer on his investment. This sort of break-down forces members of various departments to meet together to arrange an integrated course for the students.

2. A device which has been employed in the author's college, with a total teaching staff of 24, divided into four departments, is to mix departments up in the geographical distribution of their offices around the campus rather than group them on a departmental basis. It is surprising how much more contact there is between colleagues whose offices are only separated by 3 or 4 metres than between

those whose offices are separated by several hundred meters.

Other Detailed Points:

1. Avoid students spending too much time on producing superb-looking laboratory reports. This can be achieved by having the reports handed in very shortly after the experimental work. It was found that when they were allowed two or three weeks to complete the work, the report were much more handsome, but far less private study was undertaken on the ground that most evenings had to be spent in writing up laboratory reports.

2. Though it has not yet been implemented at the author's college, it is believed that regular-probably weekly-meetings of the whole academic staff to discuss all topical matters both administrative and academic, saves much time in writing memoranda and improves communications and therefore morale.

Research.

Most of the points to be made on administration of research have been covered in earlier sections, but it may be worth pointing out that graduate students take a great deal more staff time than undergraduates. The British University Grants Committee allows candidates for higher degrees by research to be counted as the equivalent of three undergraduate students and candidates for higher degrees by examination to be counted as two undergraduate students. In fact, for agricultural engineering, these multipliers are probably too small.

Comments on Financial Assistance to Developing Countries from British Sources (to be followed by a detailed appendix at a later date.

In general, British aid is supplied on the basis of a Government to Government request.

1. The Ministry of overseas Development recruits quite large numbers of British experts for tours of several years in various countries. An interesting scheme known as the "Home Based Scheme", which includes agricultural engineering, is the provision of specialist staff at various centres within the U.K. (including the author's college). These staff are supernumeraries for their base establishment and can therefore be called upon to fulfill overseas tours. The advantage of the scheme is that the individuals concerned have a permanent post at their home base and do not suffer from the usual reluctance to accept a short assignment which may break their continuity of employment, and place them in a difficult position in finding their next post.

2. For academic staff at universities, an organization known as the Inter-University Council for Higher Education Overseas, whose address is 90/91 Tottenham Court Road, London, W.1, handles recruitment problems for overseas universities requesting assistance.

3. The Ministry of Overseas Development is prepared to give serious consideration to proposals for postgraduate training for nationals of Latin American countries. A main criterion in approving the training is that the programme in the U.K. should suit the projected work on return to duty in the home country. Two graduates of the Faculty of Agricultural Engineering at La Molina have already received grants for such training at the author's College.

4. The Ministry of Overseas Development has relatively limited funds with which it can assist specifically approved research projects which it believes will assist the economy of the recipient country.

Theme 6·

29. FINANCING AND ADMINISTERING PROGRAMS OF TEACHING AND RESEARCH IN AGRICULTURAL ENGINEERING
by Jorge E. Quintero, Head of Agricultural Engineering, Colombian Institute of Agriculture, Bogotá, Colombia.

Considerable interest has been shown in the establishment of Agricultural Engineering in various countries of Latin America by the formation of schools for Agricultural Engineering at both graduate and undergraduate levels.

Consideration of the financing and administration of these programs are very important and should be carefully studies to establish a philosophy and prevent blunders in the development.

It is intended to show some ideas covering these aspects. These ideas were garnered from the experience gained in the administration of the Department of Agricultural Engineering in the Colombian Institute of Agriculture (ICA) in which we are accomplishing an integrated an activity of research, graduate education, and extension in Agricultural Engineering that now exists because of a law asigning them to the Institute.

I. Financing.

The production of an Agricultural Engineering program is the principal to guarantee financing.

There are several considerations that are so reasonable that we cannot ignore them.

Some of these are:

1. Agricultural Engineering is a productive service and not a social service like health, police and others and it should produce more than it costs.
2. It is not fair to ask the financier to give money to a program that does not give returns greater than the costs. The country has the right to hope for a much greater return in gross national product than the cost of contributions.
3. It is not well to depend entirely on ones source of finance. There are several sources of funds, through personal contracts with citizens or representatives of industry governmental organizations, national and foreign; international organizations of research and development. Through these contracts with agriculturists, industry and other entities, it is possible to make better research progress, particularly in those projects that may be too costly to finance through normal channels.
   In general, research projects will be of great use in graduate student can be trained in undertaking real integrated problem solution.
4. The tangibility and visibility of the results of Agricultural Engineering work are an advantage for the profession, because we can show plans, models, machines and prototypes. The product can be taken to the consumers more easily when they are shown the real thing thou when they must be convinced verbally.
5. A common error in the University structure is to separate from industry. This cooperation is essential for the progress of the profession; the opportunity for the Agricultural Engineer to accomplish this is better than in other professional areas.
6. The necessity for adequate financing of the program is very important, but so is the necessity to have flexibility in the management of funds; naturally, there are certain limits for the minor transfer of funds between different activities when it becomes necessary.
7. The financing of programs of research and teaching whenever possible should be together to make the most economical use of the investment.
8. Within any financing it is well to include the use of facilities of other organizations that are difficult to duplicate. Next to the ICA station in Bogotá are the experimental farm of National University, the National Aprentice Service (Vocational Ag.), A seed plant of the Agricultural Credit Bank, as well as various industries like Purina feeds, Colombian, Fiberglas of Colombia and others. The graduate students have access to these facilities for research work. To duplicate these plants in the same way would require a large investment.

9. The paternalism of the Latin American government, by which the small farmer is put into debt, ought to be eliminated. The services that are lent in form of publications, drawings, etc. have monetary value which when paid results in a greater appreciation for the service and serves as another methods of financing research men.

II. Administration.

Administration of a program of teaching and research in Agriculture Engineering is more difficult that that of other fields because of the broad spectrum of disciplines encompassed.

Factors like the following help to identify and solve this problem:

1. Biology, Economy, Sociology and Engineering are disciplines that use different methods and ways: and for this reason, the administrator ought to have a special capacity to see and analyze a problem from these various points of view.
2. Actually, Agricultural Engineering is not well established, and does not carry enough weight and deep roots to enable it to fragment into small groups. One needs to use the force of an integral program rather than the separate or isolated program disciplines, because these programs must depend on only one head.
3. It is of vital importance that the Direction of the program is sufficiently pointed toward the discovery of the real problems. Research in any developing country must be directed toward actual problems, more than toward problems that may arise in the future.
4. There are ideal conditions for the direction of a program, that perhaps cannot always be met, but at least a program director ought to A) Ideally be an Agricultural Engineer, B) Be familiar with all phases of Agricultural Engineering C) Have the capacity to understand the necessity and use of research. D) Understand and believe in the necessity of Extension in Agricultural Engineering. E) Understand human nature for better communication.
5. In many cases, because external financing or of lack of adequately trained local personel, it is necessary to resort to professionals from other countries to help in program development. When one deals with Agriculture Engineers in Latin American, these professionals in so far as possible should conform to the following basic personal conditions:
   a) They should know the language of the country. B) Have a sincere interest in aiding to develop the maximum potential in Agricultural Engineering. C) Be flexible and inclined to help in developing an organizational system that is adjusted to the particular country and not insist on a system like the one used in their native country. D) Have a broad perspective of Agricultural Engineering. E) Be inclined to initiate a program of Agricultural Engineering at the necessary level to raise the training to the highest level possible in a reasonable period of time. F) Be disposal to work as a member of the team, with rights and responsibilities like the rest of the members of the institution. When a professional occupies a position of advisor, like a Director of a program he has the right to accept or reject his councel; until an advisor is confronted with the same circumstances as the rest of the members of a program, it may be well for the Director to meditate in order to see what repercussions and consequences may result from accepting the counsel and the Director should at the same time consider more seriously the counsel received due to the fact that the Director assumes, that the refusal or acceptance resulting from the action will be shared with the foreign advisor.

For this reason the administrator will be more disposal to carefully consider all the pros and cons to see the potential consequences of fallowing the counsel.

III. Initiation of a New Program.

Nevertheless, failures in programs that lived a short time after initiation result from different types of problems than those previously mentioned under the headings of finance and administration. They can be grouped, among others, as:

1. Failure to create or to use correctly the appropriate structure to fully utilize the necessary human phy-

sical and financial resources.

2. Failure to create sufficient status for the profession in a manner to give it equal stature with other professions.
3. Failure to train professionals at the advanced level so that the individual will have the means to develop himself to the maximum.
4. Failure to maintain a continuity of programs and projects fixing goals and objectives even though. This does not imply inflexibility.

Theme [illegible]: [illegible]

30. FINANCING AND ADMINISTRATION OF AGRICULTURAL ENGINEERING TEACHING AND RESEARCH PROGRAMS

by L.L. Boyd, Professor and Head of the Agricultural Engineering Department, University of Minnesota.

I am pleased to have this opportunity to share my experiences with you today. Because the discussion will be based on my experiences, I believe it may be desirable to inform you about them before proceeding. My first experience came in 1951 when I began working with 12 District Agricultural Engineers located around the state of New York while I was serving as Extension farm building specialist. This program was replaced with centrally located specialist in 1955 as others and I had recommended. From 1958 through 1964 I spent about 1/3 of my time at Cornell working with the administration of graduate programs in Agricultural Engineering with the exception of the period from July, 1962, and July 1963 which I spent with the Allis-Chalmers Company in Milwaukee, Wisconsin. During that period I had the responsibility for developing the use of digital computers in the design of agricultural machinery in eight different plants of the company and also in developing a procedure whereby this work could be continued after I left. Also during my stay at Cornell, I worked closely with the Farms Building Project at the New York State Fair and served as project superintendent for a period of two years. This brought me in close contact with state officials and with over 60 cooperators in the project and exhibit. Since August of 1964 I have been Professor and Head of Agricultural Engineering at the University of Minnesota. In the fall of 1968, I spent ten weeks in the office of Vice President for Research at the University of Minnesota.

My philosophy is that the administrator should try to make it possible for the organization to maximize its output. In so far as posible, this should mean that each individual can maximize his output. However this can't be fully accomplished because the outstanding organization is composed of outstanding individuals working together and not alone. This means that each individual must do a certain amount of routine tasks that are less than fully challenging. Obviously if a staff member did not have to carry a portion of this type of load, he could more fully maximize his efforts in the areas in which he is most interested. Slight reductions below maximum individual outputs still can result in a greater departmental output because unity of purpose insures that all members are seeking the same major goal.

The best way to effectively lead a group is through their active involvement in the decision making process and through the administrator's enthusiasm, ideas, and moral and financial support. Financial support cannot be over emphasized because it is difficult to produce without the supplies, equipment and personnel to do the job. I have learned quickly, however, that salary alone is not a sufficient motivating factor for faculty in the U.S. today. There are just too many openings available in other places. In addition, the concept of complete individual freedom of choice has permeated the academic environment beyond reason.

Philosophically, administration can be divided into four categories:

(1) authoritarian, (2) benevolent authoritarian, (3) consultative and (4) participative. My concept of administration is to use the latter three. While many faculty say they desire a fully participative type of administration, I believe that it can be soundly argued that the unit cannot afford such a procedure. Participative administration requires considerable involvement on the part of the faculty. If they are to be involved effectively, they must spend a great deal of time keeping informed. There is little justification for taking the necessary time to be informed on some of the more routine and mundane things. I believe I can safely state that only a few faculty really keep themselves informed in all aspects of the programs in their unit. Therefore, I propose the benevolent authoritarian approach for those things which are more clear-cut that involve the unit as a whole. The consultative approach should be used when the things under consideration involve only a small portion of the group, or when there is insufficient time to do an adequate job of investigating it through the participative method. The participative method should be used for things about which the entire should be vitally concerned and for which all of them have a reasonable degree of competency so that they can contribute effectively and sufficiently to group action. There certainly is a need for faculty to more fully understand the administrative process and to have more confidence in it. This includes different methods of operating for different problems and with different people because of different personalities. Some people work well alone and do not want to be involved in the decision making process except occasionally. Others are insecure and their productivity limited unless they are involved almost totally.

Regardless of the administrative procedure followed, it is important to always have up-to-date data about faculty involvement in teaching, research, etc. This permits an effective evaluation of who can take on additional responsibilities when new things arise. Some well noted administrators say that one should not do anything that he can delegate. In my opinion the delegation of too many mundane and uninteresting things stifles faculty activity and limits output of more productive things. I try to delegate a number of things but also I remember that in the end, I am responsible for the successful completion of the job. Because of this, I encourage faculty to report back so that I will know that the job has been done. Some do this but some do not, so I find it necessary to do some follow up myself to be sure that the job has been done well.

Let us look now at some philosophical concepts of succession in administrative positions. In Colleges of Liberal Arts for a number of years in the U.S. almost all of the departmental administrative positions have been on a rotating fixed period appointment basis. Usually these periods vary from two years up to five years, some with an opportunity for re-appointment. In Colleges of Agriculture the concept has been more in terms of a head who was appointed to the position for an indefinite period, and who in most instances served for a number of years, frequently beyond the time that he was wholly effective. Recently, Deans of Agriculture in a number of institutions, some through pressure from their Presidents and others through their own initiative, have been moving toward the rotating chairman procedure. I fully concur that the departmental administrator should not have indefinite tenure and that Deans should be strong enough to make changes when necessary. However, I believe the disadvantages of the rotating chairmanship should be pointed out in an objective way. This can best be done by trying to point out some of the differences in operating procedures between departments in Colleges of Liberal Arts and in Colleges of Agriculture and Engineering. In Liberal Arts the prime duty of the faculty members is teaching classes and most often undergraduates. Research which most of these people do, if any, is either library or field expeditions. It frequently requires minimum financing it is done through a grant to an individual. In such a situation, a departmental administrator has a primary job of providing good instruction for undergraduate students. In such a case, the rotating chairmanship with a high degree of participative action by senior faculty may be adequate. However, even under these circumstances, there is considerable evidence of unnecessary restraint of junior faculty by the senior faculty. I firmly believe that all faculty should have an equal voice in departmental affairs, recognizing that senior faculty will have had more experience and should be in a better position to evaluate and analyze problems facing the department. In Colleges of Agriculture, the department head or chairman has responsibilities not only for teaching, but also for research, extension and international program activities. These programs are usually on a twelve month basis and involve the distribution of funds for research that the Liberal Arts departments do not have. Further it involves inter-departmental cooperation as well as intradepartmental cooperation. Mutual support is vital to the development. While I think mutual support also is highly desirable in the liberal arts type programs it is not essential. Recognizing these differences it is desirable for Colleges of Agriculture to provide for a periodic review of departments that includes the of the administrator. This would permit the Dean or other higher administrators to make changes more easily. I do not believe that there should be any fixed number of possible reappointments and that the review should be made at intervals no smaller than three years and at intervals no greater than five. Such a procedure would permit the devoted administrator to try to master administrative procedures and not be handicapped by having to devote time to maintaining a high level of technical competency. I think it is a foregone conclusion in this time of rapidly advancing technology that few, if any can do both effectively. Eliminating the mandatory rotation system also lets the person who is not at all interested in the administrative process escape what may be a mandatory turn.

A problem facing all administrators is that of evaluation and remuneration of faculty. Faculty are very apprehensive when evaluation of instruction is mentioned, yet they subject themselves without question to evaluation of their research. The usual evaluation of their research productivity, in over-simplified terms, is the number of publications which they author. We must give more attention to the improvement of instruction and to its evaluation plus provide a reward system for good instruction. The first comparable to those which we provide for research. No one is expected to do a good job of research without a good laboratory, good measurement equipment, often a technician to help conduct the experimentation and the daily analysis, graduate student assistance and computer processing equipment. All to often the instructor must attempt to teach in a box-like classroom with inadequate tables and chairs, poor acoustical treatment, poor lighting, inadequate ventilation, etc. It is time we equip the teacher with technical help to prepare his materials, adequate equipment to present it, classrooms in which he can be seen and heard, classrooms and methods for full student involvement, and convey the attitude that instruction is once more the prime objective of the University. I am not suggesting that we do away with research or minimize its importance; rather we should be emphasizing and strengthening the importance of instruction and the inter-relation between instruction and research. This type of a procedure should give a person pride in his profession as a teacher, pride in his area of specialty and a first loyalty to his department and University. We must strive administratively to provide these things so that we can assure that the loyalty is first to the institution and second to oneself. Excessive self loyalty is a society destroying element.

Up to this point I have purposely avoided the area of financing as I feel I have little to offer to this group. Methods of financing in the United States are not likely to apply to South American countries. However, we may be moving in similar directions but under a slightly different pattern. What I am suggesting is that in the South American countries likely will have almost all of their support coming from their Federal Government. In the U.S. at this time in our leading universities Federal support often exceeds 50%. However, Education and Welfare; Defence; Agriculture; Interior; NASA; and others. The grant system is surely useful for most of us if we remember that it is set up to provide stimulus for work rather than to provide total support. In many instances grant support is being used as total support. This leads some units to prostitute themselves to seek any and all grants to continue their existence rather than to seek grants selectively on the basis of support for programs in which they should be actively and energetically involved. At the present time in most U.S. institutions we feel we need a minimum of $25,000 per man to pay his salary and support him adequately in his research. Here again we overlook the support for teaching which will be only a fraction of that provided for research. A high percentage of our faculty members are supported salary wise on funds made available by our State Legislatures, although I suspect several of us may have as many as 40-50% of our faculty on salaries from grants. I imagine that most of us have well over 50% of our technician staff on the grant funds, which we often term as soft-money meaning that it may discontinue at any time. In any event we should try to provide for both teaching and research support, at least 75% of the man's salary on up to well over 100%. Obviously this varies quite broadly as some theoretical studies even with computer charges are usually fairly low, whereas experimental studies such as those involving large animals are quite high because of instrumentation and controls costs in addition to the maintenance and housing costs for the animals.

The most important concept in financing our programs is that we not try to cover everything but select those of most importance to our area and to concentrate our efforts there so that we can do a productive useful job. At the same time we should actively seek increased funds in those areas of lower priority, yet still of sufficient priority to command attention at an early date.

The departmental administrator should always remember that his prime responsibility is to provide adequate resources in the broadest context for this entire faculty. When he has done this completely, fully and effectively to the satisfaction of his colleagues, he can begin to think in terms of his own research and / or teaching programs. Thank you.

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Theme 7: RESEARCH IN AGRICULTURAL ENGINEERING AND ITS APPLICATION TO SERVE LATIN AMERICA.

31. PHILOSOPHY AND METHODOLOGY OF RESEARCH IN AGRICULTURAL ENGINEERING by L. Boyd, Professor and Head of the Agricultural Engineering Department, University of Minnesota.

Fellow Agricultural Engineers from South America, Europe and North America, I am pleased to be back in Peru and to have this opportunity to discuss the philosophy and methodology of research in agricultural engineering with you. When one accepts an assignment to appear before a group such as this, he feels it necessary to check the preciseness of his own personal definitions of terms. Webster's 7th New Collegiate dictionary indicated that the word research came from the middle French word recerchier, meaning to investigate thoroughly. The definition appropriate to our discussion was: studious inquiry or examination, especially investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories and laws in light of new facts, or practical application of such new or revised theories or laws.

Let us first look at philosophy to develop a base from which we can move to methodology. Obviously, there will be some overlap which we will try to minimize. A group such as this comes with widely diverse backgrounds and experiences so we must make our assumptions clear to each other. My first assumption is that research is essential to progress both in education and in every day life. We can gain little by spending time trying to categorize research as basic, applied, developmental, etc. even though universities sometimes are admonished that they should be doing only basic research. I submit that our researchshould be selected on the basis of its potential contribution to society and particularly to that part of society which we are trying to serve. In other words, what will the research do for the people of our state or province, our nation and the world.

A highly important basic philosophy is that we should not conduct research on things for which we already have the ability, or should have the ability, to design. Neither should time be spent conducting extensive research on things that we should be able to deduce logically. Much time is lost duplicating the research that others are doing. Sometimes this is wholly justified to verify the results under different climatic or other conditions, but more often than not it is not necessary. If you are duplicating someone else's research be absolutely sure you know why you are doing it. Attempt to dovetail, or intermesh, or preferably extend the other man's research, rather than duplicating it.

Let us compare the purpose of research done at a college or university with that done at a federal or a state research station. At the college and university, the first obligation of the faculty is to serve as teachers. Their research not only helps keep them current technically, but it also provides new knowledge beyond that which flows immediately into the classroom. In addition, research at colleges and universities has the very important function of providing valuable training for graduate students. In the research institute or station the prime obligation of the personnel is to provide new knowledge which will find its use both in new products for human use and in new knowledge to be taught in colleges and universities. The mission of the institution to which the researcher is attached certainly affects the selection of his research. I strongly believe in what I call companion research or complement research. Regardless of what we call it what I am talking about is: (1) research to meet existing and continuing need, i.e., on chemicals or other methods of controlling insects and weeds. This type of research sustains the economy and assures continued support, even though it may be only a stopgap or temporary solution, and (2) research to meet foreseeable needs and unanticipated needs. This may include following an unexpected result that may clarify a previously undefined phenomenon. In the selection of research, the chances for success should be weighed. Obviously, a trivial problem should not be selected just because the chances for success appear to be approximately 100%. Many well known people are recognized as much for their ability to select problems as for their ability to solve them, Neither should we not overlook the contributions of instuitive results, i.e., those that come as a result of serendipity-the gift of finding valuable or agreeable things which were not sought.

Faculty members, i.e. permanent personnel, should do the continuing research that requires continuity; graduate students should not have to spend precious time thoroughly retracing previous steps by graduate students who preceded them. Graduate student research should not be expected to solve a specific problem, yet on the other hand should not be frowned upon if it does. The prime purpose of graduate student research should be to train the student in research methodology and associated endeavors so that he can use these methods elsewhere. He should not select a lifetime investigations area in his doctorate work.

Research should be reported to one's colleagues frequently, as often colleagues who aren't quite as close to the work can offer excellent suggestions. The same equations often describe apparently widely different phenomena. The investigator has an obligation to make his work available to the public as well as to his research colleagues. If he does not accept this obligation and follow through most frequently there will be a delay in the utilization of his work. Extension personnel have the explicit responsibility of making useful information available to the public, but a close association between research and extension personnel is highly important. Not only does this help in extending the information more readily, but it also provides a feedback to guide the future research.

What should be the attitude and characteristics of the able and productive research investigator? Procrastination is the greatest deterrent to research that I have observed. It may result from lack of knowledge, fear of failure, etc. The good research man must have a great deal of self-discipline coupled with family understanding. Self discipline permits scheduling things, including time with the family. The investigator who is anxious to accomplish something must begin immediately by: (1) talking about the subject with knowledgeable people, not just agricultural engineers, but others in related disciplines; (2) reading relevant literature; (3) traveling and visiting other research stations; and (4) writing brief yet fairly detailed position papers, or proposals, from which he can obtain others reactions. Give as much attention to the expressions and what the colleagues do not say as to what they do say.

The good investigator should be able to interest himself in almost any important study within his area of competency. A dedicated, narrow, in depth approach usually produces good results, but should not involve a lifetime unless absolutely necessary. Often the deep penetrating study is carried well beyond the time which it is producing useful results. The completion of an important piece of work and moving on to another gives the great satisfaction of having completed a job and also the challenge of beginning something new. The researcher must always question the adequacy of present methods or answers, yet not fall into trap of spending endless hours attempting to refine the results beyond basic variability of the phenomena.

The capable and productive investigator always fully utilizes the resources available to him. This includes, not only the experimental equipment, and computational devices, but also his technical and clerical assistance. Occasionally the investigator may find it necessary to get his hands dirty to keep his project moving and to really understand what he is asking for others to do. There are times when the studies cannot productively wait for the return of a technician from vacation or a period of illness. Such involvement also enable the research man to intuitively size up the results, although this is no substitute for a preliminary and continuous analysis which will be covered in greater detail under methodology. As a young research man at Cornell University I tried to experience at least once everything I asked others to do . Later, when I had non-research responsibilities in addition and could not spend the necessary time conducting the research myself, I asked my co-workers to explain the difficulties in detail so that I could differentiate procrastination from difficulty. Now, as Department Head with even less time for personal research involvement, I try to cover some of the pitfalls which I have experienced in a introductory seminar for graduate students, and occasionally at faculty meetings.

Turning now more specifically to methodology of research, there are at least eight areas which I wish to consider with you. Obviously, they might be combined into a lesser number or expanded into a greater number. However, those which I consider vitally important are:

1. Evaluating and selecting problems of agricultural, engineering, economic and social significance.
2. Development of analytical and experimental approaches to the solution of the problem(s).
3. Development of an estimate of the cost of doing the research and an appraisal, if possible, of the chances of success and the economic payoff from the research.
4. Revamping, if necessary, or cancellation of the project if limitations of funds and / or personnel indicate that success is unlikely.
5. Collection of data in a systematic way that will lead to through, orderly, accurate and timely analysis of data.
6. Analysis of data including a vitally important preliminary analysis and the development of conclusions and comparison of results with theory and similar studies.
7. Frequent communication with others doing the research in the same general areas so that all can gain

from each others experiences.

8. Making the information available to the public as well as to other research people.

Careful evaluation and selection help make certain that the research time available is most wisely used for the benefit of society. Considerations of importance are: the health and welfare of the people; contributions to economic and technological progress; relationship to national security; ability of the group benefiting most to do their own research, etc. We also should consider the number of people, animals, farms, etc. affected favorably by the anticipated results or adversely by not doing the research. Consideration should also be given to the value of the solution of a specific problem to the solution of several other related problems. Consideration should also be given to the relationship of the research to other research being conducted or that which has previously been conducted. Will the research integrate as a part of a coordinated program and does it build on previous work rather than duplicate? Even though it can be substantiated that the research could contribute to the well being of a sizeable number of people, a judgement must be made as to whether or not the results will in fact be applied. Public acceptance of new and better methods is still one of the greatest deterents to social progress.

An analytical approach to the solution of a problem should always be developed is sufficient information is available to permit it. Even if some information is missing an analysis should be attempted. Such an approach relates to the philosophy that research should not be done on things that can be designed. All of you are painfully aware that frequently we have insufficient information to develop a valid analytical solution and that the only way to obtain the information is through the experimental approach. The attempted analytical solution, however, strengthens the experimental approach in that it helps point out many of the areas for which information is unavailable. The experimental approach must consider the application of statistical methods for insuring reliable data and for error analysis. Frequently a dimensional analysis approach using the dimensionless groups of variables rather than single variables can reduce the amount of necessary experimentation. Dimensionless group variables also provide considerable flexibility in extending the range of the variables which are being investigated. The procedure also assists, but does not necessarily insure, the inclusion of all pertinent variables. Time spent in careful analysis and planning often will reduce the amount of time that must be spent in experimentation and data analysis. Usually there is the added payoff in reliability of results. The initial planning of the experimental approach should be done with relatively little consideration of the cost of conducting the experimental work to help insure its throughness. Variables or groups of variables of lesser importance can easily be omitted at a later date.

After the tentative research plan has been carefully developed, each investigator should develop an estimate of the cost of the research. This will help him determine if he will have adequate funds to complete to work without unfairly taking funds for other projects of his or from other investigators. Research should not be initiated if it cannot be completed because of the lack of financial or personnel resources, because there is a nil chance of success. The appraisal of the chances of success is somewhat intangible and is a subjective judgement in many instances. If careful development of the approaches and of the estimate of costs have been made, it is often fairly easy to revamp the project or to decide not to initiate the research. When funds are limited but the problem is of such significance that it must be done, e.g. the prevention of starvation, the investigator moves ahead as effectively as he can and devotes a portion of his time that might otherwise be devoted to research to the solicitation of the necessary funds to continue the work. Even very limited significant results are a far stronger selling point than mere plans, at least the plans will be greatly strenghened with some significant results.

Collection of data should be done as much as possible so that it can be immediately processed without recoying, which not only is time consuming but also adds another possible source of error. Some of us in the U.S. are fortunate enough to be able to translate our analog measurements to digital form, either directly or after some preliminary processing, so that a portion of the analysis can be made almost immediately. Such a procedure often reveals missing information or incorrect information at a time when it is usually possible to regain the lost information. Investigators without this kind of equipment must take the necessary manual steps to check the accuracy and performance of the instrumentation and the adequacy of the data at frequent intervals. This will help insure that large amounts of time consuming and painstakingly taken data will not be accumulated, and then found to be useless because of missing information.

A preliminary analysis is vital to insure that all needed measurements are being made or that the mathematical model adequately represents the physical phenomena. Continuous analysis helps to reveal the equipment deficiencies and often suggests new and better approaches. When it is not possible to analyze the data continuously, then the data should be analyzed as soon as possible after it is accumulated, because the personnel working on the project are most familiar with the experimental procedure at that time and can make the best possible analysis then. The results should be compared with theory and similar studies to determine whether or not adequate information has been obtained to preclude additional studies. As soon as this is known the conclusions should be developed and setforth in as clearcut and explicit way as possible.

During the entire research investigation including the initial phase particularly, the investigator should be in close contact with colleagues working in the same or associated areas. This will permit the sharing of beneficial experiences and often may save them considerable experimental time. It is also important that the investigators communicate with each other at the close of the project and at the times of important breakthroughs. We have much to overcome in the way of professional jealousy and needless secrecy in public research, if we are to meet our social responsibilities.

The last obligation is to make the information available to the public as well as to other research investigators. Certainly the public has the greatest potential for using the information and this should have been one of the motivating reasons for initiating the research. There are a number of investigators who feel that their job is finished as soon as they complete a research paper. They have a strong obligation to the public, if possible working with extension personnel who can transmit the information effectively and also provide some useful feedback relative to research needs to the investigator.

The above eight suggestions are very general and obviously all do not apply to a particular situation. I believe they cover some of the most important things that must be done to give us some assurance of efficient, yet effective research programs.

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Theme 7.

32. AGRICULTURAL ENGINEERING RESEARCH AND LATIN AMERICAN DEVELOPMENT by Enrique Blair.

I. INTRODUCTION.

A. Definition.

The topic we shall discuss is, in itself, complex and broad. We do not have any large background information related to the subject, since Agricultural Engineering, as an institutionalized profession, is just being organized in this part of the Continent and has neither sufficient tradition nor volume to provide support to our formulations. On the other hand, the different fields of action of Agricultural Engineering which have to do with mechanics, civil construction, industrial chemistry, electricity, electronics and biological growth, reproduction and production processes, as well as the different basic and applied sciences which support this profession add to the magnitude and complexity of the subject.

We shall then try to define what we intend to analyze so as not to stray unnecessarily and not to be to diffuse in our presentation. Research, as we all know is related to the search for new knowledge, with the discovery of new phenomena, laws or principles and with the application of these findings to the production of techniques, procedures or equipment to facilitate, simplify or make the results of human efforts more durable.

Agricultural Engineering could be defined as the body of technical knowledge derived from the mathematical, physical and chemical sciences which are applied to agricultural production and to the improvement and simplification of rural life.

Finally, development is a relatively new term, even though the concept is as old as man, which is closely related to the idea of economic and social progress. This process takes place to the extent in which the net income of a region is increased with the application of technology capital and labor, and the benefits of the productive effort are distributed equitatively to the society concerned.

Our topic then refers to the search for new knowledge or the application of existing knowledge within the broad field of Engineering, to increase agricultural production and the productivity of the soil and labor to the benefit of man and society.

B. Areas Covered by Agricultural Engineering.

As we have already stated Agricultural Engineering covers the whole field of mathematical and physical sciences applied to agricultural production. In the U. S. A. where this profession has been institutionalized for over half a century, the specific fields of action have been broken into 4 broad categories, such as mechanization of agricultural production, rural constructions, processing of agricultural products and soil and water engineering. These broad categories also include rural electrification, rural sanitation engineering, roads and rural transportation and other similar specialized fields.

The aforementioned areas constitute a broad and varied field of action of particular importance for Latin America, where agriculture is as yet undergoing expansion and where the production and conservation techniques and procedures for the different agricultural sectors must be improved or modified and, in many cases, created in accordance with the ecology of the different geographical regions, with the type of product and with the habits and traditions of the people.

It could be said that the aforementioned fields of action could be served by other Engineering professions. This is true. However, the Agricultural Engineer can, more properly, face engineering research regarding agriculture and rural life because of his solid training in the physical and mathematical sciences and through the knowledge which, in the course of his academic and practical training he receives regarding the biological processes associated to agricultural production and the rural environment. In making this explanation we do not intend to exclude any profession from its contribution to the research related to the application of Engineering to Agriculture, to establish an exclusive domain for this new profession. Quite to the contrary, all the other professions should be welcomed to participate in this task. In fact, in practice, many of the major and most important contributions to the physical development and technification of agricultural processes have originated in other professions and many of the notable agricultural engineers of today have started their activities in other university professions. In Latin America, the Agronomical Engineers, Civil Engineers, Mechanical Engineers and Chemical Engineers have been the ones who have more actively contributed to the development and application of machinery, hydraulic systems and industrial processes required by modern agriculture.

Within this frame of reference we shall develop our ideas on the role and implications of Agricultural Engineering research to the development of Latin America, analizing the general problems which have to be considered to define an orientation for this research and describing some of the specific problems to whose solution Agricultural Engineering could contribute.

II. GENERAL PROBLEMS.

The development of any country or region, in essence, attempts to achieve satisfaction of human needs and an increase of the opportunities for all members of society to satisfy their needs related to food, health, education, comfort and spiritual improvement. The indispensable elements to achieve these purposes are the increase of production and income and their equitable and fair distribution among all sectors contributing to their achievement.

Within a simplified concept of development, we could state that Agricultural Engineering research must necessarily be directed to the conquest of these same objectives in the rural sector.

The increase of Latin American agricultural production might be obtained by: 1) Increasing the area dedicated to agriculture, which implies incorporating into production vast jungle or dessert regions, and 2) Increasing productivity of areas at present under cultivation, which implies a process of technifying field tasks. Either of the two routes require machinery and equipment for jungle clearing and for the different important agricultural operations and civil works necessary for providing irrigation to arid zones; drainage to the dry areas, or both, whereever required by the intertropical climate.

The use of agricultural machinery in Latin America is very limited if compared to other more developed nations of the world. As an example, we can mention that in Brazil there is one tractor per thousand hectares under cultivation and that in Peru 93% of agricultural enterprises are farms of under 20 hectares which use only 0.7% of available tractors.

Thus, we can partly explain why in Latin America a farmer produces only enough to feed 4 persons while in more advanced countries the ratio is 1 to 25 as in the U.S.A.

The increase of production either through expansion or an increased intensity however, gives rise to serious social and economic difficulties in Latin America. On the other hand, it would be risky to undertake an accelerated production program without having adequate markets for the surplusses and, even riskier still, to develop an accelerated mechanization program without concurrently having new sources of employment to provide jobs for the population which machines would displace from the rural area.

Furthermore, technification and mechanization of agriculture, as well as an expansion of agricultural frontiers require the importation of machinery and equipment not produced in the region, which would imply large disbursements of foreign exchange which might be above the availabilities of the region as a whole or of some of its countries. The solution to this problem would be to start manufacture of this machinery, the equipment and the technological inputs which modernization of agriculture and expansion of the agricultural frontier require in the region so that these factories and the complementary services which the machinery requires would absorb the labor displaced from the fields. However, the internal markets of each of the countries of the region are small and would not permit production in sufficient scale or volume to manufacture high quality machinery or technological inputs of a low price comparable to that of imported products.

In these brief considerations, we find four interwoven problems which lead to an apparent vicious circle. These are structural problems of our own internal organization and our foreign relations. The four problems are: 1) Limited markets for agricultural production surplusses exceeding internal consumption and traditional external demand; 2) Lack of sufficient occupational fronts in other sectors of production which would take up rural labor; 3) limited foreign exchange due to the narrow range of exports, for importation of the machinery, equipment and technical inputs required by technification of agriculture, and 4) limitations of the national markets of each of the region countries for these capital goods, which prevent the operation of high volume plants for production at competitive prices.

In this part of our presentation, we could state with no fear of error that the vicious circle might be broken and the aforementioned problems resolved if, with the cooperation of the U. S. A. and other industrialized countries of the world, we in Latin America adopt a firm, solidary and consistent policy directed towards the four following objectives: 1) broadening of the internal markets for agricultural and industrial products on the basis of economic integration programs, such as the Andean Subregional group which has been recently formed and, eventually LAFTA 2) Manufacture, on a subregional or regional scale, of the equipment and technological inputs required by agricultural modernization so that the latter and the complementary services absorb the labor laid off in the rural sector; 3) Joint and solidary action to broaden the foreign markets for agricultural and industrial products so as to generate the foreign exchange demanded by development, and 4) additional incentives to atract international financing and foreign investments which might be obtained on a fair and equitable basis.

At this time, I want to make sure I have not strayed from the main topic of this preparation, but truth is that Agricultural Engineering Research in Latin America, and the generation, adaptation and adoption of new technologies in this field shall be seriously limited, as they are in other fields of human knowledge, as long as the vicious circles in which we move are not broken and as long as the structural defects of our economic organization and our internal and external relations are not corrected.

III. OBJECTIVES OF RESEARCH.

Aside from the previous considerations, it would also be good to think about other factors of a general nature which affect the determination of the objectives of research, if it is to contribute to the development of Latin America.

The type of agriculture in a region and, consequently, the machinery, equipment and inputs it requires are basically determined by ecological factors: climate, soil, natural vegetation. A large part of Latin America's geographic area is located between the Tropics of Cancer and Capricorn. In fact, out of the total 20 million square kilometers of total area, about 15 million or 75% are within the tropical zone.

Within this large area of the Tropics there are some 2 million square kilometers which are above 1,000 meters of altitude, where a mild temperature, abrupt topography with small inter-andean valleys and a vast population density prevail; the rest, about 13 million square kilometers, is formed by large flat areas, mostly humid with some arid, with a hot climate and a low population density.

The warm and humid tropic , in spite of its great productive potential, has not been very attractive for human life. The exhausting heat, insects and tropical diseases have not proven to be an adequate environment for human life. Here lies the challenge to Agricultural Engineering.

With the present knowledge of modern science in the fields of thermodynamics, climatology, meteorology and human philosophy it shall not be possible to modify climate with economical equipment and procedures, if only in human housing.

Most of the humid tropical areas have abundant rainfall during certain periods of the year while there is lack of productive humidity during other alternative periods, but the average total rainfall would nearly always be sufficient for continuous plant growth. Wouldn't it be possible to control the flow of rainfall to assure the optimum conditions required for plant growth?

Tropical regions offer very favorable characteristics for plant growth: high temperature and sunlight all year round. It has been said that if humidity were controlled the tropics would have enough capacity to produce plant tissues in amounts many times that of temperate regions. The dense virgin jungles of the large American rivers are witnesses to this statement. How are we going to dominate this tremendous productive energy potential to benefit man?

But this same wealth-creating energy potential also has an exhausting effect on the soils which are cleared and exposed to its direct action. What systems, equipment and procedures must be used to maintain the fertility of tropical soils?

There are many tropical plants producing foods, fibers and medicinal drugs which are different from those cultivated in the temperate areas of the world. Some of these products have already been incorporated to the diet of all countries of the world; others are cultivated as a function of local demands while others are still ignored.

Work carried out with rice in the Philipines by the International Center operated by the Rockefeller Foundation and the Government of that country, points out to the possibility of producing 20 tons of rice per ha per year on the basis of three consecutive harvests every year. Which shall be the machines, equipment and the soil management systems which we shall employ for a better use of these discoveries?

Tropical fruits of exquisite flavour and which are nearly ignored such as the passion fruit and others, which require special techniques for their processing and conservation for, even though they are native to the Tropics where apparently there is uniformity of a climate, they are harvested seasonally.

Some tropical plants such as yucca, flame and others rich in energy as well as high protein foods such as the quinua of the South American Andes,. whose conservation and transformation for better use is still to be carried out.

Without pretending to have exhausted this section of the topic we could summarize our thinking by stating that the objectives of Agricultural Engineering research in Latin America should be established in accordance with the economic and social problems which we have already mentioned above; with the ecological characteristics of the different areas; and with the nature of the products which, being typical of those areas, have real or potential markets in the region or abroad.

IV. SOME SPECIFIC PROBLEMS

Without trying to set up here a catalog of the multiple research lines which could be followed within the field of Agricultural Engineering to accelerate the development of Latin America, we shall mention some which could be studied by the specialists.

A. Agricultural Machinery.

Within this area new machines should be developed or some existing ones should be adopted for the clearing of jungles and opening of new lands; for cultivating lands with a minimum alteration of soil structures; for cultivation of furrows of alternate crops thus avoiding exposing the soil; for planting of crops such as yucca; for harvesting of products such as coffee; for preparation, cultivation and management of soils for permanent rice plantations; for the harvesting of quinua, etc.

B. Product Processing.

The range of possibilities in this field is also very broad. Among others we could mention processing, conservation and canning of tropical fruits and vegetables; drying, conditioning and storage of grains under tropical conditions; processing of coffee; processing of quinua; preparation of protein-rich foods for human and other diets.

C. Soil and Water Engineering.

In this section, among others, we could highlight the development of equipment and procedures to preserve soil fertility in the tropics; creation and adaptation of techniques for management of irrigation waters and elimination of rain surplusses in tropical soils; the study of hydrological phenomena in the tropics; conservation of rain-water from humid periods and its conveyance during dry periods in intertropical climates, etc.

D. Rural Constructions.

Within this specialty I would dare to suggest maximum priority to the study and modification of the climate for human life in hot tropical areas; the development of practical and economic procedures to provide water and lighting to rural housing. There is also a vast field of activity in the planning of hamlets, in the use of local materials and natural energy sources for the constructions required by agriculture such as housing, silos, stables and other rural structures.

E. Rural Electrification.

Within this specialized field, it would be convenient to concentrate efforts on the study and the practical use of the energy sources available in a large part of the tropical regions of Latin America; water courses are abundant; solar energy which is constant and permanent all year around and the wind which blows relatively constantly and intensively in many of the existing temperate plains.

Simple and low cost hidraulic wheels for slow currents; solar cells and windmills could positively contribute to the development of vast areas of Latin America.

F. Transportation.

In this field, research could concentrate its efforts to the search for low cost materials and procedures for the construction and stabilization of rural roads; in the planning of communication systems which expedite transportation of technical inputs to the rural areas and agricultural products to the urban areas.

V. RELATIONSHIPS WITH OTHER PROFESSIONS.

Due to the nature itself of the sciences participating in the creation of the body of knowledge pertinent to Agricultural Engineering and because of the nature of the problems which it must solve, related to the biological processes of growth and multiplication of plant and animal species, it is obvious that there must exist a very close exchange and complementation relationship with other engineering professions and other branches of agricultural sciences.

A very important experience in this matter took place regarding a tomato harvester which was developed by the Engineering Department of the University of California. After the first prototype of this machine was built it was found that tomatoes wouldn't let themselves be harvested. Their shape did not permit efficient action of the machine. It was then that the geneticists of the Department of Horticulture of the same University dedicated their efforts to producing a tomato with an adequate shape for harvesting.

Discovery and invention are generally the result of integrated efforts which bring into play the talent and knowledge of countless, and many times unsuspected sources. This is why aside from the natural relationships which must exist among Agricultural Engineering and the other branches of Engineering and Agriculture, it shall also be necessary for the research Agricultural Engineer to maintain close cooperation and exchange relationships with Agricultural Economists, Rural Sociologists and other similar professionals.

RELATIONSHIPS WITH EDUCATION.

The researcher is a depository of science within the knowledge of his especialized field. His main ally is the Library for, in general, all discoveries of the future are made with the support of the efforts and the knowledge of those who have preceeded us.

Because of this, the researcher is the teacher par excellence. He is the best suited to write university texts: to communicate knowledge in the classrooms and the laboratories and to form, in the universities, the student youth which shall succeed him in that unending chain seeking truth, perfection and man's happiness.

Knowledge which is not communicated dies and therefore delays the progress of civilization. The researcher who communicates his knowledge accelerates progress and compensates society for the efforts it made to put him in a position to generate knowledge.

In Latin America, where Agricultural Engineering is just being born as an organized profession, it is indispensable that researchers multiply through education.

VII. RELATIONSHIPS WITH THE FARMER.

The farmer, because of his postponement, his traditional margination, his human weight which is, proportionally, so large in Latin America, his direct involvement in rural tasks, is the most important subject in this process of accelerating development through Agricultural Engineering Research. It is he who turns the initial efforts of the researcher into more abundant, more appropriate and cheaper products. He is the one who shall undergo the simplification or multiplication of his own labor through the use of new equipment and new techniques; he is also the one who many times originates new ideas and initiatives, derived from the problems and difficulties he faces in his daily work.

This is why it is important that there be a direct and permanent relationship between the researcher and the farmer.

VIII. RELATIONSHIPS WITH INDUSTRY.

What we have said regarding farmers also applies, with other dimensions and shades, to industry. This is specially important to the Agricultural Engineering researcher who many times completes his work with the design of machinery, equipment and products which must be manufactured.

Which are the facilities available for manufacture? Which are the present and potential markets available? Which are the defficiencies of the equipment and products manufactured at present? These are some of the questions which might be answered by industry which, in its turn, can suggest other lines of work for the agricultural researcher.

IX. FINAL CONSIDERATIONS.

Agricultural Engineering, in an agricultural subcontinent such as Latin America, which is in the process of industrialization, can offer great contributions to the development of this part of the world. Agricultural Engineering is an extraordinary liason tool between rural problems and urban activities.

So that research in this field can play a more efficient role in the solution of the problems of agriculture and the economic and social development of the region, it is necessary that its objectives be integrated within a development policy.

In this policy mechanization, technification and greater productivity of agriculture must be conciliated with the creation of new and broader employment opportunities; the increase of agricultural production with the availability and enlargement of internal and external markets; industrial expansion in the fringes of agriculture with enlargement of regional markets and penetration into international markets.

The climate, soils and ecological factors in general, should be indicators of the scope and the projection of Agricultural Engineering Research. Modification of the housing environment for human life in the hot tropical areas by means of practical and low cost equipment and procedures would, undoubtedly, be the most important contribution which Agricultural Engineering could make towards the economic incorporation and the agricultural development of vast virgin regions of the Continent.

Development work has multiple facets which must be given simultaneous attention with the participation of many disciplines. Agricultural Engineering Researchers should be aware of this situation to set down the course of their work and to establish the framework of their participation, within a broad spirit of cooperation and complementation with other professions.

And, finally, the Agricultural Engineering research professional, similarly to the one who researches in other Production fronts, must feel that all his efforts are directed towards satisfying the needs of society and man's happiness. In fact, the success of his work as a factor of development, shall be determined by the extent in which he has effectively contributed to the conquest of these objectives.

A . 33. GRADUATE EDUCATION AND RESEARCH IN AGRICULTURAL ENGINEERING : A VIEWPOINT by F.J. Hassler, Biological and Agricultural Engineering, North Carolina State University.

I have studied the Brief, "A Proposal for the Development of Agricultural Engineering Education and Research in the Agrarian University, La Molina, Lima, Perú". written by FAO Technical Officers UNDP/SF 80, April 1969. To my thinking the document sets forth excellent guidelines for the proposed development. Therefore, as an outsider I shall limit my remarks to some factors you may want to consider in support of effective implementation of the proposal.

First, I hold the conviction that each institution's program must have its own style as a function of local circumstances, and should always be in a state of "becoming" rather than ever achieving a comfortable excellence. Established goals at any one point in time are to be thought of as intermediate objectives that must be re-evaluated, periodically, in the sense of dynamic programming, based on experience, experiment and logic. This modus operandi is specially pertinent to an engineering department inasmuch as successful engineering connotes change.

The purpose and function of your Agricultural Products Processing Department must be consistent with the two-fold mission of a public University: scholarship and service or long-range and short-range obligations. In scholarship the university's responsibility is to lead society's thinking beyond its recognized needs while service means attention to the commonly expressed needs of the present. Though emphasis of one to the exclusion of the other invalidates the purpose and function of a university, it is well to recognize that a national anxiety will always exist about the shifting balance between the service and scholarship roles of a state supported university. Because the university is increasingly regarded as a primary force for social, economic and cultural changes, decisions relative to the balance between service and scholarship are fundamental to leadership at all levels of administration.

You are no doubt by now wondering if and when I am going to address the specialty of Research in Agricultural Products Processing. With apologies for the delay in informing the people who organized this panel of my intentions, my remarks henceforth wil deal more with the similarities among specializations within Agricultural Engineering Research rather than the apparent differences that do exist. I have several reasons for taking the acknowledged liberty: (1) teaching and research at both levels of senior undergraduate and graduate students are recognized as being inseparable; (2) graduate research follows a proposed undergraduate curriculum that does not admit specialization, with which I am in agreement; (3) specialization at the graduate level is accomplished primarily by the research problems and student interest rather than a unique set of formal courses. Except to assert that an introduction to microbiology is essential to certain problems in Agricultural Products Processing, I will leave the matter of differences among the four areas to those more competent and concerned. Furthermore, we can all agree that somewhere within the total curriculum the student must be prepared to acquire needed understanding through self-study.

The immediate challenge that I see is to explicate a combined teaching and research program in our area of specialization that is consistent with the university's mission of scholarship and service.

The nature of engineering and the learning process of students, and the interaction between the two, are fundamental to any graduate program and associated research. Engineering is a blend of art and science; each is necessary but neither is sufficient without the other. While the methods of science (which demands a good measure of subjective imagination and skillful art when applied to real life problem situations) serve to benchmark engineering design resourcefulness in the art of engineering is necessary to make it work. Attempts at submitting engineering instruction to science to the exclusion of instruction in the art has demonstrated the importance of compromise. To eliminate exercise in the art of engineering by substitution of applied science is like "throwing out the baby with the bath water".

As to the student , only the very few exceptional ones learn deductively--from the general to the specific. They learn, rather, inductively--from the specific to the general. The power of generalization can't be assumed; it requires a certain degree of maturity and experience.

This brings us to the realization that John Dewey's philosophy of education--learning by doing--for primary and secondary schooling is pertinent also to the college age group. Alfred N. Whitehead, likewise, made a cogent observation in the statement, "Show youth where beauty dwells and there he will dwell also".

I submit that one of the greatest hazards to effective engineering teaching is the bright young Ph. D. , who has mastered the generalizations contained in the advanced methods of science and attempts to force his students, before they are ready, to learn deductively rather than from the specific to the general.

A graduate program should take account of the increasing maturity of students in their ability to comprehend conceptual and theoretical knowledge. Here, high standards should be maintained, because existing concepts are formulated mathematically and since the objective of science is to establish expanding knowledge on either old or new mathematical methods, it is quite by necessity that creative workers in Agricultural Engineering should obtain as early as practicable an understanding of advanced mathematics. Furthermore, in conjunction with the space-time-matter concept, the differential coefficients of calculus represent a most powerful means of rational analysis in engineering. Also, competence in advanced mathematics will encourage and permit the individual to read and comprehend as well as enhance his verbalizations in the various branches of science as benefits his interests and needs.

Since the theories in the life sciences are based on concepts common to physical and chemical theories, it seems that in the perspective of professional training, formal study should be concerned primarily with the mathematical and physical disciplines; the acquisition of techniques and general knowledge in the biological sciences can in the main be relegated to the student's progressive and continual self-study.

Any engineering research program should be based on an explicit recognition of an important need. This condition is equally appropriate to research associated with a graduate program in an Agricultural Products Processing Department. The mission-oriented laboratory, which is pursuing goals highly relevant to the needs of society, provides a rich source of ideas and an excellent environment for thesis research. A combination of the desire to know and the need to know is a highly motivating force.

Theme 7:

A . 34. PROBLEMS OF VITAL IMPORTANCE IN LATIN AMERICAN PROCESSING OF AGRICULTURAL PRODUCTS by Hernán Barreto Boggio, IICA-OEA.

It is a general opinion that economical and social development of a country are closely linked to industrial activities and that in many cases the latter are used as measurement of the first ones. In developing countries there is a gradual displacement of laboral forces from agricultural activities to be dedicated in greater proportion to manufacturing activities. This resettlement implies a physical motion of people that come from rural zones to the cities and urban centers attracted by better salaries and pressured by emergencies proper of agriculture such as floods, droughts, plagues, low prices, etc.,that temporary or permanently do not permit them to continue with their agricultural activities.

All governments, knowing the great importance of industrial development try to force the accelerated growing of this activity as far as they can do it with the economical means available and in accordance with the established priorities. These priorities should be established by the plannification groups within the macro-economic scheme of the country.

The agricultural industry, known also as agro-industry, is placed within the industrial sector because all raw materials for this industry comes from agriculture. Its development is closely associated with the development of agriculture and animal husbandry that must provide with the raw materials. This is even more important in the case of Latin American countries where the rational utilization of the natural resources should benefit not only to the industrial sector but also to the agricultural sector that support a high percentage of the population.

In basis of the situation described above it is a primary purpose of Latin American governments to promote the growing of agro-industrial activities as it is shown by numerous laws and measures in this respect. Among these we can mention: free import duties for agro-industrial machinery; partial or total tributary exemption in the administration of agro-industrial concerns; setting institutions for applied research; more liberal loans from local banks of development when the money is going to be invested in this activity; agreement from government to government or with international institutions for establishing specific research and/or promotion programs ; consideration within the program of agrarian reform of activities related to processing of agricultural products, etc. etc.

Universities and professional education centers are institutions staffed with able and competent personnel and therefore it is necessary that their activity should be directed toward solving problems of regional or national magnitude, with the purpose of promoting the social and economical development of the area.

In the case of the universities that offer academic training in agricultural engineering it is important that besides the well planned sequence of basic courses, the content of applied courses as well as the research work be directed to solve local problems . A relationship should be established between academic work and local interest, trying to analyze those problems in the field that because of its complex nature and / or its implication in the development of the country are worthwhile to be studied in an academic institution. The emphasis that should be given to either one of these criterion will depend on the coordination that should exist with the other institutions dedicated to applied research in the field, such as, institutes for technological research, centers for industrial development, experimental stations, etc.

In order to achieve this aims it is expected that professors and researchers be aware of the existing problems and so it is necessary to establish some means of communication with institutions of the government and with the private industry.

This communication could be done through an exchange of ideas in organized meetings such as seminars, panels, symposia, etc. inviting the managing and technical personnel to the university. These people should present and explain their problems and promote discussion around them and, at the same time, a schedule of visits from the professors and the students to the industrial factories should be set up with the purpose of knowing and be familiar with their activities and problems. Another way of communication should be establishing contracts with public and private enterprises to carry out research work in some specific areas. These contracts will permit to know actual problems, to utilize more intensively the physical and human resources of the university, to get an additional income and to give the students the opportunity to be in contact with industry that will offer them job opportunities in the future. Reciprocally, the public and private sector will benefit from this cooperation because it means that they will have available technical assistance avoiding them to maintain permanent personnel and equipment and at the same time letting them to know potential candidates that may find a job with them in the future. This is even more necessary in the case of the agricultural engineers especialized in processing, that are in a new profession and must compete with other professionals such as chemical engineers, industrial engineers, chemists, etc.,generally known and accepted since many years ago.

Once the importance of the industrialization of the agriculture in the social and economical development of a country has been emphasized and keeping in mind that researchers and university people must be in close contact with the national reality, we will present some of the problems that may be studied in the area of processing of agricultural products.

One way to guarantee that new industrial centers are going to be established and have a successful operation is to have economical studies that permit to define the most convenient size of a factory and to know what is the minimum economical size of a plant. All this requires studies on marketing, at its present level and also projected for the future in base of statistical bulletins, polls, etc. Besides this information, it is necessary to have information regarding "economy of size ", that is the variation of unitary costs of production as function of plant size. Agricultural engineers should play a role in this because knowledge is required on equipment and technical design. At the same time, when dealing with engineering aspects within the project it will be necessary to take decissions about the most suitable processing methods and this requires to be familiar with the various technological alternatives. The decission should be taken considering not only the aspect of machinery but also considering the raw material through an optimization of processing parameters to keep without major change the physical, chemical, biological and rheological properties of the product.

The study of these two factors, economy of size and technological alternatives, for various agro-industries, would be a research line very timed and very practical. These studies should be carried out with the cooperation of agricultural economists in order to present an integrated solution.

Research also must be focused in areas of apparent less technological complexity but of equal or higher economical and social importance as it is the case of the storage of agricultural products. Everybody knows the fact that a high percentage of the harvested crops were lost during transport from producing centers to consuming centers due to an ineffective control of the spoilage. This control involves basic measures directed toward preventing or reducing undesirable changes, to permit an increase of desirable changes, protection of products against physical damage and against spoilage microorganisms and to reduce the period required for storage and transport. To implement these principles it is necessary to have knowledge of post-harvest physiology, as for instance is the case of susceptibility of fruits and vegetables to low temperature, freezing, heat, low oxygen pressure, etc. Other examples are the application of modern methods of spoilage control with all the required calculations and design as in the case of controlled atmosphere storage of apples; use of ethylene for coloring oranges; temperature control by means of mechanical refrigeration ; liquid nitrogen, hydrocooling evaporative cooling; transport in an inert environment; chemical control of microorganisms; design of packing structures; use of radiation in low dosis to reduce physiological changes or in high dosis to esterilize the product, etc.

Research in the area of processing of agricultural products should also include aspects related to the small and medium size industry as well as to cooperatives. These are organizations suitable to deal with processing of dried fruits; coffee and cocoa fermentation; alfalfa meal production; manufacturing of cheese, butter and dairy products; manufacturing of marmalades, jellies, snacks and candies; curing and salting of meat and fish, manufacturing of cider and other fermented beberages from fruits as well as wine at domestic level; manufacturing of fibers; fermentations of olives, like is the case in Peru where the processing of olives is a domestic industry unlike Argentine Where it is typically industrial; processing of castor beans, tea, tamarind, chili, pepper, mint, essential oils, dates, etc.

Finally, we have lines of research in typically industrial problems, very complex technologically speaking. In first place, we could include the study and measurement of many organoleptic and rheological properties such as odor, color, texture, flavor, viscosity, density, etc. and measurements of physico-chemical properties such as thermal conductivity and thermal diffusivity,surface tension, hygroscopic characteristics, determination of isotherms, heat sensitivity, etc. All this information can be used in the design of equipment and in optimizing processing parameters.

Then, we could consider the use of several methods of dehydration such as atmospheric or vacuum drum drying, spray drying, freeze drying, foam mat drying, etc. All of these methods should be applied to the drying of local raw materials like tropical fruits. Similarly, it would be very interesting to make comparative studies about the various methods of juice concentration, i.e. evaporation, freeze-concentration, dialysis, etc.,with the purpose of utilizing them in the future in connection with local agricultural resources like oranges, lemon, grapefruit, grapes, etc.

There is one aspect generally overlooked when research activities are planned and this is the aspect related with the importance of packing to preserve the product. This is very relevant in the case of dehydrated products, where the package, rigid or flexible, must have a low permeability to reduce the transfer of oxygen, water vapor and light and at the same time to protect the package against mechanical damage.

At last, research about equipment and machinery should be considered, including auxiliary equipment such as pumps, boilers, water softeners, retorts, carbonic gas plants, valves, electronic control and recorders, etc. Performance, pressure drop, network design should be studied in order to determine the best selection of equipment and working conditions and also to suggest the instructions for preventive maintenance.

Sumarizing, the orientation of research should be balanced between the academic approach, that is, a theoretical and sophisticated research and the practical approach, more social and economical and with a more simple technology, readily applicable. This balance may be changed as long as new resources become available and exist other institutions sharing the same social interest. The whole scheme may change from one region to another and from one country to another.

A.35. MINIMUM REQUIREMENTS TO ESTABLISH EFFECTIVE RESEARCH IN THE AREA OF PROCESSING OF FOODS AND AGRICULTURAL PRODUCTS by Freddy Salas Arango, Universidad Nacional Agraria, Lima, Perú.

This paper presents the ideas that in matter of research are the result of the experience that in this field have the author and some members of the Department of Food and Agricultural Products Technology of the Agrarian University, Lima, Peru.

It is a known fact that research in Latin America has not reached the level of development of other countries technologically more advanced. There are several reasons for this situation and this is not the place to analyze them, but we would like to emphasize the effort that is being done in this region to promote this activity. To achieve this objective, scienfitic institutions are being founded, technical personnel is being trained and facilities are increasing. The new attitude has come as result of the conviction that research based on knowledge of national reality is needed to solve the fundamental problems of our countries. The results of this research will indicate the techniques and methods that have to be applied.

According to the above, the minimum requirements for establishing an effective research in the area of processing of agricultural products and food technology could be readily infered from an adequate answer to the questions: what to do in research?, who must do the research? and, how to do the research?

What to do in research?

This is a fundamental question and deserves the greatest attention. In our developing countries it is necessary to consider that the problems to be studied are large in number and variety and that there are few institutions to carry out scientific research; therefore, the relatively few people engaged in this activity are practically overloaded with requests for doing research. What to select and how to select? are very important questions that must be clearly stated in order to establish a criterion of selection.

First of all, we consider that the selected topics or problems, must have national importance, that is, they must contribute to an effective solution of the basic problems of the country, It is evident that one investigation only or the work of a limited number of people cannot solve problems of national magnitude, but we have to be sure that research policy at national level must have the trend mentioned above.

In this respect, the attitude of researchers in our countries must be modest looking for an effective result rather than for scientific problems, theoretical and fundamental, very academic and attractive, but without meaning in the technological development of the country. It should be considered that many of our scientists are capable of doing sophisticated research that may satisfy their scientific status and let them to practice the latest knowledge in the field, but the lack of a clear understanding of our level of development and the lack of social motivation of their part, when selecting the research topics, may conduct them to serious frustrations or to useless work, absolutely divorced of the actual requirements of the country.

The former statement does not mean that fundamental research should be completely overlooked, because in many cases it is a needed step before going on effectively with the applied research. The intention is to place the work of our scientists within a more realistic approach. Here it is pertinent to mention an experience that happened in our Department during studies on spray drying of tropical fruits. The first experiments showed that there were many problems when we tried to obtain a powder that could reproduce the original characteristics of the fruits on rehydration and that the technical literature available in this area offered little information. As a consequence of this, with model solutions and try to obtain theoretical information about the factors involved in the spray drying operation.

A second characteristic of research in the area of processing agricultural products is that in many cases must be integrated with research in other areas, like agronomy or economy. One example that clearly shows the need of integrated research is the work that must be done in vegetable oils for human consumption in Peru. Our country has a high deficit in fats and oils and the import of these products increases year after year, affecting seriously our foreign trade. A research intended to solve this problem necessarily involves agronomical, engineering and economical aspects. Agronomic studies should be done in relation with plant breeding, plant pathology and entomology and with the general agronomic techniques; research in agricultural engineering is needed in relation with mechanization and irrigation and in the area of processing in relation with the extraction and refining of the oils. Economical studies should be carried out to determine costs of agricultural production and industrial processing. An isolated research in any one of these fields, although well planned and with postive results, is of little significance compared with the whole problem.

Who must do the research?

It is clear that the effectiveness of a research work depends very much on the people responsible for it. In Latin America beside the training in Agricultural Engineering and in Food Industries offered at La Molina and training in Agricultural Engineering initiated in some other countries, there are no academic programs designed to prepare technical personnel in the area of processing. In most of the places the work on processing of agricultural products has been the responsibility of ingenieros agronomos; on the other hand, in the food technology field, ingenieros agronomos and chemical engineers have shared the responsibility of this activity, the first ones providing their knowledge on biology, chemistry and on the agricultural raw materials and the latter providing their knowledge on processes, equipment and controls. Veterinarians in the area of food microbiology and sanitary control and chemist and pharmacists in chemical control have also contributed to this activity.

It is necessary to recognize the work done by all of these type of professionals but, with no doubt, an accelerated development of the whole activity of processing requires personnel highly trained in processing and technology. Agricultural engineers have a basic training on processing fundamentals and on the areas immediately related and are also educated in an agricultural environment ; therefore, among the various professionals they are the more qualified to do research in processing of agricultural products. Research on food technology, with more industrial character, should be in the hands of food technologists or food engineers, but, certainly, there are many instances in which agricultural engineers can make an effective contribution in this area.

How to do research?

Facilities in regard to laboratories, equipment, library, etc., are required if effective research is going to be developed.

Laboratories.

The type of laboratories needed to develop research will depend on the type of research intended; however, we can consider the following laboratories as a minimum requirements: (a) process engineering laboratory, devoted to research in engineering principles that are basic to all agricultural processes; (b) processing laboratory, where studies are made on the various processes that may be applied to the agricultural and food products and (c) quality control laboratory, in which chemical, microbiological and organoleptic controls are studied in relation with the raw material and with the final products. A storage room and a mechanic shop need also to be considered. The area of these laboratories will depend on the quantity and kind of equipment to be housed and on the future expansions as a consequence of the development of new activities.

All laboratories should have the following services available: a) cold and hot water, at a pressure of 60 psi at least; b) monophasic and triphase alternate current, c) steam, from a 15-20 BHP boiler, d) compressed air, at about 120 psi and e) gas. It is recommended that all this equipment should be installed in a machine room, under the surveillance of a competent mechanic.

Equipment.

It is natural that the equipment to be installed in each of the laboratories will depend on the kind of research needed and on the money available; however, there is some equipment that must be considered a kind of a minimum. When the selection of the equipment is done, care must be excercised not to select industrial or semi-industrial equipment because usually they require big amounts of raw materials and are difficult to handle and to move.

On the other hand, a criterion of flexibility should be present when making the selection in order to have individual pieces of equipment that may be used to set different processing lines.

Laboratory of Process (or Food) Engineering.

Some equipment that need to be considered in this laboratory are the following: (a) equipment for studies on flow of fluids, liquids as well as gases; this set should be conveniently instrumented with rotameters, orifice, venturi meters, manometers, etc., in order to have measurements of flow and pressure drop in pipes of different diameters and in valves and fittings; (b) equipment for determining the operational characteristics of pumps, fans and blowers; (c) equipment to study heat transfer phenomena, to determine thermal properties of agricultural products and foods, to measure thermal conductivity, to find heat transfer coefficients, etc.; (d) equipment for grinding, including hammer mills, plate mills, roller mills, instrumented to study the various parameters affecting grinding operation; (e) equipment to study mechanical separations such as sieving, cyclone and hydrocyclone separation, centrifuging, filtration, etc.

Processing Laboratory.

The equipment of this laboratory is closely related to the type and level of research to be carried out; we could consider some minimum requirements in the main working areas; (a) equipment for drying of foods and agricultural products that must include grain dryers with natural and heated air, tunnel dryer, vacuum tray dryer, vacuum and atmospheric drum dryer, spray dryer and freeze-dryer; (b) pilot storing chambers, with controls for temperature and relative humidity and facilities to establish controlled atmospheres; (c) equipment to study fermentations, curing and other important processes for agricultural products; (d) equipment for refrigeration and freezing, with temperature variations from plus 10° to -40°C; the equipment for food freezing should include blast freezers, still air freezers, plate freezers and immersion freezers; (e) equipment for extraction and refining, including hydraulic processes, expellers, solvent extractor apparatus and equipment for refining and purification; (f) equipment for canning and food processing in general including preparation tables, blanchers, exhausters, can sealers and cap closing machines; steam kettles, finishers, pulpers, homogenizers, evaporators for concentrate preparation, etc. etc.

Laboratory for Quality Control.

In the area of chemical analysis it should include equipment for moisture determination with conventional and quick methods; equipment for determination of the main components of foods (proteins, fats, fiber, minerals) and basic equipment for titration. The area of physical and physico-chemical analysis should include equipment for determination of rheological and textural properties (viscosimeter, penetrometer, shear press, etc.); equipment for refractometric, colorimetric and polarimetric analysis. The area of microbiological control should include microscopes, incubators, ovens, retorts and equipment for culture preparation (plates, tubes, counters, etc.) Finally, every laboratory for quality control should have facilities for organoleptic analysis.

Library.

An essential complement in research work is a specialized library, adequately supplied with books and periodicals. There are relatively few books about processing written in Spanish and in the last years efforts are being made to have available in our language books translated from English; we consider that it is more important for our scientific development to encourage and promote the publication of books in the field by Latin American authors. With regard to periodicals and journals United States and Europe usually offer the latest scientific material. Many other publications from Latin America or other places of the world, less known or prestigious, may offer a more interesting and useful information to us. In this respect it is convenient to have exchange of information with countries and institutions with problems and conditions very similar to ours.

Professional societies, meetings and general exchange of ideas.

Research to be effective need to be published, divulged and applied, otherwise remains only as an academic or scientific excercise. Professional societies, at national or international level may be found useful in this respect. At the level of Latin American it is needed to define clearly our basic problems in the area of processing and technology and to exchange information and experiences in a way to make research more effective. If some problems are common to all of us, solutions also need be common.

Theme 7:

B.36. RESEARCH IN FARMS STRUCTURES AND RURAL PLANNING by L.L. Boyd, Professor and Head of the Agricultural Engineering Department, University of Minnesota.

As I indicated earlier today in my paper on the philosophy and Methodology of Research, it is a pleasure to have an opportunity to return to Peru after five years to meet with this group. I am certain that there have been a great many developments in Peru in the five years that have passed since I was here to work with the undergraduate program and to advise about research activities. I am looking forward to learning of the progress during the open-house and the discussion of problems peculiar to South America during the following session.

Todays technology is sufficiently complex that much of our research must be of cooperative nature with other disciplines and / or with other areas within our own discipline. I want to emphasize the latter as I feel we have not done this well. Certainly, agricultural structures and rural planning research fits well into the cross-discipline and intra-discipline categories. I will enumerate some of the areas in which we in the United States are conducting or might conduct research. These areas will not be covered in their order of importance in North America, but rather as I visualize their order of importance in South America at this time.

Human housing including sanitation and water supply would appear to be one of the studies needing the first and greatest attention. Certainly housing is an important factor in improving the standards of living of people in any country. Perhaps in South America agricultural engineers are the only ones that will accept responsibility for this work. We should work with Home Economics Specialists and interested Architects and Engineers. Studies in housing obviously cover all of the structural strength aspects, the materials for the overall structure and for particular uses within such as work counters, floors, etc. Attention also must be given to arrangements of storage space, work counters, windows, ventilation, etc. , which contribute to the overall efficiency of operation within the home. Water supply and sanitation contribute directly to the health of the nation, and the health of the nation is its property. Obviously, these could be some cooperation with the soil and water engineers in the location and maintenance of a pure water supply or in purifying the water if an original pure source is unavailable. Care must be taken to provide sanitation facilities so the environment will not be polluted with the waste products in the home. The location of water supply and sanitation facilities should be a part of the overall rural regional planning.

Housing studies should include all aspects of safety for the entire family, but particularly for the children. Utilization of solar energy for heating and of the soil for both heating and cooling should receive attention. Cooling, using the soil or ground water, can relate to storage of food supplies as well as to family comfort. The sociological and psychological effects on the family should not be overlooked. This further emphasizes the importance of cross-disciplinary cooperation.

A second area of great importance is that of food and crop storage. In food deficient areas it is particularly important that the quality of the harvested products be preserved until they can be processed and that the processing prepare the food for safe long term storage. Crop storage likewise is important, but does not demand quite the same standards of sanitation and preservation as human food. Losses must at least be minimized if not prevented and thought be given to the physiological and pathological considerations that contribute to the breakdown of high quality food products. Pest control, i.e., insects and rodents, must be incorporated in storage facilities. Obviously, engineers working in these areas need the full cooperation of plant scientists who are conversant with the physiological and pathological considerations. Entomologists provide needed cooperation for pest control studies.

Another important area of study in any part of the world is the utilization of readily available products in agricultural buildings. In the United States construction has begun to move away from wood to steel because of the efficiences of mass to move away from wood to steel because of the efficiences of mass production compared to on-the-site construction. A number of new plastics are receiving wide attention. Studies to determine the suitability and possible usages of native material, including quality control and economic fabrication are quite important. In Peru bamboo grows rapidly and should receive some attention. Studies of bamboo uses should consider manufactured products as well as its natural form.

Any structural project should seriously consider the utilization of the methods of dimensional analysis and similitude. Dimensional analysis uses dimensionless groups, or pi terms, to reduce the number of variables to be investigated. Because the variables are put in combination the effect of something that is difficult to vary, e.g., the force of gravity, can be assessed by varying something else in the group. Similitude methods also permit one to work with models of the physical phenomena which require less space. Models because of the precision which they require in preparation often do not decrease the cost of the experimentation appreciably. Most people tend to think of models of physical systems, but I believe that much can be done in modeling the biological systems as well. Obviously, some will have to be done on the basis of distorted models and will require a considerable amount of time for proper evaluation.

The greatest challenges facing the agricultural engineer interested in research and in farm structures and rural housing lies in the integration of biological control systems with physical control systems. These should be enjoined with considerable regard for the social systems in the production of plants and animals is vitally important because it provides the possibility of an early if not immediate evaluation of the response of the plants or animals to changes in their total environment. As an example, in field irrigation needs of plants might well be determined by non-visual response(s) coming from the plant system rather than from waiting for the plant to wilt or by making a soil moisture measurement. Both are delayed and indirect measurements.

One might question whether or not this is a farm structures and rural planning responsibility, but it is environment. The structures majors are as well, if not better, equipped in the various aspects of environment than majors in any other area. The response of animals to housing or confinement conditions, to the availability of water and feed, to the avoidance of solar radiation, etc., needs far more rapid evaluation than can be obtained by calculating the rate of gain, the number of eggs, laid, etc. A number of leading building and environment scientist already are working closely with their animal scientist colleagues in the utilization of implanted transducers for determining such things as heartbeat, blood pressure, temperature at various points in the body, etc. We should be able to monitor a random sample of the population of any livestock facility through telemetry and with a small computer calculate the necessary information to indicate when animals need feed, water, cooling, etc.

Systems engineering studies of agricultural structures is a most important research area. Systems studies cover both the physical system components, i.e., the buildings, the equipment, the weather, etc., and the biological system components of animals or the stored products and the humans who are interacting. Component studies can and must be made, but the interactions of open systems must always be considered. Structure's people must develop the structural equipment for management, i.e., for materials handling and for environment provision, but should seek the full cooperation and assistance of machinery people. Likewise, processing people are needed in some of the systems studies on food and crop storage.

The structures and rural planning agricultural engineer should never lack for important research to conduct. Important problems, are before him; he needs only to begin making full use of his wisdom and training.

B. 37. PROBLEMS OF VITAL IMPORTANCE IN FARM STRUCTURES AND RURAL PLANNING by Norman C. Teter, Agricultural Engineer, ICA - Colombia - University of Nebraska.

Latin America includes frigid ice caps, burning deserts, rolling plains, impenetrable forests, mountain heights, and swamps. The people include caucasians, native indians, orientals, negros from Africa and every conceivable mixture of these races. The culture, predominately Spanish and Catholic, nonetheless is a mixture of tradition based localism, animism, and a great variety of other "isms". It is evident, therefore, that Latin America has a wide variety of problems awaiting research solution. Why, with so variegated an ambience, is Latin America so widely considered as one entity? Would one normally discuss the problems of Nome, Alaska with those of Miami, Florida?

Perhaps the common denominator is poverty in the midst of riches-- a failure to fully utilize the resources and to achieve the abundant living that we know is possible. Modern technology has flown into the isolated mountain regions, widening the income gap, increasing the fatalism, apathy and frustration of the subsistent farmer. I do not pretend to know how to solve the great overall problems of rural housing, sanitation, and planning. I don't even understand them.

So let me give you a few quotations from others with whom I happen, at the moment to agree. Friedman[1] says that progress must be flexible and fluid to move toward the maximum development and that this movement must be guided by a high volume of scientific and technical research. He says[2], "There is a common-sense thesis that argues that transitional societies need not engage in significant research since technology can always be imported. This view is held in error: a country so inclined may find itself forever in the backwaters of progress". He further states that,

"Imported technology has three unfavorable consequences:

- It leaves the exploitation of monopoly based on invention in the hands of foreign enterprises.
- It foregoes the possible gains from novel factor combinations more suited to the natural environment than the imported technology.
- It fails to make the most productive use of natural resources."

I believe Friedman's points are valid because they are repeatedly verified in our experience. For example, farrowing crates, a simple item to construct in a small shop with minimum machine tools, have been imported from the U.S.A. Portable milking bails are fabricated in Colombia and often installed in permanent milking rooms with no change from the English bails. Royalties are being paid to copy some very elementary and often erroneous designs. Exploitation comes through monopolized use of foreign inventions ill-suited to the local conditions, and constructed of foreign resources. In the research chops of ICA we designed new farrowing crates and new farrow-to-finish swine production buildings adapted to the skills, the tools and the materials readily available. We combined tilt-up concrete construction with bamboo and sheet steel to design a farrow-to finish building adapted to the bamboo climate. We took the technology of the dairy, adapted it to the Sabana de Bogotá and came up with a portable herringbone double-5 unit that promises to improve the efficiency and sanitation of milking. These concrete "inventions" serve to:

- Inspire confidence in inventive progress within the country.
- Make use of the natural environment to the maximum extent. (temperature, rainfall, sunshine, soil type, soil cover, slope, access, markets, customs, education, construction material supply, and other factors combine to make "on the spot" study necessary for good judgment in designing for the environment).
- Make use of the resources of the country and the intelligence of the people available to use the resources.

Briefly, we believe in applied research. Simple day-to day approaches to solutions of problems as shown in the slides used to illustrate this paper serve to develop inventiveness, manufacturing, and resource use. With vast resource reserves like those of the North Coast where we can produce 12,000 kg. of corn per year per hectare (191 bu/

acre) we must solve the problem with machinery for rapid harvest, driers to permit high moisture harves, intermediate storage near the farm, and facilities to furnish water in the dry season.

Vital problem solutions:

* Puts more power at the disposal of the individual agricultural worker. MECHANIZES.
* Controls environment or adapts to environment to increase production and decrease losses. CONSERVES.
* Coordinates the solution to rest of the world. MOBILIZES.

The claim that mechanization creates un-employment is not valid. Employment must be productive or it should not be classed as employment. Economists use terms like disguised un-employment, non-productive employment, under-employment, etc. to describe the hopeless condition of "the man with the hoe".

$$(\text{Man Hours}) \frac{(\text{Production})}{(\text{Man Hour})} \quad : \text{Production}$$

Danger lies in insisting that the farmer needs only to own a little plot of land and a little better hoe.

Books like those written by Borda[3] or Loomis[4] point out the problems of small holdings further fragmented through inheritance. Yet some land reforms form more small plots of land ownership. This is no solution. It viciously perpetrates under employment.

Futility of labor with resultant poverty of under production is amplified by wastage through rot, mold, fire and deterioration of wet, weathered grain; mishandled fruits; and abandoned cotton.

And vast resources of the plains lie fallow because the sociologists, the economists, the engineers cannot create the mobility to promote the use of land to meet the need. The land must be used in the near future but the way toward use development is direct productive research.

In sophisticated terms of Hirschman[5], the DPA (Direct Productive Activity) should lead the SOC (Social Overhead Capital). Why? Because we lack the omnipotent intelligence necessary to plan all the power stations, roads, sewers, milk receiving plants, schools and all other institutions and constructions needed for social living before the real need exists. Mistakes in big SOC investments retard, they do not develop.

Quoting from Friedman[6], a practical planners wisdom has these points:

"1.. Learn to live with an imperfect world that is perfectible in part only, never in whole.
2.. Learn to appreciate that some improvement is better than none at all.
3. Do not try for symmetry in the designs of solutions; tailor solutions to local circumstances and needs.
4. Do not attempt to solve all problems at once; do not even try to understand them all; you will find yourself plumbing a bottomless pit. Concentrate on truly important things first. Some problems vanish if you leave them alone.
5. Proceed step wise, incrementally, along the path of least resistance. Among important things to do turn first to those that are easy to solve.
6. Do not be over concerned with overlapping functions, fuzzy boundries, conflicting jurisdictions. Some redundancy may be worthwhile, uncertainly makes one proceed with caution. Competition is also a problem-solving device.
7. Step back occasionally to regard your hand work: Assess the total situation with a keen, objective eye, divine the changes in values that have occurred, if necessary redefine your problems, clarify your objective, critically review your strategy and tactics".

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Theme 7:

B.38. MINIMUM REQUIREMENTS FOR ESTABLISHING EFFECTIVE RESEARCH by Robert G. Yeck, Consultant FAO

An event in nature, an eye, a mind and a communication device are the minimum requirements for effective research. It can be as simple as that. The application of the scientific method calls for observing some events of nature, drawing an hypothesis and testing the hypothesis through further observations. Research administrators (I am one of them) have added "publish results".

Of course, most problems will require a more complex research approach. Events in nature, machines, etc., will need to be manipulated or simulated to determine behavior over a range of conditions. Instrumentation will be needed to aid the eye in sensing and help the mind in recording important aspects of the events. A variety of techniques and machines might be involved in the analysis of data. These could range from simple graphical analysis to costly electronic computers. No matter how sophisticated are the devices the success in the use and operation of them depends on the skill and judgement of the researcher. Therein lies a clue to the minimum requirements for effective research in graduate training.

The training of a graduate student should have the flexibility to meet the specific need of each student. Some students will plan to work in research where many such devices will be readily available. It would be desirable for these students to attain experience with the equipment they would be using. Others may also conduct research but will have only the simplest devices and facilities with which to work. They should be taught to make the best of their resources rather than be "spoiled" with elite devices. Important aspects of a master's research program are supervision and guidance. A student's advisor should be prepared to spend much time with the student.

Such a discussion provides little assistance to the administrator who must arrange for finances, conduct planning, and arrange for implementation of plans. The administrator should realize that the requirements for conducting research will vary with the problem as well as among researchers working on the same problem. In my experience the best approach is limiting advance preparation to furnishing office space, a clean laboratory area (suitable for drafting and instrument care), an inside laboratory area (or outside or combination thereof), and a small research machine shop area. Other than standard office and laboratory equipment, the procurement of instruments and equipment should be delegated to the researcher to be accomplished when he begins work. This requires setting aside adequate funds for this purpose. In this regard, it has worked well to set funding on the basis of the scientist's salary. Other costs, including secretarial and other subprofessional assistance, should be estimated at between one and two times the scientist's salary. The case of the graduate student is usually different. Generally, he will have to conduct his research within the limitations of equipment on hand or available on loan from some other laboratories.

For farm structures research, environmental measuring equipment, structural strength testing equipment, load and deflection measuring devices are considered basic to graduate student needs. Both field and laboratory testing sites should be available.

It should be noted that some excellent research can be conducted in cooperation with farmers or industry where the cooperators will pay the cost of a prototype structure and the researcher's cost is limited to his time and travel plus that associated with making measurements.

Publishing of results was mentioned earlier. The words "publish or perish" have caused cries of protest among many scientists, but let us remember that most research is conducted to provide knowledge or devices to solve problems.

Generally the application of the research results is the responsibility of others. Therefore, communication of results becomes very important.

Once a manuscript is prepared, research institutions have a responsibility to assist in arranging for publication. Technical journals are becoming more restrictive in the space available for research reporting. Research institutions should be prepared to publish research reports and bulletins. Emphasis should, of course, be placed on the quality of research and getting the research ompleted but publication of results remains important.

Theme 7:

39. RESEARCH IN POWER AND MACHINERY by P. C. J. Payne, National College of Agricultural Engineering, Silsoe Bedford, England.

There are many alternative classifications of the areas in which Power and Machinery research is needed, but the following are suggested as being particularly relevant to a developing country:

1. Need for and specification of equipment.
2. Development of measuring apparatus and techniques.
3. Development of components or whole machines.
4. Improvement in existing techniques.

Need for and Specification of Equipment.

This classification may not be worth singling out in an induatrial country because mechanization has already proceeded far enough for the gaps and failures in the broadest sense to be obvious to all concerned, while, when a really detailed appraisal is required, it would generally be undertaken by a commercial company under the heading of "Market Research". For instance, in Britain, it is generally recognized that no complete potato harvester which will operate under adverse conditions is yet available and many vegetable crops still remain to be fully mechanized. The problem is not that techniques which would solve the problem are unknown but that these techniques are either uneconomic in relation to the acreage grown, or so sophisticated as to be unsuitable for use on a farm.

In a developing country, however, with almost the whole job of mechanizing its agriculture yet to be undertaken, correct decisions on priorities become of vital importance and in the author's view, justify a place under power and machinery research. The work will nearly always call for a team approach; the team to include sociologists, economists, agronomists and, of course, agricultural engineers, who may well be in the best position to lead the team. There would almost certainly be situations in which the team would be successful in identifying needs with commercial potential, and here , their main problem would be to convince a manufacturer that there was a sufficient market to justify his undertaking the development.

There may be other areas in which public sector organizations such as government Research Stations and University Departments can carry out all the basic research such as quantifying the likely size of market and the price of machine that would both be acceptable and satisfy the requirements, but thereafter leave the engineering development work and marketing to a manufacturer who, without being provided with the product planning stage, would never have entered the field.

In other cases, however, the profitability of a market will be altogether too doubtful to interest manufacturers and all functions, except production, may have to be performed by the public sector organization. A good example of this is a simple hand-pulled and operated rice transplanter of timber construction now gaining ground rapidly in the Far East. The specification, the design and the testing were all carried out by public sector researchers. It is understood that wood was chosen as the construction material in order that local carpenters could easily effect repairs and manufacture could be undertaken at many centres on a small-scale, batch production basis. There remained the problem of distribution and , in this case, the Massey-Ferguson Company offered its own and its Dealer's services in the interests of goodwill, and no doubt with a longer term eye to improving the money income of the rice farmer, thus enabling him to purchase more sophisticated products in the future.

Development of Measuring Apparatus and Techniques.

Unlike the previous area where, in many circumstances, commercial organizations will be paramount, the development of apparatus and techniques for measurement must remain almost wholly in the hands of universities and research organizations, because it is rare that there is any expectation of commercial profit. In the author's view this is a particularly suitable field for universities, and in particular graduate students, as the proportion of intellectual requirement is usually high relative to the routine work.

In developing countries a good example of the type of apparatus referred to would be devices for measuring the human effort required in various manual operations, or the development of formulae for calculating the maximum cost of specific mechanization operations that can be justified on economic grounds.

Development of Components or Whole Machines.

This is the type of research most commonly associated with the power and machinery area, but in the U.K. it has also frequently proved disappointing when undertaken by universities and research organizations. There have been numerous examples of apparently sound machines being developed at great expense and demonstrated successfully to manufacturers with the idea that they should make a bid for production rights. Sometimes, none has bid. At other times, several have bid and a great deal of diplomacy has been required in deciding which should be allowed to go ahead. Assuming that all this is done, the manufacturer frequently seems to be somewhat half-hearted in his efforts and, in converting the experimental design for production, often seriously reduces the performance of the prototype.

The greatest successes of research in the field of machine development have occurred where something previously believed impossible has been proved possible and manufacturers have then produced their own alternative solutions.

The reasons for the failure of researchers' products when put into commercial production are probably partly psychological, in that it is expecting a lot for a manufacturer to throw his whole resources behind a development which the world knows not to be his own. Moreover, patent problems often arise. Though the development may be adequately covered, the manufacturer who eventually obtains the rights to manufacture has an uncomfortable feeling that so much publicity has been exhausted with the original demonstration that little is left for him, and anyway, his competitors may have been stimulated to come up with alternative solutions.

Most of these problems can be obviated if, instead of going ahead on their own, the researchers enlist the help of a single manufacturer right from the start, probably asking him to take a financial stake. Like this, the problem of which company should get the contract is avoided and psychologically the manufacturer is perfectly happy to describe the development as having been carried out in conjunction with such-and-such a university department, when he would not be nearly so happy to describe the project as having been carried out by the university department. Even where, in a developing country, the word "manufacturer" really means "jobbing engineer", "blacksmith" or "wheelwright", it is important to involve him right from the start so that manufacturing techniques are not included which would be beyond his capacity.

Improvement in Existing Techniques.

In industrial countries this area of research generally involves studying efficiency of the man/machine complex and includes ergonomics, physiology, psychology and a host of other disciplines. It is interesting, but generally only provides marginal improvements in profits and is omitted altogether from the early stages of most developments.

In developing countries, however, it may well prove quite the most profitable sphere of activity. It may be expected that the first classification of research will identify routine jobs with a poor output per man, and allocate priorities to those which are of the greatest importance to the territory being considered. Workstudy may be needed to isolate the least efficient operations, or they may be immediately obvious. Output per man will usually be the main criterion and it may be necessary to measure the muscular effort involved by respiration or cardio meters. The feelings of the workers will also have to be taken into account as their goodwill must be ensured and for this, it is generally necessary to make it obvious to them that there is something in it for them.

A simple example of the type of improvement that may be possible may be cited from East Africa, where it was traditional to pick cotton with one hand, into a bag hung from the picker's shoulders, while the other hand was used to hold the neck of the bag open. The basic improvement was to use a loop of wire to hold the bag open, at all times, thus freeing both hands for picking. This improvement led on to further questions as to whether it was best to use both hands on one row or with the particular spacing employed, to pick two rows at a time. Obvious sounding improvements, such as this, are often beset with pitfalls as it may turn out that the extra energy required to operate two-handed under conditions of intense heat or high altitude necessitates frequent rests which may even add up to a reduction in output, or at least an uneconomic improvement.

Another example with slightly more elaborate equipment might be the provision of an artificial draught from a fan to increase the number of days upon which traditional winnowing, by throwing the grain in the air, can take place. It may well be that the obvious solution of employing a petrol engine to drive the fan is unacceptable, perhaps because fuel is too expensive or because the necessary skills to maintain the engines are not available.

An alternative which appears to be working in parts of Africa where the bicycle is indigenous is to prop the back wheel off the ground, replace the rear tyre with a rope belt, thus using the pedal mechanism as a source of human power to drive the fan.

A third profitable line of attack, using devices for measuring human energy, is to compare various hand cultivation tools on the basis of energy consumption per unit of work. This whole approach of making relatively minor improvements to traditional methods is termed "Intermediate Technology" in Britain and currently has a very strong following from people experienced at working in the tropics.

Some see a clear technological battle between the intermediate technology approach and the more obvious direct application of established methods of mechanization, but in the author's view, every case must be considered on merit and in many situations the low capital approach can be used for certain operations alongside sophisticated mechanization for others.

OBJECTIVES FOR RESEARCH

In the context of this conference, it is worth drawing attention to the differences that exist between research conducted with the prime aim of teaching the researcher and that conducted with the prime aim of achieving economic improvements. Other labels would be, staff research and graduate student research, though in a well-conducted programme which has developed its main themes it should be perfectly possible for most of the research undertaken by graduate students to contribute to the staff programme. Nevertheless, the objectives of direct economic progress and teaching should not be confused. The prime function for the graduate student is to instil into him scientific approach and method. In the author's experience, the vital points which students must appreciate, are as follows:

1. Break the problem down into successively simpler components until what the candidate originally described as "The Mechanization of the Rice Crop", in consultation with his supervisor and as a result of hiw own reading, eventually becomes "The Value of Trash in Providing Flotation for Vehicles in a Rice Paddy".

2. Having decided the main question to be asked in the work, stick to it and do not take sidetracks, however promising they may be. Of course, most theses should have a section at the end entitled "Future Work" and pointing out the most promising sidetracks that were thrown up during the present work.

3. Never allow a student to set out to prove a preconceived idea. This sounds like a truism, but it is amazing how often research students are insufficiently objective and really attempt to prepare a case rather than test a hypothesis.

4. Quote an authority for every significant statement. This is really part of being objective and it is not surprising that the inexperienced should accept as gospel, widely held beliefs in their home dis-

trict. In fact, if the supervisor thinks this belief is suitable, it may make a sound basis for the work, to set out to test its accuracy. Quoting an authority cannot always mean giving an experimental result or a reference. It may be necessary to quote opinions, but if so, it should be clearly stated that they are opinions and the credentials of those holding them should be given briefly, e.g. long experience of the problem.

5. Accuracy should always be quoted, but it should be remembered that it is not an absolute quantity. To waste time in obtaining a higher standard of accuracy than is necessary for the purpose is almost as bad a fault as accepting too low a standard.

6. Wherever possible, go back to first principles, as they are least likely to involve hidden assumptions.

7. A corollary of this in the author's view, is to use simple apparatus. To quote an example, a frictionless bearing was required and an extensive search of literature for the lowest friction possible was made. Balls, rollers and even air bearings proved to have too high a friction and then it was realized that three strings suspended from a high roof would in fact, with the application of the pendulum theory, provide much more accurate results than the most expensive and elaborate bearing systems manufactured.

8. In teaching research, do not allow the candidate to spend more than a period agreed at the commencement on the literature review. The important thing is that the candidate should get experience on experimentation; far more important, in fact, that that he should not miss a few references.

9. Give reasons for all decisions, even simple ones, such as "The literature search was ceased in order that time should be available for the experimental programme".

10. Do not under-rate "look-see" experiments not involving much measurement. They are of value both in finding orders of magnitude and as a rehearsal of the use of apparatus.

11. Distinguish clearly between "conclusions" and "comment on significance of result". True conclusions, though they may have to be hedged about with qualifying statements on the conditions under which they hold, need no comment. In the author's opinion, the acid test of whether a candidate has really learned from his research course is whether or not he can separate out the conclusions from the comments, etc.

12. A highly practical point which it may be impertinent to make, but is often overlooked and then regretted by candidates, is the importance of keeping neat, clear field books and preces of references read. The former is vital to the accuracy of the final results and the latter saves re-reading references at the end of the work when writing up is being undertaken. A similar practical point is to remember to give (probably in an appendix) full details of data such as actual experimental results. The importance of this becomes apparent if it is necessary to check back on some doubtful figure, or if the work is re-analyzed by another for a different purpose.

ECONOMIC RESEARCH

The basic difference in this type of research which is usually undertaken by staff, though often with student assistance, lies in the importance of the results rather than the methods, though of course the results will be suspect if the method was wrong. The practical difference is that though time is always short, it is rarely guillotined in the way that it is for students. Even if the member of staff leaves, it is likely that someone will replace him and carry on the work. In teaching research, the intellectual value is generally much greater if the object is to test a hypothesis. On the other hand, for economic research, especially in a developing country, the "feed'em, watch'em, and weigh'em" approach is often the only one practicable, at least in the early days.

Especially in developing countries where resources are likely to be particularly limited, it is vital that preliminary work to establish the chance that the results will be of economic importance, is undertaken, and it is of course far more important that the literature search is comprehensive, to avoid wasted effort on duplication. With these differences of emphasis, the same criteria apply.

RECOMMENDATIONS.

1. That wherever possible, initial research approximating to market research be carried out by public sector organizations, preferably with the object of interesting manufacturers. Where this cannot be done it is still vital to identify priorities and decide rough specifications for machinery before more conventional power and machinery development work is undertaken.

2. That particular attention be paid to the improvement of existing techniques- frequently manual operations- by the employment of extremely simple devices.

3. That particular attention be paid by research students to the development of measuring apparatus and techniques.

Theme 7.

C.40. PROBLEMS OF VITAL IMPORTANCE IN LATIN AMERICA RELATED TO AGRICULTURE MECHANIZATION by
Johan D. Berlijn, FAO Reg. Agricultural Engineer, Latin American Regional Office, Chile.

TOWARDS A TECHNICALLY MODERNIZED AGRICULTURE.

1. Agricultural development in Latin America has been slow in the past; production has not kept pace with growing demands for food and other agricultural produce for local consumption and exports.

2. During the next decade, it is estimated that the productivity per unit of land must be increased by 1.7% annually; and the cultivated area expanded by 1.8% annually. This is a tremendous task, the magnitud of which becomes clearer by realizing that this includes an extension of the cultivated area by 35.000.000 hectares in the next fifteen years.

3. In order to comply with this basic task, it is worthwhile to consider first the principle reasons that caused the relatively slow development in the past. As a matter of fact there exist in most countries sufficient natural and human resources to obtain a considerable increase in agricultural production. Consequently, the slow developments in the agricultural sector have not been caused so much by natural limitations, as mainly by obstacles of an institutional and technical nature. Particularly the low degree of agricultural technology and technical modernization constituted in the past a serious impediment for a more rapid agricultural development.

4. Actually, the agricultural production system is still rather traditional in most places; based principally upon the natural fertility of the soils; in which a high proportion of the total population is still engaged; whereas the production could be increased considerably by making use of capital instruments, machinery, installations and modern techniques. It is urgent that this limited production system ought to be substituted by a more advanced, technified, modern and efficient agriculture.

5. The application of modern agricultural engineering techniques has greatly contributed to build up an efficient, high yielding production system in the northern countries; and the application of these in Latin America's agriculture is certainly opportune in view of present requirements, provided of course that they are adapted to local conditions and that due regard is paid to other aspects of agricultural improvements and to industrialization.

6. Gaining new land for productive use almost always requires the intervention of heavy agricultural equipment. It involves also numerous infrastructural measures, and it must be executed through suitably mechanized operations to be successful.

   The increase of the productivity per unit of land is almost entirely dependent upon the application of machinery, installations and modern techniques.

   It is therefore becoming increasingly evident, that the region could benefit greatly from a proper technification for its next stage of development to meet the growing demands for agricultural produce.

THE TRANSITION PHASE.

7. Speaking in general terms, the agricultural sector in Latin America is in a transition phase; halfway between two states. The first one was the stage in which a quantity of agricultural produce could be obtained rather easily by using only natural and human resources. The next stage, which is coming nearer rapidly now, is the one in which modern sciences and techniques are being applied to agriculture. This process of transition is difficult, and it implies also the provision of techniques, and indispensable tools and machinery in order that the farmers are able to take ad-

vantage of the capital resources that have become available by modern technology.

8. The technical modernization of agriculture is the process of applying new, technical knowledge, techniques and equipment in agriculture to improve production and the standard of living. The change inherent to this technical modernization process, involves:

   - adaptation of modern techniques and machinery to local conditions,
   - search for a type of technique and machinery suited to the pattern of resources endowment in these countries,
   - development of appropriate skills through educational and other institutions.

   Apart from these implications, however, the transition phase towards a mechanized agriculture requires that consideration be given to socio-economic and other aspects as well.

9. The introduction of machines and techniques calls for care because these are almost invariably capital-intensive instruments, and sometimes also labour-saving. Dr. Walter Kugler of Argentina * said for instance:

   "In order to facilitate a rapid transformation of the agricultural sector, in which better and more products are produced at less cost, and by which potential labor becomes available for other tasks, it is necessary that an adequate orientation be given to the country's development programmes. It requires that Governments take several measures to interest and stimulate farmers to make use of new techniques and capital investments. To do so, it will be necessary to adopt a positive policy in respect to financial support and exemption from import duties for agricultural machinery and prime materials".

10. Furthermore, the process of applying machinery and techniques requires care because most farmers in the region have not, as in more developed countries, grown up in a technological environment. As a matter of fact the application of modern techniques has taken on, in nearly all cases, a professional structure; and the history of most technical fields touching the modernization process is one of increasing specialization. Therefore, a successful introduction of mechanization and automatization depends greatly upon the establishment of specialized education, training and research facilities in the region.

11. Another important consideration is, that apart from the lack of technical knowledge and capital, one cannot always obtain a more extended use of machinery simply by importing tools and equipment designed and manufactured in other countries. For instance, the "campesinos" in the Andean Region lack both the technical knowledge and the capital to make use of mechanized systems on an individual basis. But apart from that, experience has shown clearly that existint equipment in many cases is not suitable, neither socially nor economically and technically for the peculiar conditions of this region. Each region requires tools and machinery that are adequate for the characteristic local conditions of soils, climate, and also of local customs.

LOCAL CONDITIONS.

12. Differences in local conditions, such as topographical, ecological, climatic and socio-economic differences, have enormous magnitudes; as is the case with practically everything in this great continent. It is evident that these differences have considerable influence upon the need for and the way in which mechanization and technical modernization must be applied.

13. For instance, in the coastal zones of Chile and Peru most of the arable land is farmed with stan-

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* Minister of Agriculture and Livestock till 1966- "Gran Cruz de la Orden al Mérito of Chile".

dard tractors and machinery. Lands are mostly level, capital relatively plentiful, labor scarce and fodder for draft animals expensive. Thus there is scope for a very high degree of mechanization and for a more efficient use of agricultural machinery, as well as for the introduction of new or modified equipment for specific needs.

In this region several new irrigation projects have been and are being set up, the execution of which require the use of heavy tractors and earth moving machinery, followed by regular machinery for the day-to-day farming operations.

14. The coastal area of Ecuador and Colombia and great part of Central America have different conditions. The tropical climate, and the farming under tropical conditions require specific machines and methods to mechanize the work in banana plantations and the cultivation of soybeans, peanuts and other tropical crops. But at a relatively short distance from the coast, all along the continent, one finds an extremely different area. It is the "Sierra de Los Andes" with its peculiar aspects and its proper topographical, climatic and socio-economic conditions. The Andean Region, lying mainly between 1000 and 5000 meters above sea level, has few large farms, the picture being one of dense population, land fragmentation and an agriculture that is lacking in both capital and technical knowledge. The Andean farmer is not able to improve his standard of life as long as he depends upon the "arado de palo" (wooden plow) a universal instrument for practically all field work. This primitive tool made of wood serves him for plowing, leveling, cultivating, sowing and harvesting; and it is evident that its efficiency is inversely proportional to the number of different uses. The work is painful, and the limitations of this general instrument make it urgent that great efforts are made to introduce suitable tools and machinery based upon previous studies of the characteristics, customs and implements that are suitable to be used under the typical conditions of the region.

15. The Governments have recognized the need to promote the cooperative use of machines and equipment in this region. These machines must be introduced, tested under local conditions, modified as necessary, and a programme of training for the farmers initiated. This process should of course be supported by a suitable financial system.

16. East of the Andean Region lies the enormous, humid, tropical Selva and Amazone Region, which is the least exploited area of the continent. In the wetter and more mountainous part of this region, mechanized agriculture has little application, but machinery is needed for land clearing prior to road building in gaining access to the lower Selva. Although this is not an agricultural operation in the strict sense, it frequently forms part of rural development projects, and at present there is no provision for the study of appropriate methods or for training in their execution.

17. In the drier sections of the lower Selva there exist possibilities for mechanized agriculture on a considerable scale. In these areas work is needed on methods of land clearing, earth moving, and mechanized crop production under tropical conditions, where fertility maintenance and erosion are critical factors.

18. South and South-East of this gigantic Amazone region lies the rest of the Brazilian territory, with its vast extension, comparable with a small continent in itself. It presents remarkable ecological economical, and social differences. The characteristics of the agriculture in the northern and northeastern regions, already different between them, have little similarity to those in the South, East, and Middle-West. In almost all of the Brazilian territory prevail tropical and sub-tropical conditions. The most fertile soils often have an irregular topography, which require special conservation measures for their protection against erosion, and which makes mechanization on a large scale difficult. The lack of a solid infrastructure also conspires against a rapid modernization of the Brazilian agriculture. These and other reasons have caused that mechanization far from satisfies the requirements. In 1966 only 1.8% of the farms used mechanized equipment in agricultural work. However, despite these great obstacles that hinder at present a rapid mechanization of Brazil's agriculture, the most varied resources are offered to a people with a pioneering

spirit, conscious of the extraordinary potentialities of this country. For instance, the hydraulic potential in the order of 23.000.000 HP, guarantees in the near future the supply of sufficient electricity to rural areas and for large scale irrigation, which is basic for the forth-coming technological progress and modernization of Brazil's agriculture.

Another programme, equally ambitious, with respect to agricultural mechanization, is the rapid increase in number of tractors from the actual 100.000 to 200.000 tractors by means of an expansion of the existing agricultural machinery industry, together with the creation of factories to manufacture heavy tractors.

19. The area of Santa Cruz and the Chaco of Bolivia, Paraguay and Northern Argentina distinguishes itself in practically all aspects from the rest of the Latin American region. Lands are fairly level, and suitable for the use of regular machinery. Labor is scarce. However, there are severe limitations in respect to accesibility and communications. It lacks almost any dealer service, and the relatively poor fertility makes cropping difficult. Natural pasture lands are dominant, and mechanization has little application as yet.

20. In respect to mechanization the territories of Argentina and Uruguay offer good possibilities. This is for instance shown in the relatively large number of tractors. Argentina possesses almost 50% of all tractors in use in South America. Also, there exists consciousness related to the need for rapid technical changes in cropping and methods of harvesting by substituting manpower by machine power. This strategy is clearly adopted by INTA in its extension work; and this is most important to adequately stimulate a transition towards an advanced agriculture.

21. It is not pretended, that the foregoing gives a complete picture of local conditions, that affect mechanization; to the contrary, their variety and scope are too wide, and it lacks sound studies on the subject. As a matter of fact, very little efforts have been made up to the present to implement coordinated regional investigations on conditions and requirements in the field of agricultural mechanization and modernization. There are some studies, but these are mainly of an economic nature and include neither the technical aspects nor the necessary parameters related to soils, crops and climate. The many soil studies that have been made in the past in various countries, unfortunately, have not been used to obtain at the same time information basic to mechanization, such as supporting capacity, penetration forces, cohesion and traction and other parameters, that are basic to planning and machinery selection for land preparation, cultivation, land clearing methods and earth moving. It is urgent that regional studies and analyses are made, in a coordinated manner that include those conditions which determine the way of application and the type of agricultural machinery suitable for use; because their acquisition represents considerable investments.

MECHANIZATION AND RURAL ELECTRIFICATION.

22. There is a wide-open field for actions in the field of agricultural mechanization and rural electrification. The relatively low degree of agricultural mechanization is shown by the following table:

Region	cultivated land per tractor	HP/ha of cultivated land
Latin America	197 ha	0,27 HP *
Western Europe	32 ha	0,93 HP
U.S.A.	44 ha	1,02 HP

* of this, only 0,18 HP comes from tractor power.

23. At least 0,5 HP/ha are required to achieve high yields, which means that in order to arrive at appreciable level of agricultural technology in respect to mechanization, it is estimated that the number of tractors, machines and installations ought to be double or triple in the near future.

24. To guarantee in future a sufficient supply of food for an ever increasing urban population, as well as of raw material for agro-industries, it is therefore essential to use suitable machinery on a considerably larger scale than hitherto, because this involves:

- more timely land preparation, seeding, cultivation and harvest, which is also essential to obtain the expected results from the use of better varieties and of fertilizers.

- several works are better performed by mechanical equipment than with animal-drawn equipment or hand tools or pure handwork; more particularly in the case of land clearing and earth moving.

- the cost of operation with mechanical power is considerably less than with horses or oxen.

- when tractors replace animals as source of farm power, crops and crop by- products fed at present to these draft animals, can be used for salable animals that supply meat, other food, and raw materials.

25. In respect to replacing draft animals it is noteworthy that for instance Chile maintains 570.000 horses and oxen, that require an enormous area of land for feeding, under conditions difficult to expand the cultivated area. This replacement urges particularly in such cases, because good use could be made of the relatively cheap local sources of energy like gasoline and diesel fuel, that are available at prices considerable lower than almost anywhere else.

26. Apart from the need to stimulate agricultural mechanization in the entire region, there is also room for ample developments in the rural electrification sector. The application and expansion of electric power is of such importance, that it could easily be compared with the introduction of the tractor, machinery or fertilizers. It might well be that within the next 10-15 years, the modernization of rural life will be primarily dependent upon electric power, because it improves the most diversified aspects of living conditions.

27. This new technical resource has two main objectives for the rural society: it contributes greatly to increase the productivity of human efforts; and it constitutes at the same time one of the most important factors for improvement of the standard of living and the degree of comfort for the rural population.

28. In countries such as Belgium, Denmark, France and Japan, the proportion of the rural families that have electric power at their disposal, varies between 90 and 100%. On the other hand, in many Latin American countries the percentage of the farms with electricity hardly reaches 10-20%. These figures clearly show that priority is to be given to rural electrification. Fortunately the process is underway; but it requires an accelerated expansion to achieve that all rural housings in all parts of these countries may have electricity, in sufficient quantity, for production and for improvement of living conditions.

29. **It is worth mentioning that agricultural mechanization and rural electrification also ought to be considered as an indispensable complement in agrarian reform programmes. In the Latin American countries, which are often committed to far-reaching programmes of land reform and resettlement, this aspect is sometimes completely ignored. It is most important, though, that the necessary studies are made to find ways by which these settlers may also benefit from new techniques and the use of suitable machinery.**

THE USE OF POTENTIAL LABOUR.

30. Apart from the problems mentioned, one of the factors that has also considerably hindered an adequate mechanization in the region is the high proportion of the rural labor-force that is either under-employed, unemployed, or is used in an inefficient way. The existance of abundant and cheap labor has been the origin of fear that advancements in the field of mechanization and rationalization would cause even less employment possibilities.

31. It is indeed a fact that mechanization and automatization of agriculture causes the release of labor, because mechanical means multiply the capacity of the rural labor-force several times over; therefore less strain and less handwork is involved in the performance of a certain duty. However, it would be a fundamental error to apply a policy to maintain an excessive number of workers in agricultural production, who do not have adequate technical means at their disposal, and who are unable to produce sufficiently.

32. It is questionable whether the employment balance of a country, in its totality, is affected adversely by the application of machinery and suitable technical means. In the first place one must take into account that an expanded and advanced agricultural production system causes increased activity within industries that provide field supplies and that this in turn creates employment opportunities. At the same time, improved agricultural production requires extended activities in the processing industry, such as warehouses, mills, canning plants and packing houses; as well as in transport and storage plants. Also commercial activities, in both agricultural supplies and products, will benefit from an expanding and technified agriculture.

Another aspect, which is equally important, is that vast areas of the region are still practically unused; and the majority of the people that live in the slums of the larger cities often come from these areas. The solution to this serious problem lies mainly in structural changes that facilitate agricultural advancement and creation of productive work in these non-exploited areas.

33. It is obvious that most serious efforts must be made, institutional and social barriers must be removed, and particularly suitable technical means are to be made available in order to ensure a better use of the potential labor force. Its productivity, and through this the standard of rural living, is to be raised considerably.

34. Actually the rural labor force lacks skills and the technical production means to enable it to comply with its basic task; and too little attention has been given up to now in research programmes to economy in the use of both labor force, power and equipment for rational exploitation of existing natural resources.

CONCLUSIONS.

35. One finally arrives at the conclusion that up to the present the principle problems that have been hindering a more rapid development in the field of agricultural mechanization and rationalization, are of the following nature:

36. In the first place, there is a lack of sound studies of local conditions, that include not only economical aspects, but technical aspects as well, paying due regard to ecological, climatic and social conditions and customs, that will serve as a basis for the planning of efficient actions, to determine requirements, and to formulate adequate projects for the development of a rationally mechanized agriculture in the various regions of Latin America.

37. Existing machinery is not always suitable and adaptable to local conditions in certain regions of the continent. Consequently there is a need for adaptions of new designs to obtain machinery and techniques that are appropriate for those regions. The studies, mentioned in the previous paragraph, will be helpful in determining the requirements, and at the same time they will pro-

vide basic data for the required adaption and design, as these studies will include the necessary parameters.

38. An efficient introduction of machinery and techniques requires that an adequate orientation be given to agricultural development programmes, including various measures to be taken by the Governments in order that the farmers, and the small farmers as well, are interested in using new production elements and capital instruments . Such measures are for instance:

- an adequate and positive policy in regard to agricultural credit, the promotion of agricultural cooperatives for cooperative use of machinery, and the creation of machinery pools,
- a partial or complete exemption of import duties in the case of imported agricultural machinery and raw materials,
- stimulation of studies and research related to the introduction of mechanized operations and rural electrification within agrarian reform programmes and resettlements,
- creation of clear consciousness of the need for rapid transformation of agricultural techniques by substituting human work for machine work; with a consequent increase of production and improvement in the standard of living,
- the paying of due regard in research programmes to economy in the use of both labor force, power and equipment for rational exploitation of existing natural resources, and
- the adoption of a positive policy regarding the creation of efficient and productive employment of the rural labor-force, either in gaining new land for agricultural use, or in agro-industries, commerce, road construction, or community services.

39. Another serious impediment is the shortage of trained personnel and research workers with ample technical knowledge in this specialized field of mechanization and rationalization of agriculture. A successful introduction of machinery, installations and techniques depends greatly upon the establishment, on a large scale, of training facilities and programmes, not only at university level, but also at other levels. This includes programmes such as specialized extension work with advice to individual farmers or groups of farmers; field courses and demonstrations; and vocational schools for practical and theoretical training of farm mechanics and machinery operators,

40. Up to the present these have been the main obstacles for a technical rationalization of Latin America's agriculture; but this development must no longer be retarded, and it is of vital importance that proper measures are taken to bring about the solution to these problems.

Theme 7:

C. 41. MINIMUM REQUIREMENTS FOR ESTABLISHING EFFECTIVE RESEARCH by Howard F. McColly, Agricultural Engineering Department, Michigan State University.

Research involves searching the unknown for answers to problems. Since research requires careful, studious, critical and exhaustive inquiry, it is clearly obvious that the attitude and ability of the researcher is of foremost importance. Possibly in considering the minimum requirements for establishing effective research, the division between basic research and applied research need not be critical. However, the very necessity to solve problems will dictate that a large portion of the resources for research will be expended for applied research.

Need for Research.

Research must serve a useful purpose. Some basic research may prove useful several years after it has proven the answers, but some one knew a need would arise.

When problems get too close to required answers, random trials result in trying to obtain short-cut solutions on an emergency basis. It is of course most desirable to anticipate forth-coming needs, thus progressing with research to have the answers available when they are needed.

Some basic research establishes its need by proving that the adoption of its findings are beneficial. Minimum tillage can be placed in this category.

Research must never be established for researchs' sake - just to keep some one or some facility operating. Examine programs and investigate needed studies in order to develop effective research.

Research Staff.

Of course to conduct research, it requires people researchers. The selection of staff to conduct these important tasks is highly important. Once under effective progress, research programs will develop new researchers, and help others to grow.

A research staff must have research aptitudes, desire, and enthusiasm. Since research requires a great deal of creativity and curiosity, there must be a balanced drive to accomplish useful results.

A research staff needs strong, effective, objective and clear leadership. They need encouragement, and very importantly, the chance to develop and move ahead. Researchers can be destroyed by restrictive and discouraging measures. Research accomplishments are directly influenced by the research leadership and the well-being of the research workers.

Graduate Program.

A graduate program should center in the research activities. This enables the student to receive valuable training, and the professor to accomplish more. The staff member who can multiply himself in research efforts by the effective leadership of several graduate students is a much more valuable staff member than one who must do his own individual research, often limited to a project or two.

Research problems have many facets. Often a staff member must, by necessity, lend his personal efforts to practical answers to his public. The basic facets make excellent graduate problems, and are not pressed by public need, but ofen can obtain answers for future use, or supply a link of knowledge in a chain of endeavor.

A strong graduate program affects the stature of the entire department program. The teaching and extension efforts are strengthened by the research program, and since the research program can be strengthened by the graduate program it is paramount that a strong graduate program be developed.

Research Environment.

For research to flourish, it is necessary for a conducive climate or environment to exist. This cannot just happen; it has to be developed and nurtured. The environment is created by administrators and the leadership responsible for the activities. Researchers themselves do much to maintain, develop and improve the research atmosphere.

The research environment thus is created and maintained by the human factors as well as the structural facilities and the contents. Boss Kettering of General Motors Research once said it is more important to invest in the right kind of men, than to create fine laboratories without the right people. Of course we could say , have both if possible.

Researchers must have challenges and goals to achieve their accomplishments. Usually individuals wish to create their "laboratory" to fully feel their challenges and accomplishments. Thus, research facilities could be a basic structure and area, and the researchers utilize portable dividers to establish "his area", and to protect his work.

Research Facilities and Equipment.

Research facilities, equipment and instrumentation are important ingredients in research programs. The degree of their development is often the stumbling block hindering research accomplishment. Too often there is too much importance placed on the adequacy of the laboratories and the instrumentation, with the result that no research is started. Many administrator can cite examples of outstanding research accomplishments and great discoveries being made in obscure laboratories with meager equipment.

It is not to be inferred that facilities and equipment are not needed. It is however, urged that Utopian conditions are not necessary to start a project. Start on a small prove-the-way basis if necessary to get under way. Positive results will often then bring support, interest, and necessary recognition for project development.

Involve supporting industries to contribute knowledge, materials, equipment and money in your research plans. Strong liaison between the research worker and his interested industry worker can materially enhance research results.

Farmers must no be forgotten as a research resource. These people have the need for problems to be solved, but they also have facilities, knowledge, and support so often needed to accomplish effective meaningful research.

Research Funds.

Funds are necessary to pay salaries, labor payrolls, and office help. Also finances are required for materials, supplies, transportation, travel, equipment and instruments. It is first important to pay people. The rest of the research funding is in the same category as facilities and equipment. Often much can be done with little financial support beyond paying people, especially in initial stages of projects.

There is a great variance in the need for funds in projects. Some are very expensive to operate, and others are minimal in fund requirements.

Important research, worthy of investigation can get done, but often it is necessary to initially prove the value and need for the research in order to receive proper funding to satisfactorily conduct and eventually complete the study.

Preliminary Investigations and Projects.

Research development can effectively utilize the technique of employing preliminary investigations to examine the necesity for a project, and to establish its scope. Thus, some proposed projects will be determined not necessary, because preliminary investigations for a year or so obtained sufficient answers. Also after some preliminary investigations certain projects will increase in interest and scope, and will result in much more effective specific projects.

It is possible for a preliminary investigation project to exist for an indeterminate time, but it must have parameters itself to be meaningful. Thus, Preliminary Investigations in Machinery might be a title, and the project accomplishments each year would have different and fresh sub-titles. Initially, the preliminary project might investigate hay conditioners, but the later larger project would be a study of hay harvesting systems.

Research projects do contain preliminary investigations, and projects of known magnitude can be immediately organized for specific studies. The preliminary investigations segment of an organized project should not be confused with a project which is a preliminary investigation.

Research projects often get into ruts. Projects should be examined each time results are interpreted to determine if the project is effective in its coverage, needs revision, is completed, or should incorporate with another project.

Research projects should never be allowed to go ineffectively on and on. There are numerous needed studies to utilize staff, facilities and funds, rather than to stifle in unneeded, ineffective efforts.

Conclusions.

Minimum requirements for establishing effective research involves the careful allotment of the several resources necessary to organize a research program.

When need has established the necessity for research, adequate staff must be obtained. Research competency coupled with strong definite leadership will enhance research success. The wholesome environment so necessary for successful research will be developed by people, and they will help create the facilities and obtain the equipment.

A strong graduate program is necessary for successful research accomplishments. The resultant training develops researchers, teachers and personnel for all categories of agricultural engineering endeavor.

Funds for research are important, but should not be the difference between some research and no research. Often it is necessary to prove the importance before funds can be obtained. Worthy research rarely lacks funding.

Projects should be developed in scope to obtain answers to problems. Projects should be definitive with clearly established objectives, and the results to be obtained listed as completely as possible.

Review projects for freshness and need. There is so much research needed that ineffective studies should be questioned.

Minimum requirements must examine all resources necessary and available, then build a balanced forward-thrusting research program.

RESUME.

Research involves searching the unknown for answers to problems by careful, studious, critical and dedicated people. Minimum requirements does not need to concern a division between basic and applied research, but necessity will dictate that a large portion of the resources for research will be expended for the applied area.

Research must be needed to serve a useful purpose. Research must never exist for researchers' sake, for to so do it is to get into a research rut.

Of all research resources, the research people are the most important. The staff must have research aptitudes , desire and enthusiasm. The research leadership must be strong, effective, objective and non-ambigous.

Centering in the research program should be a strong graduate program. This is an important research manpower resources, and it trains more and future researchers and educators in the entire agricultural engineering endeavor.

Research workers affect the research environment. They help create, develop, and maintain the research atmosphere. The structural facilities and equipment are also important factors, but the right kind of people is the most important.

Cooperation with relevant industries and the farmers is very important. Here the problems will be vividly brought forward. Besides these people can contribute knowledge, facilities and support for research.

Funds for research are important but should not always dictate the ability to initiate research, if a research staff exists. Therefore, funds are first necessary to pay qualified staff. Some projects are more expensive to operate than others, and it is often necessary to explore for sources of support.

Projects should be organized on a basis of need and clearly state objectives and list the results to be sought. Preliminary investigations in projects will develop scope. It is sometimes desirable to have a long term Preliminary Investigation project in a research area such as Machinery, Irrigation, Processing, and others in order to screen projects and to develop project types.

Research resources in their entirety must be analyzed to establish minimum requirements for establishing effective research in agricultural engineering. The resources of staff, which is directly affected by the funds available for salaries, graduate student programs, facilities, supporting funds, and other items need appraisal to establish the extent of research programs.

Theme 7.

D.42. RESEARCH IN SOIL AND WATER ENGINEERING by E.H. Wiser, North Carolina State University, U.S.A.

The author first understood the purpose of this paper to be a review of research in the field of soil and water engineering in the United States. On further consideration it became apparent, however, that this would be an impossible task. The third volume of the Water Resources Research Catalog dated December 1967 lists over 4,200 research projects, of which certainly a majority are related to some extent to soil and water engineering.

Rather than trying to summarize such a large number of projects, I will discuss to a limited extent a number of the topics that have fairly recently become subjects for research and seem likely to continue to do so for some time in the future. The choice of which topics to include is arbitrary, and undoubtely reflects my personal prejudices. The order with which they are presented has no particular meaning, and is certainly not intended to carry any significance of priority. I claim no particular competence with respect to Latin America, and the topics are certainly not selected on a basis of being important to this region. It is hoped, rather, that the reader will choose freely, according to his own understanding of the problems in his own country. There is, hopefully, something for everyone.

It seems to me, however, that one general principle holds true in almost all research activities today, dealing with the topics of models and systems analysis. An incredible amount of applied research has been carried out in the United States that has been intended to obtain answers to limited design problems. Limited in scope and limited in execution, little of this mass of research has had any lasting value.

Consider, specifically, the subject of drainage. Countless drainage experiments have been carried out for the purpose of determining drain spacing in specific soils. Out of these experiments came a body of experience from which were distilled some rules of thumb and numbers that engineers used to lay out drainage systems. We are now ready to make much more sophisticated analysis of the problem using systems analysis and other optimizing techniques, and we discover that we have no information to use in the solution. Data on as basic a problem as the effect of a high water table for a certain period of time on growth of a crop simply are not available. The experiments have to be carried out all over again.

My plea, then, is that no research be started without developing first a picture of the system as a whole, and a model at least of the part that is being studied. Then, even though extension of the results may be beyond the scope of the project, the data will be of use to later research work.

Presuming the particular importance of these two topics, there follow several topics of research, present and future, in the field of soil and water engineering.

MATERIALS.

Because the engineer is expected to build things, he usually receives some training with reference to the materials he uses. The agricultural engineer is particularly well equipped to do this, because he routinely works with non typical materials such as wood, plastic, etc. The possibilities of substituting new materials to solve old problems are extensive. I cite two recent examples:

1) The use of corrugated plastic for tile drains;
2) The use of glass lined steel, used for silos, for erosion control structures.

INSTRUMENTATION.

The agricultural engineer often has training in electricity and electronics as well as mechanics and is therefore often called upon by other agriculturists to suggest or develop instruments. Some of the more recent developments include neutron and gamma soil moisture measuring devices, the osmotic tensiometer, remote sensing, water quality measuring devices, telemetry, computer input devices, pneumatic lysimeters and laser beams. There are possibilities in the use of sound in studies of the soil.

DATA PROCESSING.

New instruments imply more data collection, which in turn mean data processing problems. Much work is being done on getting data into computer accessible form, so that computers can do the processing.

PROBABILITY AND STATISTICS.

Data often are to be analyzed statistically. In many cases standard methods are available, but this is not always true. Also, there are many new developments, such as queuing theory, stochastic processes, and risk theory that may be useful in a variety of ways.

FARM WASTE DISPOSAL

As farm become more advanced and population increases, water pollution from farm wastes as well as pesticides, herbicides and fertilizer leads to serious problems. Research on ways to reduce these pollutants has very high priority in the United States at this time.

WATER LOSS REDUCTION.

As water becomes more scarce as resource, it becomes more economical to look for waus to reduce water losses. Research continues on canal lining materials and on monomolecular films over lake surfaces.

WEATHER MODIFICATION.

Weather modification has been proved to be successful in increasing the available water supply. The agricultural engineer should be aware of the effect this might have non projects he is developing. He should also be able to provide information useful in developing the operations plan of a weather modification scheme.

GROUND WATER RESOURCE DEVELOPMENT.

In many areas, surface water supplies are not adequate to serve an expanding economy. Ground water represents a potential source of water in such areas and its possible use should be explored.

MODELS.

The importance of the use of models in most research projects has already been emphasized. There is now considerable research activity dealing with the development of models.

Hydrologists are developing watershed models, and soils specialists are developing models for water movement in the soil. Much work is now being done on development of a plant growth mode, which will show the effect of microclimatic changes as well as soil moisture changes.

One observer has suggested that a spectrum of models exists. The simplest models consist of a single equation often fitted statistically which may be considered as a black box. As the model is made more realistic, it may be called a physical model. However, as the model is continually refined to reflect a complex reality, it loses its physical relation and becomes a black box again.

SIMULATION.

The use of simulation as a research tool has come largely with the development of computers, and it is severely limited in its utility unless a fairly large high-speed computer is available. Although it can be used with models to e. g. simulate plant growth, it is more often applied to hydrologic problems. Here the stochastic behavior of rainfall or streamflow is simulated by a Monte Carlo procedure combined with appropriate models to generate records which are much longer than those observed.

ECOLOGIC, SOCIAL AND POLITICAL PROBLEMS.

In no other area of agricultural engineering is the engineer so involved in the larger system as in soil and water engineering. The wastes that are discharged into a stream may affect the ecology of a lake. The limits on whether a project is constructed or not are often social or political rather than economic. Often the solution of a problem is political rather than technical. The engineer must learn to take account of these factors in his designs.

SYSTEMS ANALYSIS.

Systems analysis is a tool which allows the engineer to look at a system in its entirety. The necessity of doing so has already been emphasized, in order to place items in their proper perspective. Irrigation projects have too often been designed without regard to potential drainage and salinity problems. The combined design of all aspects of agricultural water management will require the use of systems analysis. Water resources development in a river basin can also be approached in this manner.

The technique generally requires development of a model. If the model is a mathematical model, the problem can often be solved by linear or dynamic programming. If the model is a computer model, Monte Carlo simulation is used to obtain a solution.

The principal drawback with the technique as it is used currently is that the solution is simply the optimum economic one. When there are social or political factors involved, the optimum economic solution may not be practical. In such case, it may be possible to compute the cost of selecting a solution which is less than optimum, but this is seldom of use since the benefit is not comparable.

CONCLUSION.

In conclusion, it is emphasized that the group of topics above is not intended to be a complete review of research. The long-run research projects in irrigation, drainage and erosion control have not been listed, not because they are not important but because it is assumed that the reader is already well acquainted with them. The particular interest in such project now is when they are being used to develop models, which may in turn be used to stimulate a system in order to choose an economic optimum by systems analysis. The models are no good unless fitted satisfactorily to good data.

At best, the list may encourage the reader to consider the problems that face his own country, and to determine what avenues of research he should explore. If it does so, the paper will have served its purpose.

Theme 7:

D. 43. PROBLEMS OF VITAI IMPORTANCE IN LATIN AMERICA by Jorge E. Quintero, Director, of Agricultural Engineering,Colombian Institute of Agriculture- I.C.A., Bogotá, Colombia.

It is well known that agricultural production must be balanced with the population growth or the human race cannot survive.

The rational use of soil and water resources form the primary basis for production along with other basics like fertilization, good seed credit, mechanization, and cultural practice complemented with a satable market, adequate transportation and processing.

The work of bringing water to a field to irrigate it does not guarantee success, but besides the factors previously mentioned we have men of varied cultural background, "hide bound" by tradition, a most powerful force.

Latin America has the highest population growth rate of the world. In the last 20 years the rate of growth has been 2.8% per year and for the next 10 years it is estimated at 3% compared with 1.1% in Russia, 1.4% in the United States, 2.4% in India, and 2.6% in Africa. At this rate we will expect to have a population of 364 million in 1980 in Latin America.

Latin America has a rate of growth of agricultural production of 3.2% per year (Mejía Salazar, 1968) but this is not enough to fulfill the minimum necessity to provide sufficient food as well as to maintain exports necessary to maintain foreign exchange. If we look at a local condition, Bogotá, we see an annual population growth of 7%.

The Interamerican Development Bank estimates that Latin America ought to have by 1980, 30 million hectares of new lands to meet the needs of the exploding population.

There are 1,500 million hectares of agricultural land and forest reserves, of which only 538 million are usable by agriculture and 162 million are presently exploited. In terms of areas under irrigation, we have only 8.7 million between Argentina, Chile, Colombia and Peru. At the present it is estimated that the agricultural production meets 95% of the need and we are confronted with the necessity to import wheat, oils, wood, cacao, while the exports of coffee, the basic export product is becoming smaller.

For this reason, the Colombian government has concentrated its forces on the objective of improving the agricultural land and they have a 5-year plan to put 250.000 hectares under irrigation besides pursuing the land tenancy reform.

How can Latin America reach the necessary levels of production? For one part, it seems that we can increase the area cultivated, and on the other hand, we can increase the yield per hectare.

The first possibility, using large projects, in intimately field to important aspects like external finance, time for execution, etc. These projects have a popular acceptance, especially from apolitival viewpoint, but they are costly and require a long period of time to acquire full production.

Smaller projects surely are easier to implement, can be financed internally, and can be completed in a reasonably short time.

The second possibility to bring about better use of resources is to improve the efficiency of water and soil relations. (Revelle 1963) noted that about 1/2 of the water used for irrigation is lost in transport and 1/2 of that reaching the field is used by plants.

The author does not have, unfortunately, a fundamental knowledge of the entire group of Latin American countries and for this reason will confine his remarks to his native land (Colombia).

What factors can make the most contribution to development of Soil and Water resources?

(Kuiper, 1965) , a member of the American Society of Civil Engineers, colaborated in what can be considered basic soil and water planning. He mentions several factors that merit attention, factors that are sometimes missed by those designing works of resource development and use included in a very broad classification.

A. Basic informations. B. Economic basis for protection. C. Water requirements. D. Development of the plan.

The author asks: "Do we consider investigation of these mentioned factors when we pursue our grand work? It is possible that we underestimate possibilities of navigation, repeated use of water to produce energy, recreation, flood control, water for human and industrial use. Do we start isolated local works without considering the regional aspect? A knowledge of climate, soil, vegetation, and human habitants of the region is imperative. Experiences in other latitudes and practical rule-of-thumb theories are not always applicable in different ecologies.

Land leveling has been shown to be good practice in several continents. No doubt, in the tropics in the low lands the soils having a low organic matter content tend to seal and become impermeable when under cultivation. These soils have poor stability because of the rapid oxidation of organic matter.

Formulas for evapotranspiration have been developed in various parts of the world. If they are used indiscriminately for tropical conditions they can result in serious.errors. Research has shown that a comparison of these formulas, well developed in the regions where proved or in similar geographical or climatological areas, when applied in tropical conditions in their original forms they produce quite high values.

The previous examples illustrate the necessity of through consideration of the following points before executing a plan: A. Work under a sectorial plan, B. Exploit all possible projects of multiple use. C. Consider the interrelations with other fields of Agricultural Engineering, aspects of mechanization, transport and processing. D. Water requirements for crops, varieties, seasons, etc.

It seems necessary to classify, as long as it is possible, the aspects on water legislation, to establish rules on classification of soil and water for the tropical conditions, because the actual rules are based on U.S. classification systems when the situation is different.

It could be possible to initiate works on field investigation, especially in areas where irrigation is needed, by the time of build up and development. Such factors as preparation and training of personnel in every level using the. actual installations and institutions and creating a need for research are very important.

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Theme 7:

D.44. MINIMUM REQUIREMENTS FOR ESTABLISHING EFFECTIVE RESEARCH IN SOIL AND WATER by J.E. Christiansen, Utah State University.

I am sure that the minimum requirements for establishing effective research in Soil and Water Engineering is essentially the same as for other branches of Agricultural Engineering. I would list as some of these requirements: 1) The individual research worker, 2) The organizational structure, 3) Adequate budget, 4) Physical facilities, and 5) Recognition and definition of problems. Many other items might be mentioned.

The Individual.

Good research begins with the individual in charge of the research project. Research work is different from many other professional activities. The person engaged in research must have imagination and curiosity. He must be interested in solving problems, learning new things through experimentation as well as from study. He should not accept as fact everything that he reads, but must question and seek proof. Above all he must enjoy what he is doing. He should be alert to responses, even though they may not have been anticipated.

He should be a good cooperator or collaborator, as the most effective research is often the result of team effort by two or more with different specialties that can be brought together to solve the specific problem. Above all, he must have allotted time, and must not be expected to carry on research as an added responsability in addition to a full time teaching load. Research complements teaching, but it must not be considered a side line that can be done outside of regular working hours. Some well qualified individuals are good teachers, but poor researchers, while others are good in research but are not the best teachers. The time allotted to each activity should, in as far as possible, be in conformity with the wishes and abilities of the individual and should not necessarily be the same for all staff members. Above all, the research worker must be completely honest in every way. He must not compromise with the results obtained even though they may not be in accord with preconceived ideas. He must have patience and persistence. He should be willing to work extra hours when required, and should be fully worthy of the trust that is placed in him. He must be willing to take the responsibility that should be placed in him.

Effective research can best be accomplished under a project which is assigned a number. The researcher should have a clear idea of the problem he proposes. He should be able to write a proposal that clearly states the objective, and method of procedure. He should have somehypothesis that is to be tested, and should be able to conceive of ways to make the impartial tests required. Above all, he must be willing to complete the project with a satisfactory report or published paper. Many excellent pieces of work are not brought tothis final stage of completion because the researcher becomes interested in something else before the writing is completed.

The Organizational Structure.

Effective research can best be accomplished under an organizational structure that recognized the value of research, and which has permanency and stability. Those administering the program must recognize the value of research and must be willing to support it through encouragement and by working to obtain adequate funds.

The University is an ideal organization for supporting research, but the administration from the President or Rector down must first believe in research and then give it the support needed to obtain results. Too often the business management of the University does not adequately understand research and fails to give adequate support. Unnecessary restrictions are often placed on the acquisition of equipment and supplies, that delays the work and discourages the researcher.

Budget.

A realistic budget for the Project should be set up and administered by the University or other research agency. Effective research can be done on a modest budget, but it should be adequate for the work to be done. The budget should show the funds allotted for:

1. Salaries for research workers.
2. Amount for labor or part-time assistance.
3. Amount for needed equipment (inventor)
4. Amount for supplies.
5. Amount for transportation.

Transportation is indispensable in most soil and water research work, as in most instances, the problems are in the field. If transportation vehicles must be purchased for the project, the amount budgeted must be adequate to cover costs. Often vehicles are owned by the University, but the budget must cover a charge for use on a mileage (kilometer) basis.

Facilities.

In addition to office space, effective research in soil and water requires laboratory facilities. For example, one of the problems frequently encountered in the soil and water field is that of salinity. Laboratory facilities for analyzing soil and water samples, and trained personnel for such work, is essential if economic solutions are to be obtained. Sometimes , essential tests can be obtained from existing laboratories for a reasonable fee, but where no such facilities are available, work space and essential equipment should be provided for in the budget.

Good research should always begin with a review of literature on the subject. University libraries are generally adequate, but sometimes special publications should be purchased and this should be anticipated in the budget. Reprints of selected papers can often be obtained gratus from the authors.

Problems.

Research in the Soil and Water Field of Agricultural Engineering is most often applied research and problem oriented. There are many problems in the Latin American countries that require research to adequatly solve. Some of the more urgent ones are in soil conservation, drainage and salinity and irrigation water requirements. Hundreds, and possibly thousands, of hectares are being lost to agriculture each year in the Andes through soil erosion and gullying. More effective, and less expensive methods of controlling erosion are urgently needed. This may involve farming practices and the introduction of better grasses or other vegetation to protect soil, as well as engineering structures. Methods developed in the United States may not prove effective on the steep slopes, or may be much too expensive to be practical. The problem is acute and needs a vigorous attack.

Likewise, most irrigation projects soon run into drainage and salinity problems. Investigational procedures need refining and improvements that can only be accomplished through research. Some of the more standardized procedures for determining the soil permeability and required spacing of drains give very misleading results under some conditions. More study is needed to develop satisfactory tests to determine the effectiveness of drains that are constructed. Since research budgets seldom allow for actual drain construction, every opportunity should be taken to study and test drains that are constructed. by other agencies. Appreciable savings are possible in drain construction through more reliable determinations of proper drain spacing and depth. Research in this field should go hand in hand with drainage construction in an effort to improve the effectiveness of drainage, and for lowering the cost.

Reclamation of saline areas, and the prevention of salinity through better drainage and more efficient use of irrigation water, are other fertile fields for research. Drainage solutions that may be adequate under humid conditions, are often not satisfactory for controlling salinity under arid conditions, especially where rainfall is nil as in the coastal area of Peru.

Studies on actual evapotranspiration from crops are needed to more accurately define the water requirements. Great savings in construction costs might be realized through a better knowledge of actual water requirements and improved irrigation efficiencies. Very few actual determinations of evapotranspiration have been made in Latin America.

Technical Paper:

1. HARVESTING CORN WITH A GRAIN COMBINER by Roy Bainer, University of California, Davis, California, U.S.A.

In 1931, Logan[1] reported on a commercially available modified grain combine designed for harvesting corn. A rasp-bar cylinder was used with fairly satisfactory results. It was operated at a speed about 25% below that recommended for wheat. The stalks were cut at a level below the ears and fed into the machine. The machine, however, was never accepted by the farmers because of its inability to handle lodged stalks and the lack of drying facilities for handling wet corn.

Hopkins and Packard[2] presented a paper entitled "Corn Shelling with a Combine Cylinder" before the ASAE Winter meeting in 1952. Their introductory paragraph stated: "The mechanical corn picker has been a boon to American agriculture, but it has had its day and should give way to better methods of harvesting. The picker loses more of the crop than does a combine, and it is responsible for four times as many accidents."

During the fall of 1953, Lely, a small manufacturer at Orland, California, built an attachment for an Allis-Chalmers all-crop harvester for cutting corn stalks and feeding them into the machine. It was not accepted because of the heavy wear and tear on the machine and the slow fields speeds due to the heavy load on the machine.

By 1954, California farmers, because of acreage allotments on cotton, sugar beets and rice, turned to corn production. Within a year or so there were close to 1/3 of a million acres planted to corn. Since California had never been a producer of corn, corn harvesting equipment was not available. Furthermore, there was some question as to whether or not corn would become an important crop, especially in light of the possible reduction in the curtailment of the acreages of the crops mentioned above.

With the knowledge that the angle-bar and rasp-bar cylinders used in combines were satisfactory corn shellers, a decision was made to try and adapt the combine to corn harvesting. The first step was to persuade manufacturers of combines to furnish ear snapping devices as attachments to their machines. Since they already had experience in building snapping devices, it was relatively simple to attach them to combines.

By the summer of 1954, two old line companies had corn heads ready for field testing. After a brief period of development, they were ready for manufacture. The use of ear snapping devices eliminated the necessity for handling stalks, thereby greatly increasing the capacity of the machine.

Field tests indicated that cylinder speeds in the range of 2500 to 3000 feet per minute (peripheral) were satisfactory for threshing unhusked ears of corn. Clearance between the cylinder and concave ranged from 1 to 1 1/4 inches at the front and 3/4 to 1 inch at the rear. Only slight adjustment of clening sieve openings and the flow of air were required for cleaning the threshed product.

It is interesting to note that the corn heads for combines developed to take care of an emergency in California have now been accepted throughout the corn producing areas of the mid-western section of the United States.

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Technical Paper:

2. MODERN MAN-MACHINE SYSTEMS IN AGRICULTURE by C. G.E. Downing, Agricultural Engineering, Research Branch , Canada Department of Agriculture, Ottawa, Canada.

Technical progress in the form of improved and complex machines for production practices arrived relatively late to agriculture. The start of the present trend towards widespread mechanization of farm work is usually dated from McCormick's first successful field trial of the reaper in 1834 and John Deere's invention of the steel plow in 1837. Actually each of these inventions had been preceded by a series of experiments with various types of plows and reapers. Still only since that date has progress in the mechanization of agriculture been rapid. Even as late as the 1840's most grain in North America was seeded broadcast and harrowed into the ground.

The ancient method of threshing grain by flailing by hand, and treading manyally or with animals and then winnowing by tossing the grain into the air so that the breeze could blow the chaff away from the grain was still in use in some parts of North America as late as 1850. This practice, however, is still in effect in many of the developing countries of the world. The first threshing machine was built in Scotland around 1800 and was introduced into the United States about the same time. The first machine to come into Canada was brought in by Daniel Massey in the Cobourg, Ontario area about 1830. Most of these early models were powered by horse treadmills given the coined name of "horsepowers".

Remarkably enough, the combine harvester appeared early on the scene and had considerable use in California around 1860. The machines developed at that time were very huge machines, sometimes requiring as many as forty horses to pull and were operated by ground drive. About the same time a stripper harvester that stripped the kernels and heads from the stalks of grain rather than cutting the stems was introduced in Australia in about 1843. The first modern-day combine developed by Massey-Harris was first tested on the prairies in 1922 at the Swift Current Experimental Station and since that time there has been no turning back in the further development of such machines.

Although early combines were powered through ground-drive wheels the introduction of the power take-off when tractors came into being, was soon adapted to this type of drive. Experimentation with the self-propelled machines by Massey-Harris occurred in about 1936. The introductory combines of this era were small in size compared to the first model introduced in 1860 but with the development of tractor power and self-propelled machines, there has been a continuous growth to larger and more complex machines, with a great diversity of utility from simply harvesting wheat to the handling of almost any type of crop including rice, corn, soybeans, oilseeds, grass seeds, etc.

The forerunner of the modern tractor was the steam plow first patented by Hussey in 1855. Most of these early machines were huge monsters weighing twenty tons or more, developing as much as 120 horsepower. However they were slow and cumbersome and required a large crew of men to operate. The four-stroke cycle internal combustion engine introduced by the German scientist, Otto, did not develop into a tractor until after the 1890's but rapid development occurred following that time and by 1920 more than 160 companies were selling one or more models in North America. Initially also, these tractors were mainly large in size but in the early 1920's when they became more suitable for field work other than stationary threshing and field plowing, a definite trend to smaller more economical models soon developed.

Two important developments that occurred in the early 1920's were the introduction by International Harvester of the power take-off and the farm-all type tractor which became an all-purpose tractor that could plow, cultivate, do row-crop work, and a wide range of jobs. These two developments were followed by the most significant development of tractor improvements and that was the introduction of rubber tires which increased the pulling power of the tractor by 25% and made possible much higher field speeds.

However, all of these three developments created accident hazards which had not existed in similar circumstances. The power take off (drive left) and (open drive unit) between the tractor and the pulled machine, the tricycle type of farm-all tractor with high wheels and narrow gauge was prone to tip over, and with the rubber tyred tractors operating at higher speeed, this problem was accelerated.

During this same era, mechanization occurred in a parallel way in the field of tillage and seeding of crops and in the haying and forage handling areas. All of these developments have assisted in increasing the unit productivity of the land as well as the total productivity of agriculture and the efficiency by which this production has occurred. The labour force in agriculture during the forty-year period of most of the recent developments has been reduced to one-third of its original size while unit productivity has increased by 50% and the improved acreage of land being operated has increased from 80 million to over 120 million acres.

However all of this progress has not been without problems in relation to human welfare of the individuals involved. Accidents and harm to farm people has followed the development of mechanization in a pattern not dissimilar to that which occurred in mechanization of other industries. Because of the diversity of the industry and the conditions under which much of this equipment must operate, it is conceivable that accident rate has been higher than in other industries, less easy to monitor or control or to give assistance in the way of prevention.

Since farming in varying degrees is land extensive, there are inevitable location effects in regard to their operation. Farms tend to be isolated in terms of distance from the supply and service centres in towns, and from the health facilities needed in emergencies. Also when involved in field operation, the individual may be isolated from his main headquarters. Because of this isolation, there is a tendency to improvise rather than seek additional help and to extend the day in order to complete an operation before returning to the home base.

This is likely to increase the risk of accident. If an accident does occur, the potential time lag before those affected are discovered and reach medical attention increases the potential severity of the effect of the accident. The inclination of the farm machinery operator to carry on regardless, using makeshift repairs, working long hours, with poor lighting is encouraged by the critical timeliness effect of agricultural operations. Weather affects both the rate of work and the time available to complete many operations and therefore in order to avoid serious loss there is pressure to complete operations as soon as possible. This can obviously increase the risk of physical injury and damage to health.

Other economic pressures may also be important. As a business, farming tends to have a high risk in terms of the availability of output. There is therefore a need to keep down production costs in order to avoid or minimize the loss in those years when returns are low. As they are not directly productive, the cost of safety precautions and specialized safety devices are very often avoided with the purchaser accepting the possible danger of so doing without full consideration of the risk. The organization of agricultural farming operations due to the continually changing economic conditions and changes in the production relationships within farming is resulting in a number of marginal farms which are under an economic squeeze. These farms have difficulty in achieving the rates of capital needed to keep their mechanized plans up to date and consequently on these farms there is added pressure to make do with unreliable and inadequate machinery and to economize on less directly productive, protective devices. This leads to high risk situation in the context of accidents and occupational health.

These economic pressures also lead farmers to keep down their labour costs. To do so there are occasions when inexperienced young people, often children and less agile older men, are called upon to take part in seasonal and sometimes other operations. Due to such instances and because they are frequently present as onlookers at the various activities, the farm environment holds danger for virtually all members of the farm family.

In machine design and development there appears to be at all times a trade-off between utility in terms of effect of operation and cost and welfare in terms of comfort and safety. Almost by tradition, machines are engineered first for function and are subsequently modified to provide tolerable limits of safety and comfort for the operator. In some circumstances, however, the two goals conflict and utility usually gets the preferred treatment over safety and comfort. For instance, for practical reasons, tractors are designed with large wheels and with a high ground clearance. This causes the seating position of the operator to be high off the ground and also gives the tractor a relatively high centre of gravity. Thus the operator has to climb up and down from his seating and operational position sometimes with minimal provision in the way of steps and through impeded access around power take-off shafts and other hydraulic mounted components, even though in the course of operation the need for machinery adjustment and other stops may require him to get off and on many times in the day. This may predispose the operator to getting caught or falling with the associated risk of injury. The high centre of gravity adversely affects the stability of the tractor, both on sloping surfaces and at high speeds thus creating a risk of the tractor overturning.

To facilitate additional functions, farm machines are increasingly fitted with an expanding variety of extra equipment such as hydraulic handling devices on tractors, including front end loaders or rear-mounted loaders, semi-mounted and fully-mounted items of machinery. Each additional item increases the amount of attention required for control. Unless the control mechanism is improved to maintain the manipulation required of the operator within certain levels there is likely to be increased danger due to inattention to various vital controls. In order to provide power for additional equipment and to achieve faster rates of work, there is a trend towards longer and more powerful farm machines. This trend has several possible effects. It may increase the level of noise emitted by the machine and thus increase the risk of hearing damage. It may also increase the level of vibration. This can indirectly cause physical damage and combined with the noise and the need for continual concentration, provides the ingredients for increased tension and operator stress. In turn this causes fatigue and again increased risk of accident.

As the rate of operation is increased so is the amount of information the operator must digest in order to control the machine effectively and safely. Control studies have shown that added tasks reduce the effectiveness of operating performance and consequently cause increase risk.

With increased power and speed there is greatly increased pressure on methods of control many of which may be inadequate even on smaller machines. In particular, extra power and speed put greater stresses on tractor stability and on steering and braking mechanisms. Some of the shortcomings arise because such mechanisms have a dual function. For example, brakes on tractors are designed primarily for turning to supplement steering under heavy lugging conditions. Because of their design and the fact that they have two separate pedals, these brakes are far from ideal when required to stop a tractor at road speeds. A variety of other machine features either are, or can be detrimental in their impact on the operator or those around him. Poor visibility from the operating position seems at least partly responsible for accidents in which small children are run over. Bad seat design is suggested as the primary cause of spinal damage. Cramped conditions and poor control layout are known to be significant in relation to the reaction rate in emergency situations. Exposed operating parts, particularly power take-off shafts and V-belts and chains are a serious source of danger.

It has been very difficult to obtain or to relate statistics in regard to farm accidents because there has not been a great deal of interest over the years to obtain statistics or to seriously attempt to reduce the accident problems. The Province of Ontario during the past ten to fifteen years has undertaken extensive as well as intensive surveys and has carried out an extension program in regard to farm safety. Saskatchewan and Alberta in the West have also been somewhat conscientious of farm accidents and have established safety programs as well.

However, even with this limited information certain trends or evaluations can be given to the data that is becoming available. There is some evidence to indicate that fatality rate with farm tractor accidents have increased during the past fifteen years and that when related to the decreasing farm population, there is evidence to indicate that the fatality rate per unit of population has practically doubled during this period. In relation to fatalities on all types of farm machinery there are three specific age groups in which the fatalities seem to predominate. One is the very young children between 1 and 4 years of age who get run over by tractors and machinery in and around the farmsteads or who are sent out with father on the tractor to keep them occupied while mother does the work, goes shopping, etc. and they fall off the tractor or machinery and get run over. The second age group and one with the highes percentage fatality rate is in the teenage group who are called on to operate high powered and complex machines without experience and who are inclined to show off and are unaware of the potential of accidents. In this group the greatest area of fatality is in the overturning of tractors. The third group is the farm operators over fifty years of age who are becoming less agile, who fatigue easily, and who are using rather complex machines without a background of experience.

The most comprehensive farm accident survey ever made in North America was carried out in Ontario between 1959 and 1960 by the Ontario Department of Agriculture and Food, in which some 5500 farm accident reporters conducted the survey which was associated with the 120,000 farmers in the province at that time. The results of this survey showed that during the 12-month period included in the survey, the number of accidents-7,835, number of fatalities-293 , number of permanent injuries-336, number of temporary injuries-5,868, number of days off work-112,500, cost of medical bills-$700,000, amount of property damage-$5,250,000. It appears that at least 75% of accidents with farm machinery are with the farm tractor with the high percentage of these due to the overturning of the tractor. Combines and balers account for less than 10% with corn pickers accounting for a high percentage of the permanent injury type of accidents. It is also important to observe that a high percentage of tractor fatalities occurred on highways and roads.

The main type of injury that occurs from a tractor turnover is a skull fracture or crushed chest. The farmer tends to work long hours particularly during the seeding and harvest periods and this frequently coincides with the more inclement type of weather, when heavy and excessive clothing is frequently worn and the individual is not quite as agile and his reflexes not quite so keen as during the warmer weather. The time of day also appears to have some effect on the occurrence of farm machinery accidents. There appears to be three peak periods, one between 10:00 and 11:00 in the morning, one between 1:00 and 2:00 in the afternoon, and the third one between 6:00 and 7:00 p.m.

Aside from the accidents caused by physical movements, there are other hazards in the operation of farm tractors and machinery. The one that is receiving considerable interest at the present time is tractor noise. The noise level of tractors under normal operation appears to register a sound level of between 90 and 108 decibels. Operation for long periods at this level can cause permanent deafness in short period of time. Frequently the addition of tractor cabs without proper insulation and acoustical control raises the noise level even higher. The noise level combine harvesters is somewhat less than the tractor level but still at a level which can cause serious deafness.

With the advent of rubber tires, tractor bounce and vibration has increased appreciably as tractor speeds have increased. The design of suitable seats and configuration of seating positions has not kept pace with the developments and this has resulted in serious back damage to many farmers.

The results of farm safety or accident prevention programs are quite intangible as compared to assessing results from other types of research and activities. Although it should be assumed that if specific accident prevention activities are promoted, and specific farm safety legislation developed, there would be a reduction in farm accidents, there will still be no positive evidence even through farm surveys that such safety education and legislation has been successful and effective , due to the wide diversity of farm operations and the individual units. This very fact tends to inhibit farm safety education and tends to discourage the workers in farm accident prevention. However this must not be allowed to deter plans of action in the accident prevention education area, in the development of machines that have safety features incorporated in them or in farm safety legislation.

There is progress being made in regard to improving safety standards related to farm machinery. Safety frames in the form of roll bars are being installed on farm tractors which when combined with safety belts keeps the farmer from being crushed when his tractor rolls over sideways or backwards. These have undergone serious tests in Europe where legislation now exists, particularly in Scandinavia, that all tractors sold must be equipped with satisfactory safety frames. Much improvement is being made in regard to tractor seats which will absorb the vibrations and reduce the back and kidney injury of the operator. Tests are being undertaken in regard to tractor noise. Standards have been established for shields on power take-off shafts. Slow-moving vehicle emblems have been developed to help protect the farm operator when he must travel on the highway. Provincial farm safety councils and committees continue to be active and are creating a greater awareness of farm accidents and the need for accident prevention programs and legislation. There is, however, still no national farm safety council or program.

Technical Paper:

3. SIMULATION OF HYDROLOGIC DATA by E. Wiser, Associate Professor, Biological and Agricultural Engineering Department , North Carolina State University, Raleigh, North Carolina, U.S.A.

INTRODUCTION

Simulation of hydrologic data is becoming a useful tool for the soil and water engineer. Although many engineers have hesitated to make use of simulated data because it is artificial, the recognition is spreading that such data are often helpful when observed data are either not available or available over too short a period to be useful for prediction.

Since simulation is generally applied where it cannot be tested, it is important that the models used reflect characteristics of observed data as accurately as possible, without becoming too cumbersome. Then after adequate testing where data are available, the technique may be applied to similar locations where data are not available.

This paper will review techniques that have been developed for simulation of streamflow and rainfall data, and then give a few examples to illustrate applications in the field of soil and water engineering.

SIMULATION OF STREAMFLOW DATA

Autoregressive Models.

Although workers as early as Hazen in 1914 made use of synthetic streamflow sequences, the development of models for simulation of streamflow data began with work done by Thomas and Fiering of the Harvard Water Program (Maass et al., 1962; pp 459-493).

In their development, Thomas and Fiering started with the simple linear regression

$$Q_{i+1} = \bar{Q}_{i+1} + b(Q_i - \bar{Q}_i).$$

Stated simply, the streamflow during the (i+1) st period, Q_{i+1}, is equal to the average streamflow during that period, $\bar{Q}_{i+1}$, plus a linear function of the amount by which the streamflow during the previous month differed from its average, $(Q_i - \bar{Q}_i)$. The equation matches the general observation that a period of above average flow will probably be followed by another period of above average flow.

There is one obvious difficulty with this simple form. Once the averages $\bar{Q}$ and regression coefficients b have been calculated from the data and an initial value Q_1 assumed, the sequence is fixed. This is undesirable, and certainly does not represent real conditions. That it occurs results from replacing the correct statement above that a period "will probably be followed" by a similar period, with the assumption that a period "will be followed" by a similar period.

In order to introduce the possibility that a period might not be followed by a similar period, a random component is introduced, and the equation becomes:

$$Q_{i+1} = \bar{Q}_{i+1} \; b_i(Q_i - \bar{Q}_i) + t \; \sigma_{i+1}(1 - r_i^2)^{1/2} \quad .$$

The terms are as above, but a new term is introduced as a products of three factors. t is a random normal deviate with zero mean and unit variance. $_{i\ 1}$ is the standard deviation of streamflow during the (i 1)st period and r_i is the correlation coefficient between streamflow during the (i)th and (i 1)st period.

The random deviate t may be positive or negative with equal probability. Thus the streamflow may be greater than or less than the streamflow in the linear regression model. The magnitude of the random component is a function of the parameters $_{i\ 1}$ and r_i. If the streamflows for the month have a large standard deviation, the magnitude of the random component will be large, usually larger than the linear component. Increased correlation between the months reduce the random component drops out completely and only the linear component remains.

In practice, e.g. for simulation of monthly streamflows, the mean standard deviation, regression coefficient and correlation coefficient are calculated for each of the 12 months from the data. Then starting with a given month and selecting an arbitrary streamflow for the previous month, the equation is solved month by month to obtain a sequence of monthly streamflow records of any desired length. The simulated data will have the same statistical characteristics as the observed data.

In more recent work, Fiering (1967; pp 28-32) uses the form:

$$Q_{i+1} = \bar{Q}_{i+1} + r_i (Q_i - Q_i) + \sigma_{i+1} (1 - r_i^2)^{1/2},$$

i.e. the regression coefficient is replaced by the correlation coefficient as the linear multiplier. This form more closely matches the first order autoregressive scheme used for a Markov process, and it is more correct in preserving the variance of the observations.

Because the random deviate is taken to be normally distributed, the resulting simulated discharges are also normally distributed. Since discharges for short time periods (a month or less) often have skewed distributions, maintaining the mean and variance of the observations may not be considered sufficient. Fiering (1967; pp 34-36) gives a general technique for matching higher moments, and gives a specific technique for the case when the streamflows are gamma distributed. Essentially, the technique requires transforming the random normal deviates into random gamma deviates.

This technique has been used by several other workers. One noteworthy extension is the method proposed by Benson and Matalas (1967) of using regional analysis both to improve estimates of the statistical parameters and to make estimates at ungaged locations.

Deterministic Models.

Many models have been developed for simulation of streamflow given rainfall data and physical characteristics of the catchment. The models reflect to varying degrees of complexity the movement of water from the time it reaches the land surface until it either reaches the stream, percolates down into the groundwater or evaporates or is transpired back into the atmosphere.

The best known and most widely used of these models is the Stanford Watershed Model (Crawford and Linsley, 1966). This model simulates water movement over and through the soil to stream channels and then routs the streamflow to the point at which flow is being simulated. Unfortunately many of the parameters that must be fitted are not directly related to measurable physical characteristics of the catchment, and must be estimated by matching observed and simulated data by a trial and error procedure. Nevertheless the model has been applied on a variety of widely different catchments with considerable success.

A model that is specifically applied to very small areas has been developed by Huggins and Monke (1968) A fairly simple model was developed by Dawdy and O'Donnell (1965) to study the accuracy of estimating parameters by fitting streamflow. Other models are currently under development by the U,S. Weather Bureau and U.S. Hydrograph Laboratory.

The large number of models already developed or under development would indicate that probably no single model will even prove adequate in all circumstances. The reason for this is the fact that, given the complexity of catchment behavior, a model gets unreasonably cumbersome if it is to do all things well. Thus a simpler model for a single situation will always work better than a more complicated generalized model.

Interrelated Records.

It is often desirable to generate streamflows at a number of points which are fairly close to each other. In this case it is well recognized that the records should be correlated with each other, i.e. if the flow during one month is above average at a given location, it is probably above average during the same month at nearby locations.

Thomas and Fiering also dealt with this problem. They determined the flow at a given station from the flow at an adjacent station by use of the relation.

$$Q_{y,i} = \bar{Q}_{y,i} + b_i (Q_{x,i} - \bar{Q}_{x,i}) + t\, \sigma_{y,i} (1 - r_i^2)^{1/2} .$$

Here the flow at station y during the (i)th month is obtained as the sum of the mean for the given month, a linear function of the deviation at station x, and a random function. b_i is the regression coefficient for station y on station x during the (i)th month, and r_i is the correlation coefficient.

Using this technique requires that flows be generated at a single (key) station using the autoregressive model, and then flows at adjacent locations are obtained using the above relation. Thomas and Fiering suggested consideration of correlation coefficients between the various points to determine which pairs of stations to relate.

Beard (1967) has developed a method in which correlations between all stations are maintained in the generated records. In his technique, the flow for a given time period at a given location is calculated as a linear function of the flow at the same location during the preceeding time period, the flow during the same time period at other locations where the flow has already been calculated, the flow during the previous time period at the remaining locations, and a random component. Beard uses logarithms of flows in his computation.

One difficulty with both of the above techniques is that all interstation correlations and autocorrelations are not maintained. Fiering (1964) proposed a technique by which component analysis is used to resolve this problem. He uses the data to construct a set of principal components which may be considered as an artificial set of independent locations. Records are generated for these locations and then transformed back to values at the actual locations. The data generated in this fashion maintain all moments and correlations in the observed data.

The Stanford Watershed Model can also be used to generate streamflow at several locations. Its use will be most suitable for generating records at several locations in the same catchment.

SIMULATION OF RAINFALL DATA

Simulation of rainfall data is not yet as well developed as in the case of streamflow data. Some of the techniques that have been developed will be reviewed briefly.

Chow and Ramaeshan. Chow and Ramaeshan (1965) developed a model that is essentially the same as the autoregressive model used for streamflow simulation. The model was intended only to generate hourly rainfall amounts during major storms, and its use has only been demonstrated for annual storms.

Pattison. Pattison (1965) used the properties of a Markov chain to generate hourly rainfall records. If the preceeding hour was wet, a first-order dependence relation was used to assign a rainfall amount. If the preceeding hour was dry, a sixth -order dependence relation was used to determine whether or not rain occurred. If the results indicate that a rain will occur, a first-order relation is used to assign an amount. Pattison tested the model rather extensively. His results indicate that dry periods between storms are not represented very well by the model, but other characteristics of the observed data are matched rather well.

Grace and Eagleson. Grace & Eagleson (1966) developed a model for synthesis of 10-minute time intervals during summer storms. The Weibull distribution is first used to generate time intervals between storms and storm durations. Regression analysis between rainfall amounts and storm durations are used to assign amounts to each storm, and then the amounts are divided among the individual time intervals to match certain characteristics of the observed records.

The model fits almost every characteristic of the observed data and hence should simulate data reliably under the conditions for which it was developed.

Wiser (1965a, 1966a) developed a model which consists essentially of two parts. First, models of rainfall events are used to determine whether or not rain falls during a given period. If rain occurs, a frequency distribution of amounts is used to assign an amount to the period. The results have been generally successful for daily rainfall, and are fairly satisfactory for hourly rainfall, although some consistent deviations have been observed in matching summer thunderstorm-type rainfall.

APPLICATIONS IN SOIL AND WATER ENGINEERING

Streamflow synthesis has been extensively used in studies of river basins. Perhaps the first major application was made by the Harvard Water Program (Maas et al., 1962) . A later application was made to the Lehigh River (Hufschmidt and Fiering, 1966). The literature on recent applications is too extensive to report here.

The Stanford Watershed Model has been used to solve a number of problems for which inadequate data are available. One such study was that made by James (1967) on flood control measures and the effect of the urbanization.

A simpler deterministic model was used by Wiser (1966b) to study the effect of supplemental irrigation on the hydrology of a catchment. In this case, for example, there never will be sufficient data to make an analysis by any means other than by simulation.

An application of rainfall synthesis is given by Wiser (1965b). In this instance, a soil moisture budgeting model is combined with a rainfall simulator to determine the distribution of the number of irrigations required in a humid area. A much better picture of the distribution could be obtained from 625 years of generated data than could possibly have been gained from a 25-year record.

Only a few illustrations have been given here of the possible uses of simulation in soil and water engineering. It is hoped that they may provide an insight into the type of information that may be gained by judicious use of the technique.

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Technical Paper:

4. DEVELOPMENT OF A FURROW RATE OF ADVANCE MATHEMATICAL MODEL by Jaime Velazco Linares, Water and Land Resources Department, National Agrarian University, La Molina, Lima, Peru.

To establish the model, let's assume the following:

A. The field is homogeneous: this means the slope, furrow section, roughness and rate of infiltration are the same along the furrow.
B. The flow rate at the entrance is constant (Q) and the flow is subcritical.
C. The flow depth at the entrance is constant.
D. The furrow slope is within the range of subcritical slopes.
E. The furrow section can be reduced to the trapezoidal or V forms.
F. The free water surface is of parabolic shape within a common point at (o, y_o).
G. The rate of advance curve can be expressed by:

$x = a\,ta^{b}$

$o < b < 1$

$o \leq x \leq L$

$o \leq t_a \leq t$

Symbols:

ta = advance time

t = application time

a, b = constants

x = advance length

L = furrow length

Q = flow rate at the entrance

P (y) = furrow wetted perimeter as a function of depth

I = infiltration

Ia = average infiltration along the furrow

i = rate of infiltration

k, n = constants

t_i = infiltration time

y = water depth

Y_o = water depth at the entrance

Development of the model:

By continuity:

$Q t = P (y) L Ia + V_s$ ......(1)

Attainment of Ia:

$$I \frac{k}{(n+1)} (t_1 - t_a)^{(n+1)} \quad \text{......(2)}$$

$$I_a = \frac{\int_o^{t_1} \frac{k}{(n+1)} (t_1 - t_a)^{(n+1)} \, a \, b \, ta^{(b-1)} \, d \, t \, a}{x_1} \quad \text{......(3)}$$

Solving (3) and introducing beta function (F), solved by Kiefer.

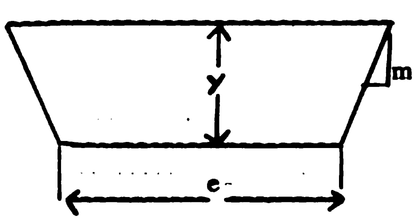
$$I_a = F \frac{k \, t_1^{(n+1)}}{(n+1) \quad (n+2)} \quad \text{..................(4)}$$

Attainment of V_s :

Assuming that the water free surface is given by the following relation:

$$Y = Y_o \left(1 - \frac{1}{t} \left(\frac{x}{a}\right)^{1/b}\right) \text{........(5)}$$

if the furrow section is



$$V_s = \int_o^L \left(e \, y_o \left(1 - \frac{x}{a}\right)^{1/b}\right) + m \; Y_o^2 \left(1 - \frac{1}{t} \left(\frac{x}{a}\right)^{1/b}\right)^2 \Big) \, d \, x$$

which after solving is:

$$V_s = (e\ Y_o + m\ Y_o^2)\ L - \frac{b(e\ Y_o\ 2\ m\ Y_o^2)\ L}{(1+b)} + \frac{b\ m\ Y_o^2\ L}{(2+b)} \quad \ldots\ldots\ldots\ldots(6)$$

Attainment of $P\ (y)\ L\ I_a$:

$$P\ (y)\ L\ I_a = \int_o^L (2\ y\ (1+m^2)^{1/2} + e)\ Ia\ dx \ldots\ldots\ldots\ldots(7)$$

Substituting (5) in (7) and solving

$$P\ (y)\ L\ I_a = I_a\ L\ (2\ (1+m^2)^{1/2}\ Y_o - \frac{2\ (1+m^2)^{1/2}\ b\ Y_o}{(1+b)} + e) \ldots\ldots\ldots(8)$$

Substituting (4), (6) and (8) in (1)

$$Qt = F \frac{k\ t^{(n+1)}}{(n+1)\ (n+2)} (2\ (1+m^2)^{1/2}\ Y_o - \frac{2\ (1+m^2)^{1/2}\ b\ Y_o}{(1+b)} + e)\ L$$

$$+ (e\ Y_o + m\ y^2 o)\ L - \frac{b(e\ yo + 2\ m\ y^2 o)\ L}{(1+b)} + \frac{b\ m\ y^2 o\ L}{(2+b)}$$

$$L = \frac{Q\ t}{\frac{F\ k\ t^{(n+1)}}{(n+1)\ (n+2)}\ (2\ (1+m^2)^{1/2}\ Y_o \frac{(1-b)}{(1+b)} + e)\ \frac{be\ Yo\ (2+b)}{(1+b)\ (2+b)} + \frac{2\ m\ Y_o^2\ (b^2 + b - 1)}{(1+b)\ (2+b)}}$$

This is the mathematical model, which permits the prediction of the rate of advance in furrows with trapezoidal section. Furrows with V section are a special case in which e is equal to zero, then:

$$L = \frac{Q\ t}{\frac{F\ k\ t^{(n+1)}}{(n+1)\ (n+2)}\ (2\ (1+m^2)^{1/2}\ Y_o \frac{(1-b)}{(1+b)} + \frac{2\ m\ Y^2 o\ (b^2 + b - 1)}{(1+b)\ (2+b)}}$$

SUMMARY

Is developed a mathematical model which permits the prediction of the rate of advance curve in furrows from infiltration and furrow shape measurements.

ACKNOWLEDGEMENT

The author wishes to thank Ing. A. Fujimori, for his revision of this paper.

Technical Paper :

5. RURAL SETTLEMENT AS PART OF RURAL PLANNING by Amin Aly Ibrahim, Technical Officer UNDP 80, Farm Structures & Rural Planning.

Introduction.

There is hardly a country in the world which has not been trying to undertake at one time or another a rural planning project which usually includes a rural settlement programme.

The profound political changes which occurred in many European countries as a result of the second world war, emphasized the importance of intensive improvements of new territories.

In some cases, the necessity for planning was a result of migration due to changes of political borders as did happen in Germany, Finland, India and Pakistan.

Another factor which emerged during the last decades, particularly in Asia and Africa, is the increasing degree of political independence of new countries confronted by growing impatience with existing land problems.

Rural planning in general will deal with agriculture planning, economy planning and social planning.

The undertaken projects directed the planner to find ways to increase the productivity of the land, change the deserted or scarcely populated areas to fruitful and inhabited productive sources for the increase of the national income.

In countries which have overpopulated agricultural areas, planning for reclaiming new areas are essential. These plans aim at increasing the availability of soil for use.

In many of these countries, agrarian reform measures were adopted as a necessary means to facilitate accumulative process of economic development as well as agricultural, offering help to the mass peasants.

The newly developing countries are characterized by such features as low income, a high percentage of the labor force in agriculture, high fertility and mortality rates, a low per caput energy consumption and a high illiteracy rate.

In all these developing projects, settlements are to be planned, new houses are to be constructed and service centers are to be established.

Now, with the few development projects going on, many of these developing countries face today the rapid decline in the death rate and a constant or a slowly increasing birth rate. That increases the burden of the planners. More land is needed and more houses have to be constructed and more services have to be offered for the new groups of people.

Agricultural Planning Objectives.

The Agricultural objectives of the development plans are generally derived from such overall objectives as increasing the national income, reducing inequalities in income distribution, improving the balance of payments or increasing employment opportunities. While there are naturally differences in emphasis from country to country, the agricultural objectives are strikingly similar among the developing countries.

To increase the availability of soil for use, one or more of the following projects can be included :

1. The reclamation of lakes and marshland in countries that have overpopulated agricultural areas
?. and limited space as in Holland and the Nili Delta of Egypt.
2. Obtaining "New land and water resources" as a consequence of new irrigation projects such as in Spain, Peru and the newly added desert areas in Egypt due to "The High Dam Project".

3. The settlement of unpopulated or underpopulated areas by establishing new sources of water by digging wells as in the "Huaral Project" of Peru or the "New Valley" in Egypt which includes the oases.
4. Projects for clearing the "Forest Land" such as the "El Pimental" project in the "Selva" of Peru.

Together with the previous mentioned objectives for agricultural planning, the above types of projects have many and varied other objectives:

1. Thinning the density of Population in the over crowded and overpopulated areas.
2. Use of the underpopulated areas.
3. Resettlement of displaced groups. The displacement ofthe inhabitants may be due to political reason, natural catastrophies or projects such as dam constructions that may inundate their land.
4. Creation of model and new type of farms and communities that is different from the traditional one existing in the country.

To obtain a carefully planned project for new land and new settlements for new communities, the planners should subject the project to statistical, social, political, historical and economic inquiries.

This is to be made in accordance with the rules to substitute the complete knowledge of the past experiences to the experience of today.

It is emphasized that reliable estimates of population growth and related demographic data, national income and household expenditure by income groups are required.

The problem to be faced and solved is a problem essentially connected with the "Planning", the main factors of which are "Man and Land".

Man and his adaptability, his attitude of learning, his assimilation of the agricultural methods, his degree of civilization are to be studied together with the positive and negative aspects of the land as far as natural services from the economic point of view are concerned.

Some of the factors to be also studied are the infra-structures such as road, civil-services and housing.

The information about roads is necessary for the rapid approach to inhabited centers for socio-economical reasons while civil services and housing offer the comfort of modern life.

The technicians and specialists who must be well trained are left to collect and select the data concerning the problem "man land relation" for the planner. The planner, after interpreting and developing the data, will be able to propose proper solutions for the attainment of a satisfying development and welfare of the community.

In rural planning, we have to differentiate between planning for a community already existing, but running a land reform or new land which is newly put in use either by clearing forests or reclaiming desert or lakes.

The already existing land has some limitations due to the existing conditions while the new land can have the modern theories of planning that will suit the new ideas and studies of the planner with no ties except, may be, tradition.

Rural Settlements.

Before we talk about settlements, let us define "Rural Areas", "Agricultural Settlements" and "Settlement Pattern". The term "Rural Areas" refers to areas where agriculture is the chief or even the sole industry. "Agricultural Settlement" is a community location in which mainly agriculturists and persons in related production of services live and work.

The term "settlement pattern" is an expression of the agricultural economic political and social trends of the general layout of an area. The rural settlement pattern is determined by the arrangement of the residences, size of the farms, division of fields or grouping in relation to service centers.

Patterns of Rural Settlements.

There are two main patterns for rural settlements namely:

1. Scattered settlements or dispersed individual farmsteads.
2. Gathered settlements where the residences are gathered in a centralized area which also includes rural centers, public buildings, public areas and community services.

Each pattern has sub-patterns as solution to avoid the difficulties arouse if the planner sticks to one stiff rule. To each pattern, there are advantages and disadvantages. There is no good solution for all cases, but the best solution for each case should be found with a certain combination and compromise on the following principles:

a. Best results in farming, technical and economical.
b. Sufficient participation to the community life, social and economical.

Scattered gathered settlements.

A. Scattered settlements.

It can be defined as the system under which each house has separate location with individual domestic services within each family holding. The public and social services are centralized in the central or service village.

The farmsteads may be at a relatively large distance from each other or in small groups close to each other along the road or at cross roads.

This plan may lead to better management because of the continuous attention and care without losses of time and interest since the farmer almost always live on the farm to better application of technical principles to more ability to increase the number of animals and to better use of time. The farmer is usually only attracted to go to the village for useful or important meetings.

But it also has its disadvantages. The long distance between the settlement and the nearest village makes transportation a big problem. It is also known that scattered settlements create difficulties in organized community services such as supply of drinking water, excreta disposal, electricity, social services and security. In other words we can say it creates high development.

B. Gathered settlements.

Usually these settlements are called villages. The village will have the residence together with the rural centers and public buildings.
There are two distinct types of this plan:

1. The houses are built outside the farmers' holdings.
2. The residence with its yard is attached to the farm but they are all near the public social and civil services.

Such a plan has its advantages that the facility of modern life services can be offered easily and that the investiment needed for necessary services such as drinking water and electricity is less than that needed for the scattered settlements. Provision and purchase of commodities will be easy for the farmers. More social life, more family feeling, more security and more self-aid and cooperation are expected.

Usually this system is used where small holdings area are prevalent. This lead, through the years and traditions,to the following disadvantages:

- It's very hard to make any extension in the houses due to increase of the family members and total increase of population.
  This difficulty if not put under control and check, will certainly lead to the destruction of the beauty of the plan of the village and eliminate the streets gradually and turning them to blind alleys.

- If there is no farmyard attached to the house, or if the farmyard attached to the house is limited in area, the increase of the number or farm animals will be limited.

- If the farmer keeps his animals in a stable inside the house, the accumulation of dirt and manure in the streets builds a health hazard.

- In countries where the farmer uses his farm by-products as fuel and which are usually stored on top of roofs, there will be fire hazards due to close contacts of houses.

If we study carefully the advantages and disadvantages of both systems, the scattered and the gathered, we will find that the gathered settlement system will suit the newly developing countries while most of the disadvantages of the scattered system could be overcome in the more developed countries through the modern methods of transportation, mechanization and technology.

The new village in the United Arabic Republic.*

Since man knew the art of agriculture together with raising cattle, he started building a permanent residence to himself and settled to become a farmer.

Following the history of ancient Egyptians, system of irrigation, insecurity because of the nomads and the value of the fertile land, it would be clear and understandable that the farmers would not settle in separate houses scattered over the fields: the villages were built on mounts or hill-tops away from the flood.

The farmer was therefore restricted by conditions and by labor to an inhabitable area which he utilized to the maximum benefit for his family and livestock. The compact village, therefore, left no room for wide streets play grounds or public facilities.

Due to the increase in population and the restriction in space, the farmer extended his dwelling upward. He also paid no attention to the streets and he extended his house horizontally and turning the streets into blind alleys. In the same time there were no civil or community services.

The old villages, therefore, look as if they have grown without planning. Not only that, but most of the disadvantages for the gathered settlements coincide with these types of villages.

When the revolutionary government came into power in 1952 and new projects for land reclamation started, planning for new settlements were under study trying to avoid the disadvantages of the old crowded village.

While studies, inquiries and statistical datas were collected and analyzed, few solutions were suggested, few villages were constructed and few experiences were gained.

1. Dense village with community services.

Due to traditions, the planners of 1952 did not want to make sharp changes in the life and habits of the farmer. The houses were built in small blocks separated with wide streets. The main square had the community services. A hospital, a school, a mosque or church, a consumer co-operative society and public buildings were constructed.

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* This study and the new suggestion is made by the author and a graduate student, Ing. Farouk Heidar, for a thesis submitted in partial fulfillment of the requirement for the M. Sc. degree.

The animal stable was still built inside the farmer's house.

Although many solutions were suggested and tried to eliminate the bad-effect of sticking to the tradition of having the animals live with the farmer, none was successful to prevent the accumulation of manure and animal waste near the houses and thus spoiling the beauty of the village and creating health hazard.

2. Dense village with co-operative dairy farm.

Other planners went to the other extremes in their village planning.
The farmer does not own his dairy cattle but he was a member in a cooperative dairy association. The dairy farm was built outside the village.

The village proved to be very clean, but the farmers were not happy. They did not accept the co-operative dairy farm theory and it was considered as a sharp change in their social, economical and political way of thinking.

In solution 1 and 2, the village used to serve an area of 1,500-2,000 acres divided into small plots each of 5 acres owned by a farmer and his family.

3. Semi-gathered settlements.

When the farmers showed their disatisfaction with solution number 2, the planners tried to find a medium one between 1 and 2.

The village residences were small in number and the stables were built outside the houses in a special area taking into consideration the direction of the wind. The village will serve 200-400 acres of land.

The solution was very satisfactory, the village proved to be clean and the farmers were content. The animals were within a walking distance from their houses.

For the government which was paying the expenses of constructing these villages (but paid back by the farmers in a 40 year loan-base) this proved to be an expensive solution. Investments for roads, drinking water, electricity and other services reaching to the new settlements were high. But the success of the solution encouraged the planners to keep trying to find the right one.

4. The co-operative village.

It is a combination between plan 1 and 3. The village was divided into clusters where the houses were separated from the stables. The clusters were surrounding or near to the public and service buildings such as the school, the mosque (church), the hospital, the veterinary clinic, etc., . The village also was planned to have a machinery station, community grain silos, a mill and milk collecting center.
The design philosophy stemmed from the desire to provide the villages with an environment which suits his traditions and way of life to a great extent- yet fresh in approach and vigorous in expression, symbolizing his new life on a new land.

The concept for the new village is a direct result of the consideration of the relationship between the residence area and the "field". By locating as many of the areas of services near the village center, the relation between these elements will be that of movement.

If we consider the housing unit as the base point, the pattern of movement will be from the house to the center of the village or animal shelters and from the house to the field.

To be sure that the communication to the village and its components is easy and that the facilities are within reach of the residents, the following studies and analysis were made.

a. analysis of clusters arrangement.
b. analysis for pedestrian paths inside the cluster and the village.
c. analysis for vehicular paths to and within the boundaries of the village.

Technical Paper:

6. PROVIDING A UNIFORM DRYING ZONE OF GRAIN IN A FIXED BED by Carl W. Hall, Michigan State University, East Lansing, Michigan, U.S.A. (Based on research by Drs. F.W. Bakker and W.G. Bickert)

Background.

Fixed bed drying of grain with natural air is a relatively slow process. The drying process may be accelerated by adding heat to the air using wood, gas, fuel oil or electricity. Grain may be replaced in the bin layer-by-layer. Grain may be mixed or removed and added back to the bin in order to reduce the variation in moisture content throughout the bed. Continuous dryers, using high temperatures, are also widely used.

With a fixed bed in a deep bin, the drying takes place in a drying front, with a zone of drying developing and moving through the bin in the direction of air flow. If heat is added to the air to increase the drying rate, over-drying of grain at the inlet may occur. Increasing the air flow may require an increase in cost beyond the returns because diffusion of moisture from the product might restrict speed of drying.

Objective.

To develop and evaluate a procedure, particularly for temperature-sensitive products, a method for obtaining uniform drying throughout a fixed bed of product.

Approach.

Install an electric heating wire in the fixed bed so as to increase the moisture carrying capacity of the air without causing great variations in moisture content throughout the bed. A fixed bed will be used to minimize handling and possible damage to the grain. Parameters of design will be identified and evaluated.

Analysis.

a) The heating cable could be placed at the entrance of air (usually bottom) to the bed. The effect would be similar to increasing the temperature of the incoming air. Greater variations in moisture content of the grain throughout the bed would result. There would be no distinct advantage from the viewpoint of drying capacity as compared to other heating methods.

b) The heating cable could be placed at the air outlet. There would be no advantage except to reduce condensation outside of the grain bin, or unless the air were recirculated.

c) The heating cable could be placed somewhere between air inlet and outlet so that the moisture carrying capacity of the air could be increased. The drying could be increased without over-drying the grain at the air inlet which would result if the incoming air were at a high temperature.

The above analysis is used to establish the boundary conditions of the problem.

Procedure.

a) Drying bed of 3 ft. and 6 ft. depth used with a 1 ft. x 1 ft. cross section.
b) Air flow rate of 10 cfm per bu used. Measure airflow and static pressure.
c) Initial air conditions of 70 deg F (natural air) and 100 deg F and 50% relative humidity were used.
d) Two heating mats, 70 watts per sq ft were available.
e) Tests were made with the following arrangements for heating:
   (1) no heating mats
   (2) one heating mat at 1.5 ft. from air inlet
   (3) two heating mats at 1.5 ft. from air inlet
   (4) two heating mats at 3.0 ft. from air inlet
   (5) two heating mats at 4.5 ft. from air inlet
   (6) various combinations of above, depending on findings.

f) Temperatures measured throughout the bed with a 48-point recorder, at 30 min. intervals.
g) Grain moisture contents determined at several cross-sections, using the oven-dry method.
h) Observe mold growth conditions.
i) Moisture-humidity temperature analysis was made with psychrometric chart.

Results and Conclusions.

Many data secured are still being analyzed. In general, with the heaters at the center of the fixed bed:

a) A small increase in temperature, 10 to 20 deg. F, nearly doubled the moisture carrying capacity of the air.
b) Condensation of moisture for an extended time was avoided so the damage to the product from visible molding was eliminated.
c) Overdrying of grain at air entrance was considerably less than if the heat were added at inlet. Appropriate control of heating mat is required to prevent overdrying of grain next to the heat source.
d) With unheated air (70 deg. f), the drying time from 30 to 13% was reduced by about one-half, from 140 to 70 hr, also reducing the cost of fan operation.
e) Approximately 2 kwh of electricity were required per bushel of product.
f) The possibility of control of heating mats, based on temperatures throughout the bed, to provide uniform drying, economical use of electricity, and minimum adverse affects on the product will be evaluated.

REFERENCE

1. BAKKER-ARKEMA, F.W., W.G. BICKERT, and W.D. BAEDKE (1968) Fixed Bed Multiple-zone Grain Drying Using an Electric Heat Cable. Michigan State University Quart Bul, vol 50, n°4, pp 577-582.

Technical Paper.

7. RURAL SETTLEMENTS IN THE HIGH JUNGLE REGION OF PERU by Rodolfo Muñante, Planning and Rural Works Department of the National Agrarian University, La Molina, Lima, Peru.

Social Economic Planning

Sets up the objectives

Physical Planning

Seeks their achievement

This document intends

To achieve settlement of Peru's high jungle region in the most convenient manner, in accordance with the present reality of the country.

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1. Justification
2. Objectives
3. Resources
4. Discussion and Results
5. Conclusions
6. Summary

The need of incorporating new lands to agriculture is a fact acknowledged by the new Agrarian Reform Law which states, "in those areas where the land has been subdivided into plots smaller than the Family Agricultural Unit, the marginal population shall be determined so to provide them with land in the Rural Settlement and Colonization projects implemented by the State, preferably in the areas adjacent to or near the region where the lands are being parcelled".

This problem occurs mainly in the Highland region where the extreme division of lands is one of the causes for the spontaneous migration of families which seek immediate satisfaction of their elementary needs. Thus the country suffers a serious social pressure represented by the unemployed labor which migrates to the cities seeking job opportunities which have not been created to the extent necessary, or families which migrate to the jungle region where they do find possibilities to subsist.

Settlement of the jungle is a necessary fact which should be encouraged for purposes of reafirming national sovereignity in that region and to integrate it to the countries development. This is why at present penetration roads are being built to the low Jungle where the river becomes a natural communication route.

2. OBJECTIVES.

The plan's objectives are to achieve the social and economic development of the area's population by extending to the farmer the benefits achieved by the urban dweller, while integrating the Peruvian Jungle to the rest of the nation.

3. RESOURCES.

The preparation of rural settlement plans for Peru's high Jungle has to face the lack of basic technical knowledge regarding climate and soils, a situation which makes it difficult to determine the size of the family unit with any degree of accuracy. Furthermore, the size of the unit varies according to changes in the benefits set as objectives, production cost and sales price; or when the crops cultivated or the animals raised in each settlement have to be changed due to variations in consumer demand or because of the substitution of agricultural products by similar industrial goods.

The scarce economic resources available to the country constitute a limiting factor to be considered in the implementation and operation of the settlement.

The immigrants from zones of different ecology are of a low cultural and economic level, having no colonizing experience for conquering the new environments.

As regards to communication routes, we can say that for as long as the road does not get to the settlement, marketing shall be handicapped by the high cost of air transportation or the risks involved in river navigation in low draft craft such as canoes and others.

From the above, we could come to the conclusion that it would be inconvenient to encourage Jungle settlements but, quite to the contrary; it is felt that the available human resources represent a basic potential which must be fully utilized for the development of the country; and that the Jungle region, initially in the high zone and subsequently in the low, and if the settlement process is duly planned, shall permit the peasant not only to subsist but to satisfy the needs which the development of science might create.

4. DISCUSSION AND RESULTS.

Before any settlement is implemented, it is thought that an integral regional planning must be carried out for purposes of determining the inter-relationships among the different settlement areas and the diverse characteristics of each of them.

Subsequently, a pilot settlement developed in two stages, would be chosen. In the first stage, of approximately two years for the settler's adaptation to the environment, the best soils would be utilized to profit from the largest portion of available resources with a minimum investment, thus obtaining the subsistance products; education and technical skills would be made available through agricultural and cattle research carried out to determine the most appropriate activities to be developed in the area. This, in summary, would be the preparation for the second stage which would start with the completion of the road and development of the marketing, industrialization and constant improvement of a new town incorporated to the country.

4. 1. Clearing of lands.

Clearing and disposal of natural vegetation, including usable lumberwood is required for the use of these lands; a task which must be carried out rapidly, economically and efficiently.

To carry it out rapidly and efficiently all the available labor must be used, that is, the Aguaruna complemented by selected settlers who, participating in the conquest of the environment from the start, learn the best way of carrying out the clearing and immediately make use of the cleared land to prevent erosion. They shall apply this knowledge in the subsequent stage.

The economic use of machinery is achieved by eliminating unnecessary operations, for this reason all areas to be cleared would be concentrated.

4. 2. Initial Activities of the Settlers.

In the adaptation stage the settlers would basically obtain products for their food, cultivating subsistance crops and raising fowl, pigs and smaller animals such as guinea pigs, rabbits, etc. so as to achieve a balanced diet. This would be made in an experimental fashion to determine the most convenient varieties of the species, cultivation methods or the most adequate systems for raising and handling animals.

4. 3. Agricultural Research and Extension.

Research would be directed by professionals with the participation of the settlers of the zone and thus the results obtained would be closer to reality.

Experimentation assumes that some crops will work out while others won't. Thus the settlers would be aware in advance of the possibilities of success and could be trained to observe what they should and avoid doing what they shouldn't.

Experimentation is an activity which the settlers could not undertake under those conditions for they would not have sufficient money or knowledge. It should therefore be carried out by a specialized agency which would plan and execute agricultural research in the aforementioned manner.

Technological process indicates that experimentation must be continuous, therefore requiring the permanent presence of professionals carrying out agricultural and cattle research and extension.

These professionals should be well paid which, unfortunately, is not possible at present. They should have some incentive to remain in the area for many years for transfers to other areas are disadvantageous because continuity of the work is lost since the professional needs an adaptation period which agriculture does not permit. Transfer of the researcher-extensionist is of benefit only when made for purposes of acquiring new knowledge.

Since the professional is only a transient in the area, he has no interest in achieving better contacts with the settlers thus creating a very marked social differentiation which, in turn, creates resentments among the settlers and thus makes it difficult for him to carry out good extension work.

The professional feels that his prestige as such is not at stake, for he is isolated from other professionals which could compete with him.

Extension services are adequate when the settler sees how things are done, does them himself and receives complementary guidance.

In summary, for research and extension to have the desired results, it is necessary that the professional get the settlers to develop the best techniques available. This is a hard job and should offer sufficient incentives to compensate for the low salary he receives; for this reason it is proposed that the engineer also be a settler and thus obtain higher income.

The professional receives an area equivalent to two family units, which make it necessary for him to use hired labor which is provided by the settlers. In cultivating his plot the engineer tries to obtain the best results and for this reason uses the most rational techniques which are then observed and practiced by the settlers at the professional's plot and under his control. Thus the agricultural extension service would be provided not only by obligation or professional ethics but because the benefit obtained would also produce personal profits.

The number of settlers under each professional would amount to 30 so that each of them would participate in the cultivation work of the professional's plot at least twice a month. This also propiciates a daily exchange of ideas between the settlers who worked that day and those who didn't.

To achieve the maximum efforts from the settlers in working at the professional's plot it is necessary for them to feel, not as laborers, but as participants in the professional's endeavours. The latter shall have to undertake the task of achieving close contacts with the settlers beyond the owner-laborer or extensionist-settler relationships which apply at present.

This type of social relationship must be developed by the engineer for, if he doesn't, he will lose the only possibility of obtaining labor for his lands since the settler would work for him only up to the time when he feels he has learned enough.

This type of inter-relationship does not create social differences between professionals and peasants, establishing an integrated society of which the professional is the leader.

The task carried out by the professional should be evaluated, compared with that of other professionals in the settlement and publicized at the regional and national levels. This would be an incentive for professional improvement.

The professional's desire for knowledge of technological progress is satisfied by means of publications and courses in other areas, which would also serve for a greater exchange of experiences. The engineer's attendance to these courses shall depend on how confident he is of his settlers, since they shall continue the work in his plots while he is away.

The professional improvement of the engineer will cause his plot to serve as an efficient and permanent demonstration plot. For this reason the settlers should visit it daily before going to their own lands.

After working for the professional the settler goes to his own plot and applies the knowledge he has learned, however, the professional must provide supervision from time to time.

The extension service Unit would be formed by the engineer and the 30 settlers. The members of each unit should come from the same area, including the engineer, for purposes of achieving a better integration and understanding as a consequence of possible kinships, similar uses and habits, etc.

The higher economic capacity of the professionals' families makes it possible for them to have a higher standard of living, and thus they become an incentive for the settler families desiring to achieve the benefits produced by technological advances. Thus the necessary changes in the settler's behaviour and the application of modern methods would be achieved.

4.4. Land Distribution.

To make use of technological advances in agricultural tasks such as cultivation, fertilization, application of fungicides, etc; to facilitate the use of systems appropriate to large farms, and the most rational methods and advanced techniques it is necessary that the areas of land dedicated to one single crop be as large as possible. This is why cultivation blocks would be created. They would be large homogeneous areas of land. It might also happen that for some reason a homogeneous area might become heterogeneous, if more than one crop is planted.

Thus a different degree of activities would be carried out in each cultivation block, depending on the labor, machinery, etc. and other requirements available.

4.5. Peasant Activities.

For social, economic and safety reasons the best quality homogeneous area would be dedicated to the cultivation of vegetables, with a view to self supply. Other homonegenous areas, not as good as the first, would be dedicated to pastures and other crops. Type VIII soils would be dedicated to forestry and hunting.

The standard of living of the area's population should be uniform and not have contrasts which might bring about an unstable social environment. This would be achieved giving all settlers the same possibilities of success by allocating to them equivalent areas of land in the aforementioned cultivation blocks; each settler would receive one plot in each cultivation block. The higher economic level of the professional and its consequences have already been explained.

Labor requirements for agricultural and cattle activities would produce seasonal unemployment or daily subemployment in the area. To have a fair hourly wage other activities would be undertaken for purposes of achieving full employment of the available family labor. This would be achieved by participating in the development of operations complementary to agricultural work; temporary cattle raising activities, fishing, creation of fish farms in those areas where natural conditions are adequate; conservation of forestry parks reserved for hunting handicrafts and participation in local and regional Agricultural and Cattle Fairs.

Complementary activities of agriculture such as transportation of products from the farms to the gathering point for all the settlement's production; cleaning, classification, packing of products for marketing in addition to the possible storage before transportation to consumer markets, where their sale would be facilitated by the settlement's agricultural cooperative.

The peasant may also obtain employment from the industrialization of agricultural products.

In using forest areas as hunting preserves and in creating fish farms the inflow of tourists interested in these activities as well as in search of the country's pure air and peacefulness is encouraged. Thus providing the peasants with an additional possible source of employment.

Tourist activities have their maximum expression at the Area Agricultural and Cattle Fairs, which coincide with the festivities of the settlement's patron saint, thus achieving greater interactions among the settlers and people from other areas.

4.6. Types of Settlement.

In accordance with the natural characteristics of the homogeneous areas and the possible cultivation blocks the vegetable cultivation block is the one having the highest agricultural activity and therefore this area is one which should be closer to the houses so as to avoid excessive movements of labor and make it easier for the housewife to dedicate her attention to the crops which need it most.

The type of land needed for the vegetable homogeneous area is the best suited for the economic construction of housing since it is the flattes and smoothest.

The remaining blocks are increasingly distant in accordance to the degree of activity dedicated to each of them.

The fact that the settlers must live on the lands having the least gradient and smoothest topography means that the distribution of housing is limited to an area which generally represents a minimum percentage of the zone.

The settlement must have the least cost in its constructions and maintenance of the infrastructure, all of which represents a smaller development of the road and public facility networks.

It is necessary that the settlement avoid isolation of the peasant family, help the development of an integrated community and facilitate mutual assistance.

The relative distance between the houses and the service center should favor the latter's development for purposes of achieving greater community activity at the area and regional level.

From the aforementioned considerations we come to the conclusion that the most advisable distribution for the area is grouping the houses around a service center, thus determining the formation of a concentrated settlement having its lands broken up into cultivation blocks.

4. 7. The Grange.

The settler's need of living in his plot, of developing his private initiative and the characteristics of the area, among other considerations, make it advisable for each settler to receive, in addition to his plots in the cultivation blocks, an area of two hectares of the best lands where he can build his house and develop his personal initiative in horticulture and in raising animals for purposes of obtaining the basis for a good diet. Thus the labor provided by the housewife, school-age children and old people can be used everyday and thus avoid waste of a human resource.

Because of the need for creating an integrated community, the granges should be located on both sides of a road or street, establishing continuity. Savings in construction and maintenance of roads and public facilities make it necessary for the grange to have the minimum frontage, which is related to the length of the furrow in the family orchard parallel to the road. This length has been set up at 30 meters.

Activities in the family orchard make it necessary to have available instruments to facilitate the work, which must be kept in a shed close to the house. Access to the orchard is through a road giving service to 2 plots, the rain drainage canals run parallel to it. To make the use of agricultural machinery more economic, the orchards are bounded only by reference stakes in the corners.

Animal raising includes pasture-fed cattle, pigs, fowl, lesser animals, etc. which require corrals at the family barn. The settlers have the psicological need of defending their animals from theft and thus the barn is located behind the house. Cattle are pasture-fed and must be driven to the pasture lands daily. For sanitation reasons movements from the corrals to the pasture areas and viceversa should be carried out in an internal road dedicated exclusively to the movement of animals and agricultural machinery, located between the barn and the orchard of each grange. Since the cattle will move along the orchard's bounderies the latter must be fenced to protect the crops.

Thus the life of the farm laborer becomes completely independent during his moments of rest and leisure, creating an environment similar to that of the city which satisfies one of the aspirations of the settler. Development of a garden in the area between the house and the street also helps to create this environment.

To satisfy the settler's need for independance and ownership of his land, which in other areas is manifested by walls, stone or wood fences which are of no use and require the continuous use of labor, the adoption of fences made from fruit trees is recommended for the area involving the garden, house and family barn.

To assure feeding of cattle in rainy days when it can't be driven, as well as to feed other animals, forage must be stored in an appropriate silo built on the plot itself. For purposes of complementing the animal feed, concentrates are used which are prepared in a cooperative mill with maximum use of local materials. Formulations are prepared by the technical staff and fed to the cattle before and after pasturing.

The need for technical assistance for the cattle is satisfied by driving it, on the way to their pasture lands, through the engineer's grange where any cures, artifitial insemination, etc. are carried out. If double purpose cattle are raised, a milk collection plant should be established so as to process the production and then, for marketing and industrialization purposes it is sent to the Milk Central. Pasture lands can be bounded by moveable fences. Shade can be obtained from trees which are also useful for some other purposes.

Summarizing then, each grange is formed by the garden, the house, practical installations such as the silo and the instrument shed, the family barn and the corral.

4. 8. Land Tenure Systems.

The settler's desire to own some area of land as a basis for his security is satisfied by granting him

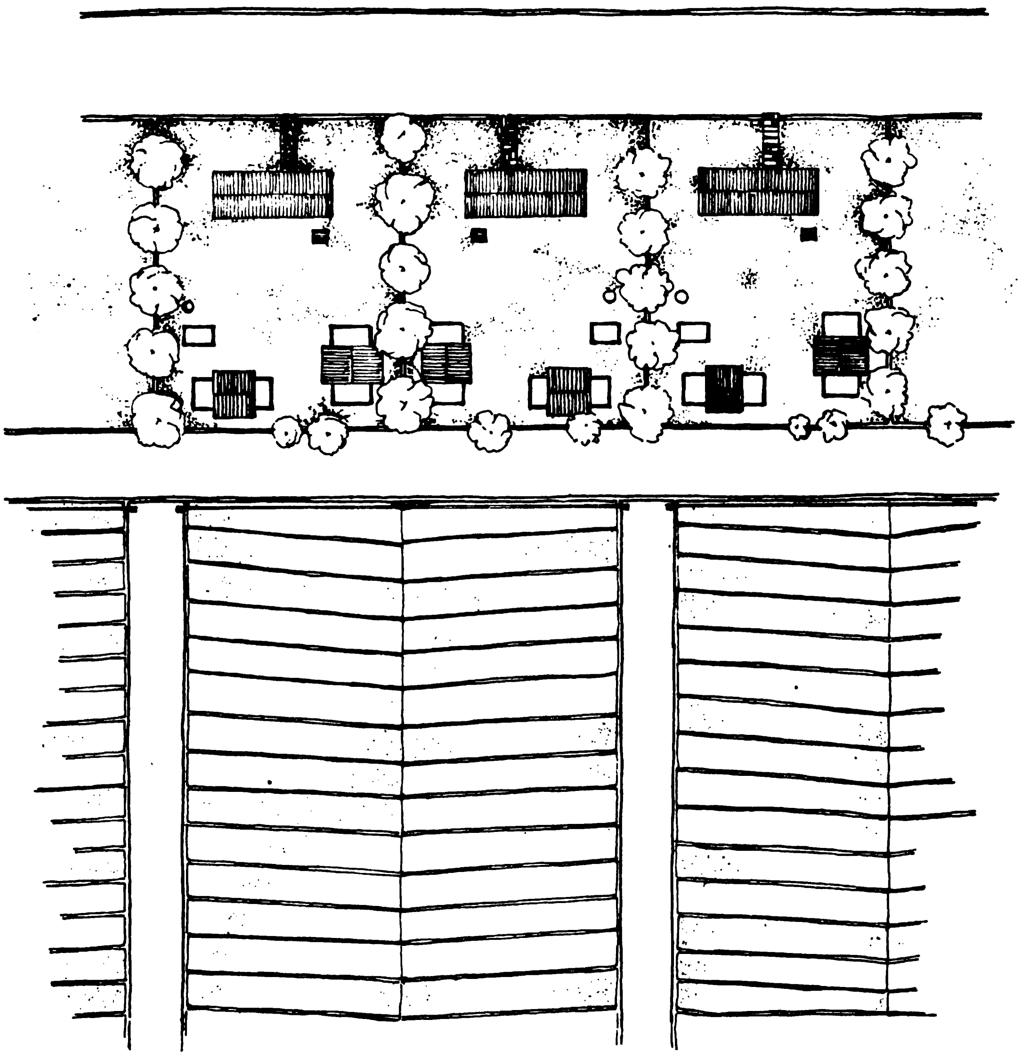


Fig. 1

ownership of the grange and the plots in the cultivation blocks.

It can happen that some family does not wish to cultivate its plots during some given periods leaving unworked areas within the cultivation blocks which might become the origin of pests and diseases might affect other plots in production. The cultivation block system of agriculture requires discipline on the part of the settlers for planting the crop decided upon and carrying out timely cultivation measures.

This discipline requires a certain sacrifice of individual freedom both in the choice of crops and animals to raise as well as in carrying out cultivation work at certain given periods of time. This loss of freedom will however, give the settler a higher purchasing power and consequently increased individual freedom to participate in economic and social life.

This makes it necessary to stipulate that unless the aforementioned conditions are met, the lands shall revert to the state for otherwise the community might suffer.

4.9. Service Center.

One of the objectives of the plan which is that of extending to the peasant the benefits achieved by the urban population means that not only must he be helped to achieve a certain economic level under the proposed plan but that he must also be provided with the life facilities, typical of the city, in his housing and work centers. This requires a change of attitude on the part of the government for purposes of eliminating differences between the country and the city; if this were not so,migration of rural families in search of better standards of living shall not be controlled.

To achieve control, the population of the settlement must rapidly receive educational, medical, hospital, and communication services, etc. which must be implemented on an economic basis aside from social and political factors; this means providing those services justified by the population and must be extended to the largest number possible. The population served shall depend on the distance between houses and the location of the service, whose distance shall increase as the number of settlers increases. This distance is relative for it shall depend on the transportation means used and the characteristics of the existing roads. In this case the distance of the service shall basically depend on the number of settler families, which shall be limited by the area of the economically arable lands available in the region, and the number of families which receive the services.

The services are grouped in what is called a service center which is broken up into residential or operational sections.

Residential services respond to historic tradition, and population's uses and habits, but with a view that the services provide everything which might lead to the achievement of the objectives proposed and not to restrictions which might mistakenly maintain present standards of living. Traditions are then taken into account only when they are true requirements for life and methods of work, and are discarded when they only represent a psychological fact of the past and are no longer valid at present.

For provision of commercial type residential services, in addition to the number of people it is necessary to know the population's economic capacity, to determine whether the service is economically justified. In the present case, many services must operate even if this type of justification does not exist, for the success of the program depends on them, that is, they should be an effect but they are also a cause, for by producing increases in production they permit a better economic level and improved standard of living.

Specialized staff, which must be provided with housing near the service center, is required for the efficient operation of the residential and operational services.

This other group of houses also takes into account units for families desiring to enjoy the advantages of country life as well as the comforts of the city, thus their design must correspond to the characteristics of a country city.

Access of the settlers to the service center requires organizing transportation, which is closely related to the type of road and the high rainfall prevailing all year. Thus it is necessary to analyze the type of services, the people, and the frequency with which they are used to determine the type of communication route needed.

Thus children under 5 years of age are taken to the nursery by their mothers or older brothers; school age children attend primary school and the three basic highschool years which are given in each service center; for the two remaining years they move to the respective service center.

To go to school at the local service center the students might ride bicycles or even walk, for maximum distance from the house to the school is approximately one kilometer.

Housewives go to the supermarket everyday or every other day to purchase the items which, though necessary for family life, cannot be obtained at the grange. In this case, the advisable transportation means is the bus or the microbus. Another alternative is that housewives resort to small stores located in some granges.

When settlers go to the service center to purchase agricultural inputs they require some vehicle capable of carrying certain loads. During the consolidation stage, when farmers go to the cultivation blocks daily, they first gather at the operational service center where agricultural machinery , seeds, fertilizers, equipment, etc. are stored and from which they are transported, in specially adapted buses or microbuses, to the cultivation areas to carry out the same agricultural work simultaneously, but each in his own plot, after having first visited the professional's demonstration plot.

Under these conditions the best solution would be the cooperative operation of a specially adapted microbus which can transport all the settlers from their houses to the service center or to the cultivation blocks and viceversa.

This means of transportation increases the radius of action of the service center, this means that the number of families in the settlement shall be limited only by the available cultivation lands of the area. It is assumed that two hundred settler and professional families would be an advisable number for the basic unit, in addition to the families dedicated to providing the services.

On the basis of the aforementioned population the economically justified services for each basic unit are determined. The services for larger populations are distributed among all the centers included in the regional planning, avoiding concentration of dissimilar activities in one single center and for purposes of promoting the development of each and every settlement and to achieve an effective integration of the region on the basis of an interdependance of the basic units.

4. 10. Road network and Public Utility Installations.

Roads are built with materials which preserve the peasant habit of walking to the main square, the center for social contacts. The streets of the settlement must have double lanes for vehicle traffic, sidewalks for pedestrians and sewers for drainage of rainwater. The internal road for transit of cattle and agricultural machinery must be capable of resisting traffic and erosion from rainwater. Access roads to cultivation blocks are built whenever necessary and with materials which economically justify their construction and maintenance.

Water supply problems are solved individually or collectively, the decision depending on economic studies. Individual supplies are obtained in each grange using rainwater which is collected on the roofs of the houses and corrals to be stored and later conditioned for human and animal use. A collective solution requires a water network derived from the springs available in the area and rainwater is used to clean the stables.

Sewage disposal is solved at the grange. For purposes of making maximum use of fertilizers, sewage and animal manure from the stables are stored at the manure pit. Sewage from housing is drained into septic tanks. Sewage at the service center requires studies on the basis of the activities performed in every

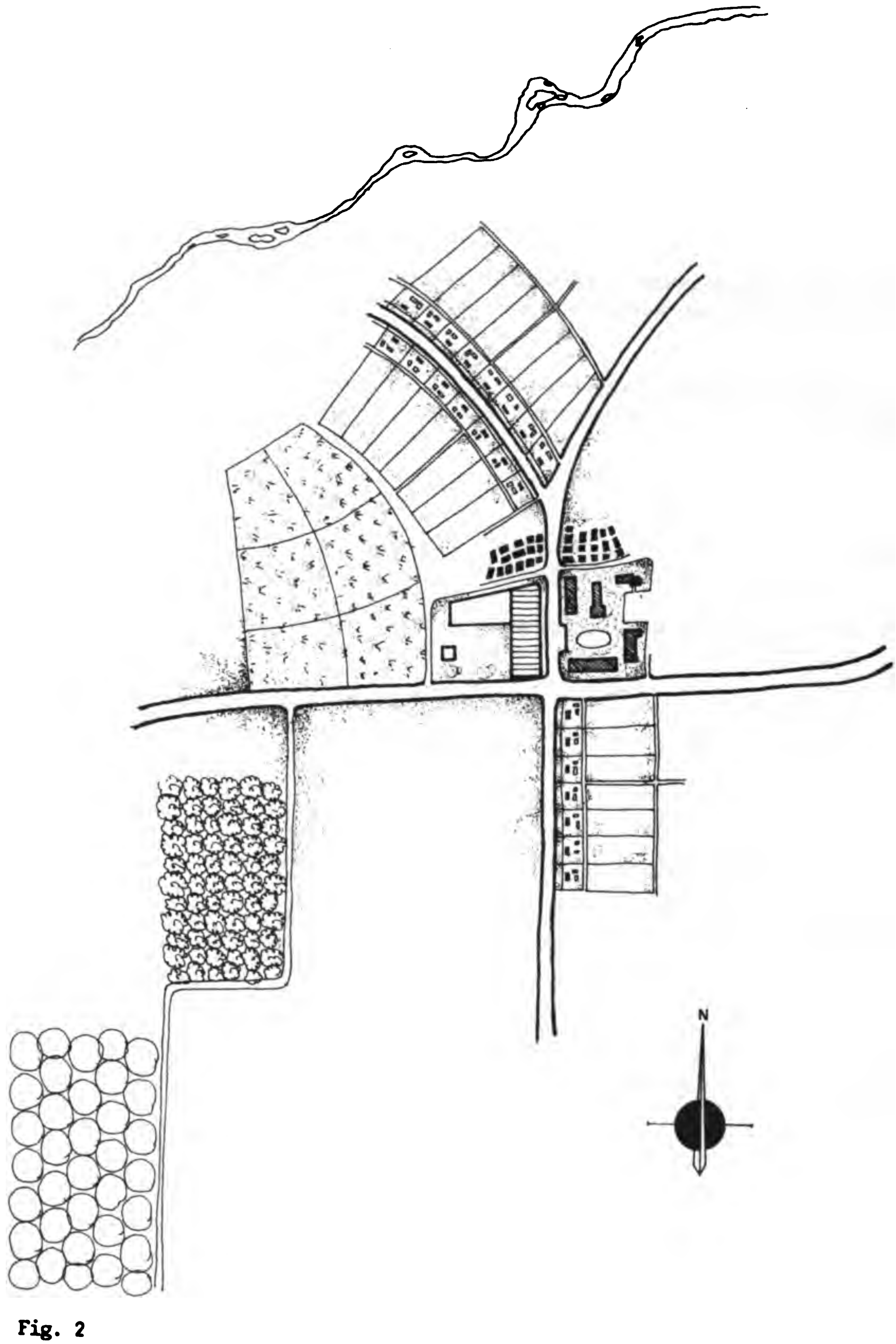


Fig. 2

building.

Electrification is solved for the settlement as a whole, taking into account the needs of the granges, public lighting, buildings for residential and operational services, industries, etc.

Torrential rains make it necessary to install a large drainage network for purposes of avoiding landslides, erosion and loss of crops, cattle, buildings, etc.

5. CONCLUSIONS.

Colonization of the high Jungle must be carried out using all the available resources in accordance with the priorities established and for purposes of maximizing the effects of investments which come from the relatively scarce national resources.

To face a technically unknown environment it is necessary to carry out continuous research so as to make immediate use of technological progress. Studies must be initially financed by the State and be implemented by some agency having the necessary resources to perform this task.

Each settlement must be the basis for a town, whose population must rapidly increase.

Thus it shall be necessary to offer new generations a higher degree of education so that they shall not tend to migrate but rather develop a marked regionalism and nationalism necessary for development.

New job opportunities offered by local investment in non-agricultural enterprises which, operated as cooperatives, offer new benefits to the rural community.

Summarizing, integration of the country and defense of its frontiers shall become a fact if social and economic problems are faced with a view to eliminating the unfair differences between the country and the city or between the peasant and the city dweller.

6. SUMMARY.

The paper proposes colonization of Peru's high Jungle through concentrated settlements (Fig. 2)

Each settlement is developed by stages. A first stage in which the settler receives his subsistance grange adapts to the environment and is trained. Subsequently, the peasant uses the plots in each cultivation block for marketing, industrialization, and constant improvement.

The service center of each settlement offers the peasant all of those services which are economically justified for a population of two hundred families. All other services necessary for the population of the whole region are distributed among all centers, so as to achieve an integral development of the whole area on the basis of interdependence of the settlements.

Technical Paper.

8. HIGH RANGE ELASTIC DEFORMATION METER by Julio Cavero, Agricultural Engineering Programme, Agrarian University, La Molina, Lima, Peru.

INTRODUCTION.

The high range elastic deformation gauge was developed at the Applied Mechanics Laboratory of Stanford University.

The idea of creating this elastic deformation meter was to accelerate the reading process while, at the same time, achieve a greater degree of accuracy in measuring elastic structure models such as models for dams, vaults, and other types of complex structural systems.

The meter was originally built for purposes of using it on the surface of the models to be studied but, subsequently it was found that it would also be employed within the body of the model permitting the experimental determination of the internal stresses of the structure. The results reported in this paper are limited to the use of the meter on the surface of elastic models.

DESCRIPTION.

The elastic deformation meter consists in a plate made from some transparent and elastic resin (the resin used in this case was URETHANE RU-2013 with the H-3762 catalyzer). This 1/2" x 1/2" x 1/16" plate has a 3 1/2 inch cavity inside; this multicurved cavity (as shown in figure No. 1) is filled with mercury while the two ends are sealed with Kovar wires one inch long and 10 thousandths of an inch in diameter. This wires which, in addition to preventing mercury leaks, serve as electric connections, are gold plated at their ends for purposes of facilitating contact with the mercury column, which is used as a resistance.

OPERATION.

Operation of the meter is based on the physical principle that any change in the length of the mercury column (due to compression or tension) determine changes in its resistance and, therefore, these changes are a measure of deformation.

Using the formula for electric resistance we have:

$$\Delta R: K \frac{\Delta L}{\Delta A}$$

Where we can see that the change in resistance is directly proportional to the change in length and inversely proportional to the change in the cross section area of the resistance element. In this particular case the diameter of the tube containing the mercury is 5 thousandths of an inch in which (through the micrometric microscope), it was seen that there were no appreciable changes even when the meter was working at maximum range. On the basis of the previous statement the cross section area of the mercury column can be considered as constant, not affecting the readings, that is:

$$\Delta R: K' \Delta L$$

Where the change in resistance of the mercury column is a function only of its change in length.

The problem arising in taking the readings is that the change in resistance of the mercury column is due not only to a change in length but also to temperature changes due to the flow of an electric current through the mercury. To avoid this, it was necessary to use electric metering instruments (electric bridges) of high sensitivity and working on low amperage. In the case of the meter, which has a 5 ohm electric resistance, it was experimentally determined that it was capable of eliminating 35 hundred thousandths of a joule a minute through its surface, working at room temperature (approximately 25 °C).

Power would be:

$$P = \frac{E}{T}$$

$$P = \frac{0.00035 \text{ joules}}{60 \text{ seconds}}$$

$$P = 0.000005 \text{ watts}$$

Furthermore, power eliminated by the resistance might be determined by the following formula:

$$P = I^2 R$$

where electric intensity would be:

$$I = \sqrt{\frac{P}{R}}$$

$$I = \sqrt{\frac{0.000005 \text{ watts}}{5 \text{ ohms}}}$$

$$I = 0.001 \text{ Amperes}$$

The formulas above indicate that the maximum amperage which might be used through the mercury column, to avoid changes in its electric resistance due to temperature, would be one thousandths of an ampere since heat generated by this amount of electric current would be completely eliminated through the surface of the deformation meter; electric resistance of the mercury shall remain constant and any changes in it shall be due exclusively to changes in the length of the mercury column.

CONSTRUCTION METHODS.

For a better understanding, construction of the elastic deformation meter can be broken down into the following steps:

1) Preparation of the mold. In this initial stage consideration must be given to the core of the mold (with which the internal cavity of the meter, holding the mercury is built) and the preparation of the mold itself (which gives the meter its shape). As the core of the mold a copper wire five thousandths of an inch in diameter is used; it is then bent giving it a multicurved shape with a total of 6 curved elements per meter. The purpose of the multicurves is to have a greater length of the cavity within a smaller area. Metal plate (A) is used in its construction. The wire "weave" is prepared on it by means of pegs which are placed in the holes of the plate. These holes are the ones which determine the spacing between curved elements and their size. (See figure No.2)

Once the wire has its coiled shape it is taped to metal plate (B) which serves as a base as well as a bearing to be placed in the mold itself,

Metal plate (B) also has small rectangular platens which are of one piece with it. These platens are found between the third and fourth curve element (as shown in figure 3) and have as its purpose to create a communication cavity with the coiled thread. Furthermore, for purposes of facilitating the release of the wire from the cured resine the wire is half-cut at the second and fifth curved elements (see figure four). Finally, both the wire and the mold are dipped in a degreasing liquid for about five minutes and are then covered by a thin layer of a mold separation oil, thus avoiding sticking of the mold and core to the cured resin.

2) Molding: Molding of the resin involves two stages. In the first stage the body of the elastic meter itself is built; to this end a mixture of resin and catalyzer giving a shore A grade 35 rigidity, is used. The casting process can be seen in figure 5. In the second stage, the communication cavity is sealed while the ends of the meter are simultaneously built. It is important to point out that the resin and catalyzer mix for this second casting would give a shore A grade 70 rigidity. The idea of having the ends with a greater rigidity than the body is to prevent the Kovar wires (which serve as electric conductors and plugs) from slipping out when the deformation meter is stretched. This slipping of the wire would interrupt the electric contact between the end of the Kovar wire and the mercury.

3) Removal of the core. This final step removes the copper wire (the core of the mold) from the set resin. Once the resin has been sufficiently cured the meter is alternatively warped in opposite directions until the copper wire, which was previously half-cut at the second and fifth curved elements, is completely cut. Then the deformation meter is frozen to 0°C. until it looses all its elasticity, when the wire can then be easily removed. The temporary hardening of the resin through freezing has the purpose of preventing the copper wire from cutting the resin at the curves.

The meter can be considered ready when its multicurved cavity is full of mercury and their ends are plugged by means of the Kovar wires.

EXPERIMENTAL RESULTS.

For purposes of calibrating and testing the operation of the deformation meter, two of these meters were cimented to the 1/2" x 1/2" x 5 1/4" test piece shown in figure No. 6. This test piece was built of the same resin as the meters which was also used as glue.

Scratched markings were made on the surface of the test piece (see figure No. 7), the changes in distance between them were determined by a micrometric microscope (this change is produced by the succesive increase of deformation loads on the test piece).

For purposes of calibrating the elastic deformation meter it was submitted to variable loads (table No. 2 and 3) simultaneously measuring both the change in electric resistance of the mercury column as well as the change in the distance between the stratched markings in the surface of the test piece.

Tables No. 1, 2 and 3 list the readings in the system and which were taken as follows:

First reading: Was taken in the same way as the previous one; the specimen was intermitently submitted to an electric charge, charging and discharging the system (with its maximum charge range) with a frequency of 10 cycles per second. This reading was taken approximately at the 600th cycle.

The third and fourth readings were taken in the same way as the second one, with the difference that for the third reading static charges were applied after the 3,000th dynamic charge cycle; and the fourth after the 9,000th charge cycle. The results shown in tables No. 2 and 3 indicate the invariability of measurements taken with the deformation meter.

Three sources of error were taken into account:

1) Error due to lateral deformation in the curved portion of the cavity when the element is subjected to tension or compression. In this case, (considering the Poisson radius 1/2) the error is under 1.2%.
2) Error due to the effects of cementing. Since the meter is placed on the surface of the structure, it suffers a lesser deformation than the latter, whether the system is under tension or compression. This was solved by filling the ends of the meter (with the same resin) in such a way that at the connection points the change in surface levels not be as abrupt and thus obtain a uniform distribution of efforts.
3) Error in measuring resistance because of the equipment. In this case the error would only be 1.5% when high sensitivity digital electric bridges are used.

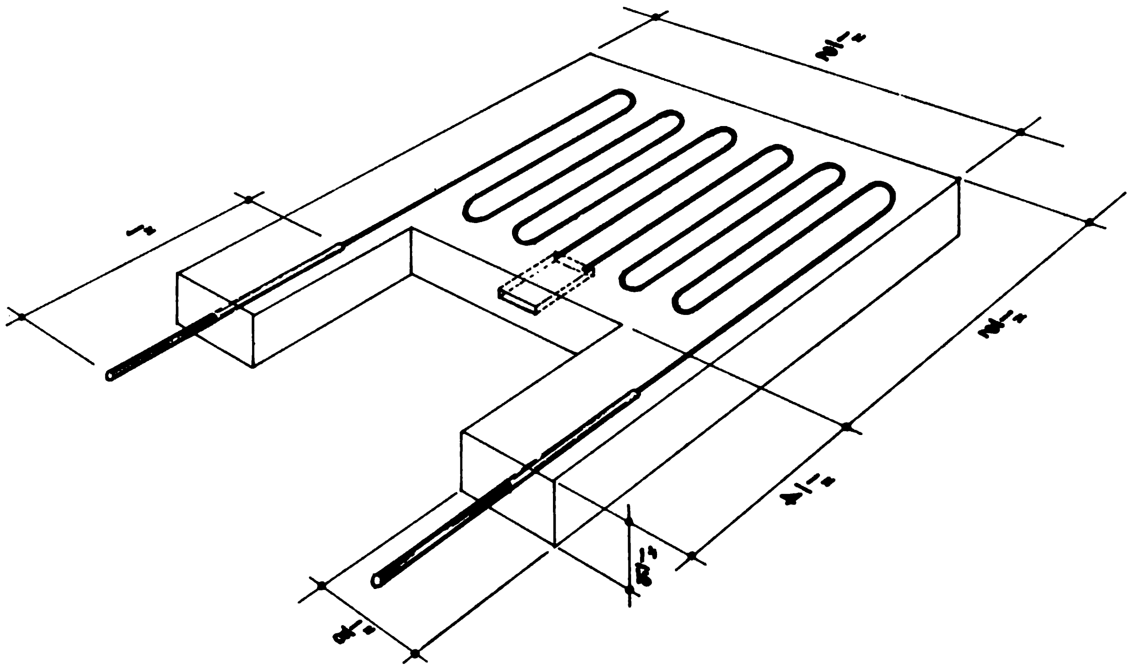


Figure N° 1

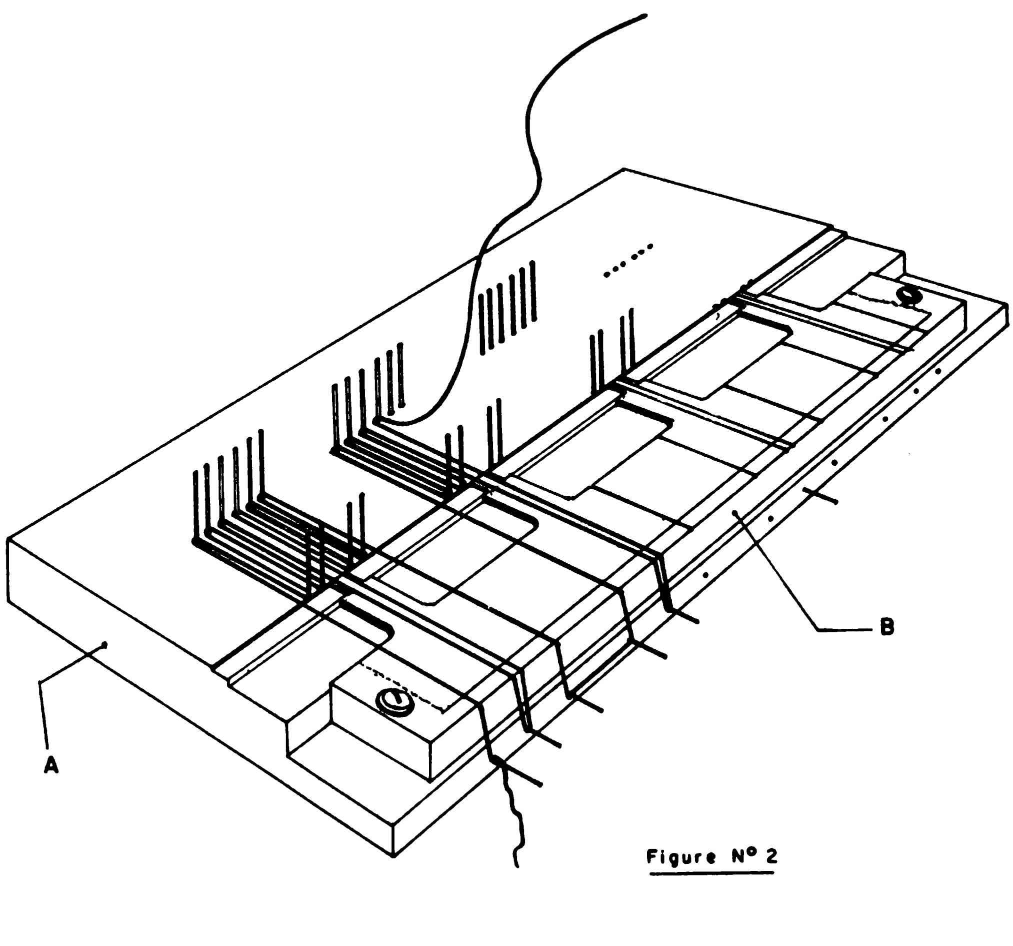


Figure N° 2

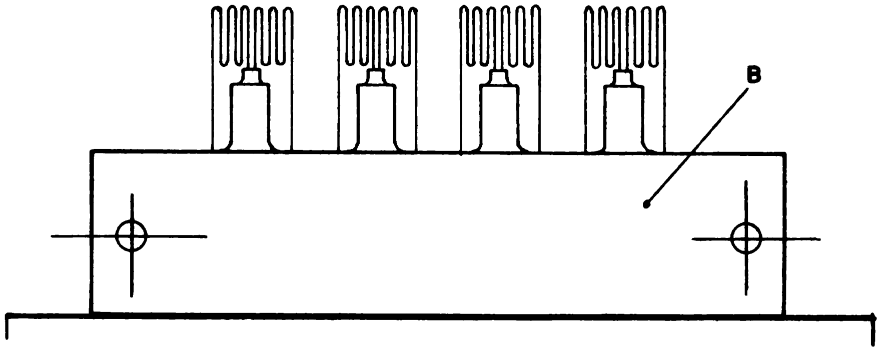


Figure N° 3

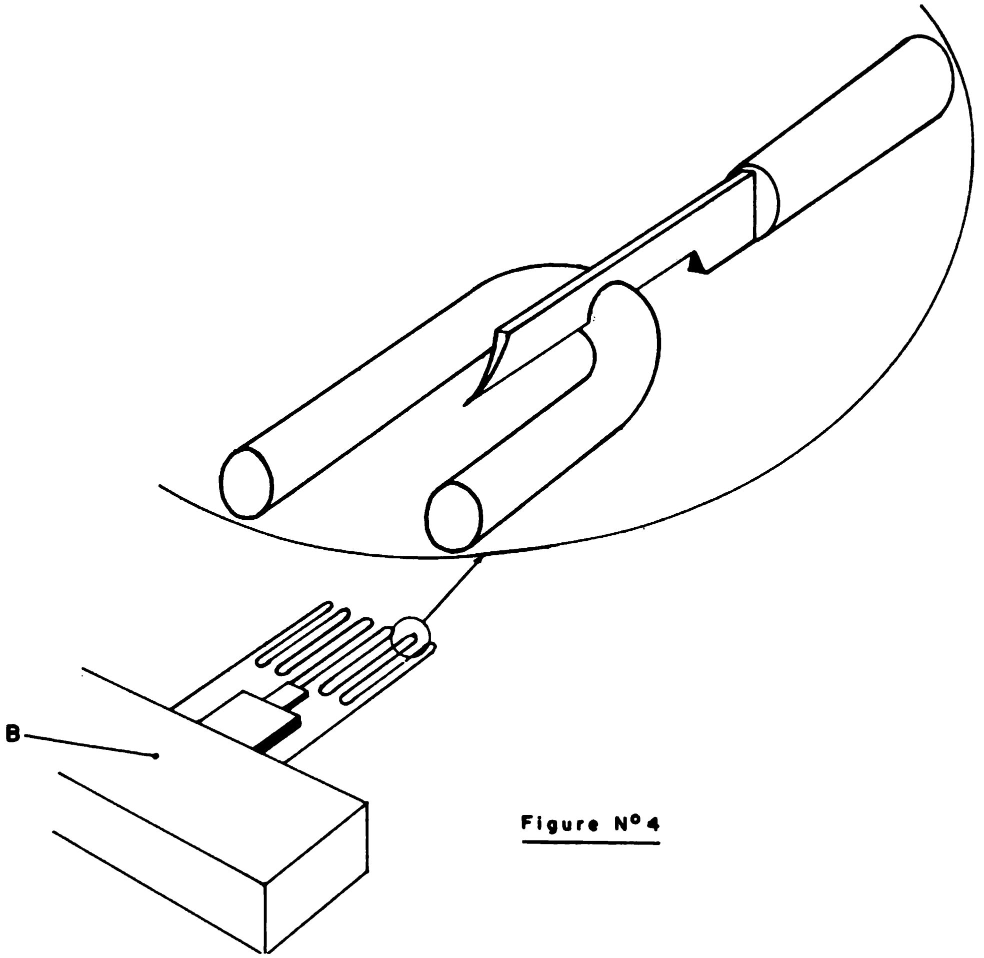


Figure N°4

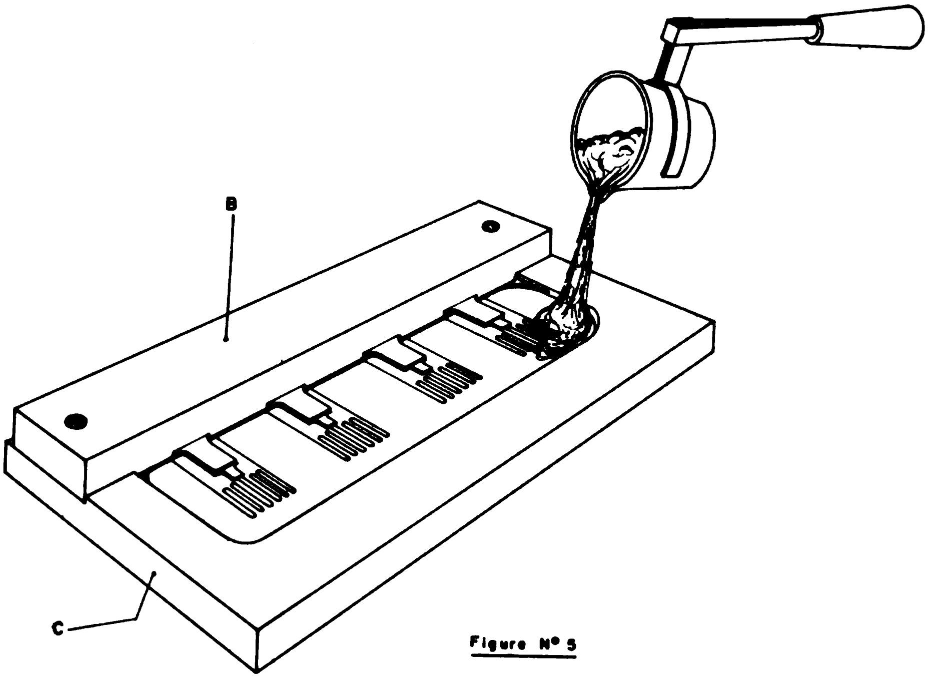


Figure N° 5

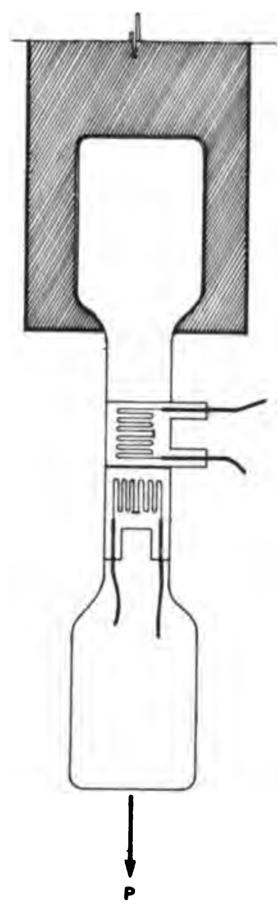
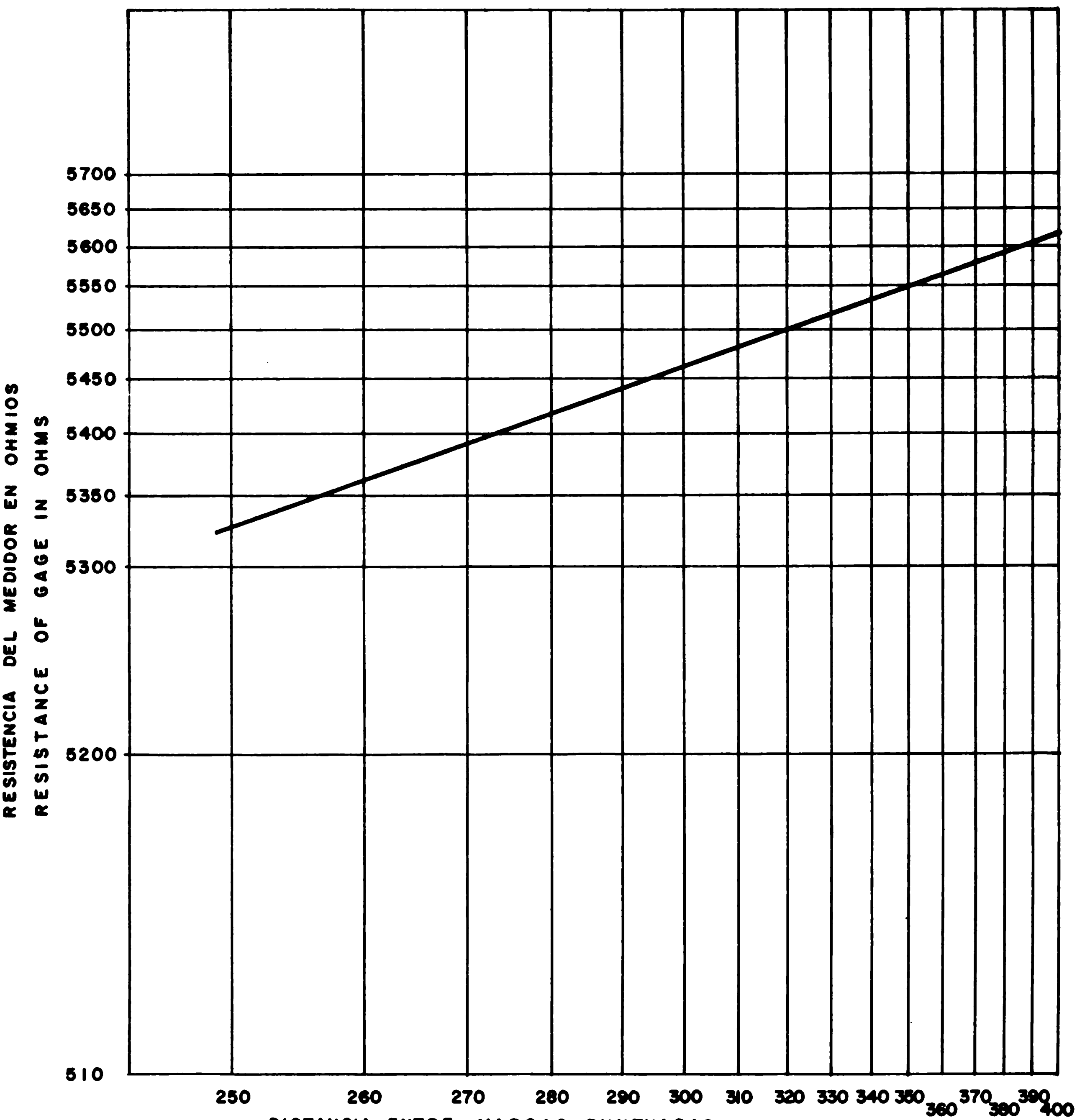


Figure N° 6

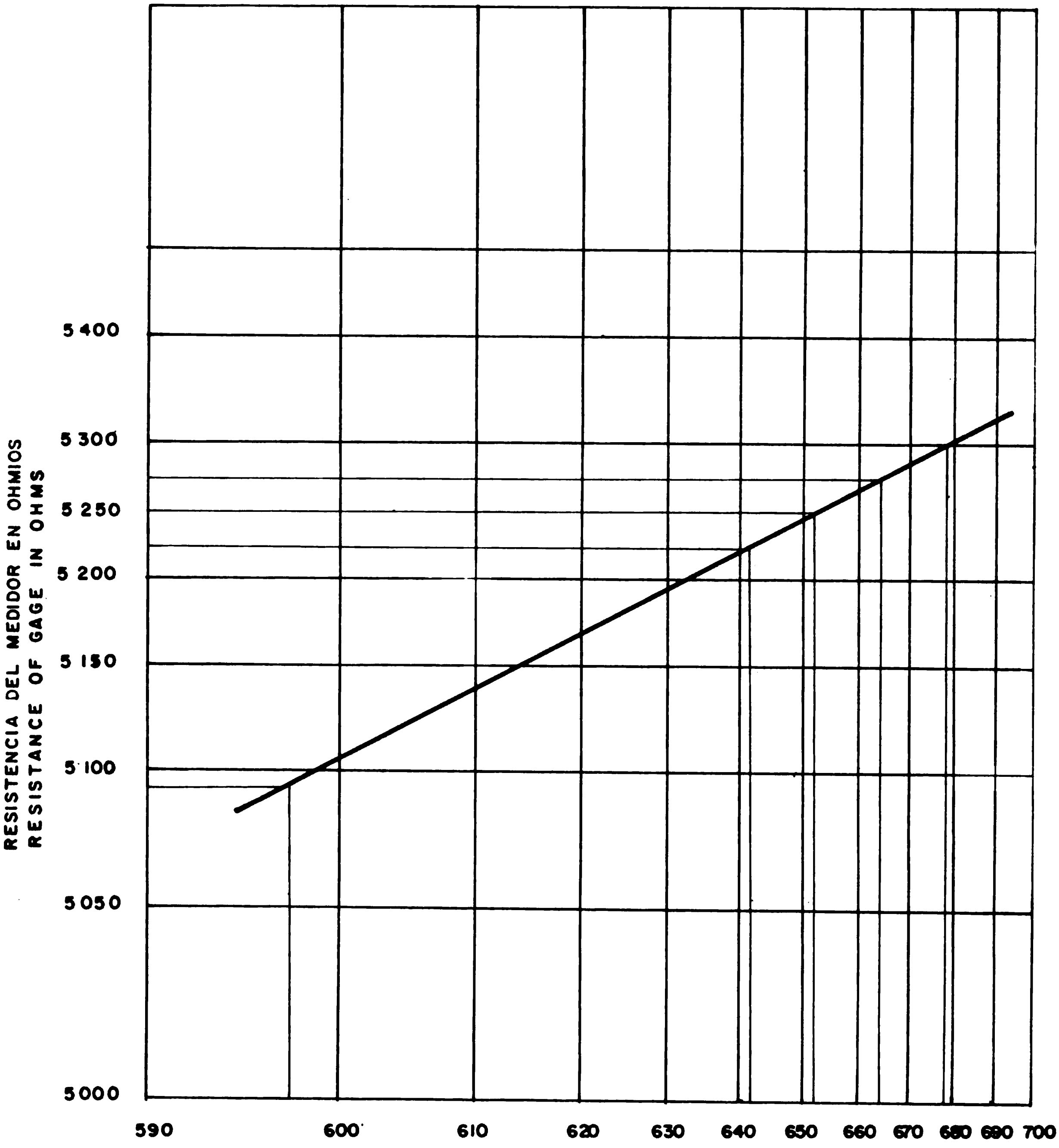
VERTICAL STRAIN GAGE

MEDIDOR DE DEFORMACION VERTICAL



GRAFIC N° 1

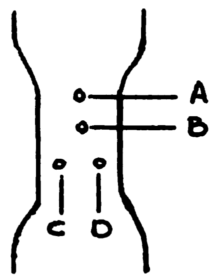
HORIZONTAL STRAIN GAGE
MEDIDOR DE DEFORMACION HORIZONTAL



DISTANCIA ENTRE MARCAS PUNTUADAS
DISTANCE BETWEEN BENCHMARKS IN INCHES.

GRAFIC Nº 2

TABLE FOR THE VERTICAL AND HORIZONTAL DISTANCES



SPECIMEN of 1/2" x 1/2" of crosssectional areas

Figure No. 7

VERTICAL				HORIZONTAL			
Load lbs	A	B	B-A	Load lbs	C	D	C-D
0	1.8530	2.0775	0.2245	0	0.6975	0.4280	0.2695
1	1.8487	2.0755	0.2268	1	0.6993	0.4315	0.2678
2	1.8407	2.0687	0.2280	2	0.6984	0.4320	0.2664
3	1.8343	2.0640	0.2297	3	0.6995	0.4333	0.2652
4	1.8275	2.0585	0.2310	4	0.6982	0.4340	0.2642
5	1.8195	2.0525	0.2330	5	0.6990	0.4360	0.2630
6	1.8115	2.0465	0.2350	6	0.6993	0.4374	0.2619
7	1.8035	2.0410	0.2375	7	0.6993	0.4385	0.2608
8	1.7950	2.0350	0.2400	8	0.6995	0.4398	0.2597

Table No. 1

ELASTIC GAUGE OF VERTICAL DEFORMATION

	1st Reading	2nd Reading (600 cycles)	3rd Reading (3000 cycles)	4th Reading (9000 cycles)
Load - Pounds	Resistence (ohms)	Resistence (ohms)	Resistence (ohms)	Resistence (ohms)
0	5. 327	5. 328	5. 330	5. 330
1	5. 384	5. 387	5. 386	5. 386
2	5. 420	5. 422	5. 422	5. 422
3	5. 450	5. 450	5. 454	5. 454
4	5. 483	5. 480	5. 481	5. 481
5	5. 515	5. 513	5. 514	5. 514
6	5. 548	5. 545	5. 544	5. 544
7	5. 580	5. 579	5. 579	5. 579
8	5. 614	5. 612	5. 612	5. 612
0	5. 328	5. 330	5. 330	5. 330

Table No. 2

ELASTIC GAUGE FOR HORIZONTAL DEFORMATION

	1st Reading	2nd Reading (600 cycles)	3rd Reading (3000 cycles)	4th Reading (9000 cycles)
Load Pounds	Resistence (ohms)	Resistence (ohms)	Resistence (ohms)	Resistence (ohms)
0	5. 330	5. 330	5. 330	5. 330
1	5. 296	5. 297	5. 296	5. 296
2	5. 269	5. 271	5. 271	5. 271
3	5. 242	5, 247	5. 247	5. 247
4	5. 215	5. 221	5. 222	5, 222
5	5. 188	5. 195	5. 195	5. 195
6	5. 162	5. 167	5. 166	5. 166
7	5. 126	5. 134	5. 137	5. 136
8	5. 087	5. 093	5. 099	5. 098
0	5. 330	5. 330	5. 330	5. 330

Table No. 3

CONCLUSIONS.

This elastic deformation meter provides great accuracy within the limits required by other deformation measuring systems. Furthermore, once calibrated, this is an instrument which is safe to use for it doesn't change with time or with the number of times it is employed (this stability becomes apparent in tables No.2 and 3).

This meter would not only be of great use in the rubber industry but would also be of great help in experimental work on elastic models since the deformation of the latter can be accurately and rapidly determined by using it.

In the future, and as a second stage, it would be used to measure the internal deformation of structures, which would solve many problems in the field of determining the internal stresses in solids.

APC/ugd.