Volume II
1973-74 Seminar Series

SEMINAR SERIES

ON

TECHNOLOGY AND DEVELOPMENT

SCHOOL OF ENGINEERING
HOWARD UNIVERSITY
WASHINGTON, D.C. 20001

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May 30, 1974

PREFACE

This document contains the speeches and biographical sketches of the participants of the second series of a two-part seminar series conducted by the School of Engineering of Howard University during the 1973-74 school year.

These seminars were made possible by a grant from the U.S. Agency for International Development. The report of the first series of seminars given under this grant is contained in a separate volume.

The seminar program was under the direction of Dr. Percy A. Pierre, Dean of the School of Engineering, and a former member of the National Academy of Engineering's Panel on the Role of United States' Engineering Schools in Technical Assistance Overseas; and Dr. M. Lucius Walker, Jr., Associate Dean of Engineering. This report was prepared by Mrs. Leatha S. Henson who was also the coordinator of the seminar program.

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INTRODUCTION

During the 1973-74 academic year, the School of Engineering conducted the second half of a two-part series of "Seminars on Technology and Development in Developing Countries." These seminars were made possible by a grant from the United States Agency for International Development.

The purpose of the seminar series was to examine the process of development, the role of technical assistance, and the application of technology to the needs of developing countries, and thereby generate greater interest in the problems of development on the part of the students and faculty of the School of Engineering. An attempt was made not only to examine the beneficial aspects of technology, but also to assess some of the possible detrimental effects of technology on developing nations in the light of the experience of technologically advanced countries. It should be noted that most of the speakers also addressed themselves to political, social, cultural and economic factors which provided an essential background for understanding how various technologies and approaches might be applied most effectively in the context of these societies.

Howard University is unique in that it has the largest Washington area enrollment of foreign students from the developing nations of Africa, the Caribbean, and the Middle East. A significant proportion of these students are enrolled in the School of Engineering. Thus, this series gave both the American and international students, whose engineering and technological knowledge will be applied to meeting societal needs, the opportunity to examine some of the myths and realities of development as viewed through the eyes of experts and scholars. The presentations also delineated some of the areas where engineers could make important contributions to development.

Since the series was also open to the Howard community and the Washington technical assistance community, it offered an excellent opportunity for individuals with similar interests to meet and exchange ideas, and through this cross-fertilization, thereby add to their understanding of the interrelationship between the goals of development and the application of technology to the realization of those goals.

IMPLICATIONS OF SOLAR ENERGY

Peter E. Glaser
Vice President
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December 5, 1973

IMPLICATIONS OF SOLAR ENERGY

Peter E. Glaser

Solar energy has been denigrated as exotic, as impractical, as very costly, and at best, finding applications some time in the distant future. We should not be prepared to accept this point of view. I believe not only that solar energy will become our ultimate energy source, but that it will be an important source of energy in the near future.

Energy is the most important ingredient in our economy, and in our day-to-day lives as we are discovering during this energy crisis. Looking at the events which led up to the present energy predicament, we note two things: first, we cannot divorce energy from the environment; and second, both have to be considered together as we try to meet our energy needs. We need to recognize that we are really dealing with one large energy system--the Earth-- and in that sense all countries are interdependent, whatever their level of industrial development.

People have recognized the importance of the sun from time immemorial. The Egyptians, the pre-Colombian cultures, they all recognized how closely their lives were tied to the sun, and thus it is not surprising that they worshipped it. Although we do not now worship the sun, we cannot help but be aware of its importance. But, do we really understand the magnitude of the sun and the tremendous source of energy that it provides us? Do we realize that even by the time sunlight is filtered through the Earth's atmosphere, we still receive about one kilowatt per square meter, or roughly one horsepower per square yard?

As an energy source, the sun is all pervasive, it is available to all nations. The difficulty lies in collecting this energy in a way that permits it to be converted efficiently and economically for our use.

We have always used solar energy, whether to dry fertilizer in Chile, salt in Utah, or fish on countless sea coasts. We use solar energy to preserve the fruits of our harvests and to maintain the quality of food available to us. And we are beginning to use

it for applications where solar energy is being converted to heat or to electricity.

The United States has had, and continues to have, an interest in helping developing countries. The solar cooker is one example of that interest. Although we used to say: "We don't need solar energy. After all, don't we have oil and gas and coal?" We have tried to develop solar cookers not primarily for our frivolous uses, but for India and for other countries. Yet, I suspect that people who want to do good for others are--perhaps unwittingly--doing good for themselves. For example, in trying to develop solar cookers for others, we found that we had not done our homework well enough. How? Well, in most of these countries the people work in the fields during the day and have communal meals at night--and we found out that it is difficult to change cultural patterns. Today solar energy is being used to some degree throughout the world. Let us look at some typical examples.

One quantity that is absolutely essential to life is water. Solar stills installed on islands have been taking ocean water or brackish water and producing fresh water--thus allowing the people on that island to be independent of rainfall. Such solar stills have been built in many small communities around the world. A solar still is effective when used by any community which requires about 10,000 gallons of water per day or less. Large solar stills have been built in Spain and Australia, for example. Solar stills are simple to construct and to operate. Water is allowed to enter a basin covered by sloping glass panes. The sun heats the water. The water evaporates. The evaporated water condenses and forms droplets on the glass covering the still. The droplets drip down into a collecting trough, and the fresh water is collected.

Solar energy is also used to heat water. Solar water heaters have been installed in villages of New Guinea, India and Japan. One such solar water heater, made from plastic and costing about $10 has been widely used in the villages of Japan. It provides from 20 to 100 gallons of hot water for use at night. Millions of various types of solar water heaters have been produced, not only in Japan, but also in Australia, Russia, Israel, etc. Some models have controls and auxiliary heaters, for use during prolonged cloudy spells. Some of these cost as much as $200, but still would be within the purchasing power of a middle-income family in some of the developing countries.

The next step is to use solar energy to provide heat to a building. This can be done when a solar collector is used to convert the sun's rays into heat. Such a collector consists of a blackened metal plate

protected by one or two glass panes. Air, water, or other fluid passes over the heated metal plate, picks up the heat and is then stored in a storage tank from which it can be withdrawn to heat the building. A solar collector on the roof of a building also enables the user to store hot water for a period of several days of inclement weather. Auxiliary heat from oil, gas or electricity can be used to provide heat during an extended cloudy spell.

The heat produced by solar energy can also be used to cool. Although this may seem a paradox, one need only remember the old gas refrigerators which were used some years back, without electricity, to produce cooling via absorption refrigeration. This technique--very important because it requires no other power source--makes it possible to use the sun to refrigerate food in extremely hot countries where electricity may not be available.

Solar systems can also be used to heat a building in winter, cool it in summer, and provide hot water year round--today. The only reason such systems are not now in general use is that they have not yet been engineered for mass production. But I believe that in three to five years many of our new buildings will have such systems. And for us, as a country with limited energy resources, it will be just as important to conserve energy as with the hot water heater on the roof of a New Guinea hut.

One simple way to use the sun is to construct a special roof which can hold a pool of water. This water can then be pumped throughout the building. Depending on the need--in accordance with the climate, or the season--one could have the sun heat the water or one could cover the water pool during the day and allow it to cool during the night. The latter technique would also allow countries without electricity to have comfortable homes even on the hottest days.

Solar energy has been used to concentrate the sun's rays with a so-called solar furnace. Such furnaces are known to date back to the 16th century. In 1955, I constructed a solar furnace in Cambridge, Massachusetts, to conduct high-temperature research on materials. More recently, the French have built a huge solar furnace in the Pyrenees with an equivalent power output of about 1000 kilowatts that can heat one ton of material to 6000F. It uses a segmented paraboloidal mirror. Flat mirror heliostats follow the sun during the day to direct its rays into the focusing mirror. This furnace can burn a two-foot-diameter hole in a half-inch-thick steel plate in 20 seconds--an awesome demonstration of the power of the sun.

Another manifestation of solar energy--wind power--has been used for centuries. In fact, we are now looking at various methods for wind to supply power on a gigantic scale. There are already various proposals for huge windmill systems in the plains' states and some have suggested that they be installed off the coast of New England. Regions where monsoon winds blow are obvious locales for such systems. Electric power from offshore wind mills could be transmitted through cables or used to produce, through electrolysis, hydrogen which could then be used as a fuel.

One use of solar energy whose potential is very substantial--but which has only been demonstrated in principle--would be the use of the sun-warmed ocean waters. In 1900, it was suggested that ships anchored in such ocean waters, for example, the Gulf Stream, could skim the warm surface water to boil off a fluid, such as ammonia or propane, to power turbines. The cold water from the depths of the ocean could be circulated to recondense the working fluid.

A central attraction of the Paris exposition of 1878 was a solar-powered steam engine that was used to drive a printing press which printed a newspaper called The Sun. In 1901, a similar machine in California was used to produce 50 horsepower. In 1913, a large solar power plant was built in Egypt to pump Nile water to irrigate agricultural land.

In more recent times, other devices were developed. For example, an air-inflated plastic solar collector was exhibited at the United Nations Conference in Rome in 1961. It produced steam which could then be used to power small turbines to produce power for irrigation pumps. The goal was that it would be cost competitive with diesel engine power. In many regions, for example, in sparsely populated regions of Africa, it is very difficult to keep a diesel engine running for extended periods, because of maintenance problems and lack of fuel supplies.

Another demonstrated use of solar energy is the so-called solar pond--i.e., a shallow pond whose sun-heated water can be used to produce steam. At the bottom of the pond is a blackened surface. Salt is added to the water to prevent convection currents, and then the hottest portion of the pond water is withdrawn to provide the power for steam turbines. Such ponds have been built in Israel and have been shown to be workable.

Finally, engines have been designed which are directly heated by solar energy concentrated on the piston. Through a thermodynamic process, such an engine can provide power for irrigation pumps.

In this country, we have recently rediscovered the potential benefits of solar energy. Now we are considering solar farms in the Arizona desert, consisting of the kind of mirrors reminiscent of the type used in Egypt in 1913, to produce huge quantities of steam to power turbines to produce electricity. Using this technique to produce 1000 megawatts (the equivalent of one nuclear power plant), one would require about 40 square miles of solar farm--not really very much land in a state the size of Arizona. A power plant powered by such a technique in areas such as those which border on the Sahara region, where there is copious sunlight, could spawn and support many local industries. This kind of power plant could be demonstrated in about ten years.

All of these devices require some moving parts and someone in attendance. But 20 years ago, a completely passive way to directly convert solar energy into electricity was developed--i.e., the silicon solar cell based on photovoltaic energy conversion. Since then, of course, we have learned a lot about such solar cells. Now they are about 16 percent efficient. In addition to silicon, other materials can be used. Thus, solar cells made of materials which can convert solar energy more efficiently represent a longer-term possibility to utilize solar energy on a very large scale.

In this country, we have primarily used the solar cells in our space program. All of our unmanned spacecraft, including Pioneer which transmitted information about Jupiter, use these solar cells to produce power. Skylab was powered entirely with solar energy. We also are producing solar cells for use on Earth to charge batteries when the sun shines. They can be used for solar flashing buoys to make the sea lanes safe, thus eliminating one of the major problems for many countries which have an active sea trade--i.e., the tending of sea buoys to replace batteries. Such flashing buoys using solar cells are already installed off the Japanese coast. Others have been used on unmanned drilling platforms off the Gulf Coast to operate signaling devices. Such devices can now remain unattended for as long as fifteen years.

One other very important way solar cells can be used, as demonstrated in Japan, is to power communications systems in very inaccessible areas, thus circumventing the necessity to lay cables and

wires. Such systems using solar cells to provide the power can be of great benefit to many of the developing countries which require a new network of communications systems.

Since solar cells will always be more expensive than mirrors, mirrors can be used to capture and concentrate the required solar energy. Such concentrating mirrors combined with solar cells placed in sunlit areas of a desert, for example, would enable us to convert solar energy to electricity. Even if these solar cells are just ten percent efficient, one square mile covered with such devices would provide us with 180,000 kilowatts--when the sun shines. Of course, since the sun does not shine all the time even in the desert, some form of energy storage would be needed; e.g., batteries, water pumped to a reservoir or electrolysis of water to produce hydrogen.

To circumvent the disadvantages of generating power on Earth, I suggested in 1968 that we consider one location where we have sunshine 24 hours a day whether the sun is shining on Earth or not. That location is an orbit 22,300 miles from the Earth. In this orbit, a satellite solar power station would be stationary with respect to any desired spot on Earth. Such a station would use solar cells to capture and convert solar energy into electricity. The electricity would then be fed to microwave generators in a transmitting antenna, and the antenna would direct a beam toward a receiving antenna that could be placed at any desired location on Earth. On Earth, the microwave energy would be converted directly into electricity.

Although all this can be done with the technology known to us today, it would take 25 years to develop a commercial satellite solar power station. This would make available electricity to those countries which have few natural resources, for example, Japan or India, or some parts of Africa. The receiving antenna for the amount of power such countries would require to maintain the growth of their industry is a very simple installation. Furthermore, thermal pollution on Earth will be a fraction compared to the pollution from power plants based on thermodynamic processes.

This very brief survey of some of the applications for developing countries indicates that solar energy provides us with many options, many of them still left unexplored. Development of even a few of these options would go a long way towards solving most of our future energy needs. Working with the energy sources available locally to specific countries, they would not need to rely on importing today's major energy source--oil.

Stonehenge, the remains of a prehistoric civilization in Britain, is a marvelous monument which indicates the keenest understanding of the sun and of its particular astronomical characteristics. Perhaps it also indicates that at least one prehistoric civilization was extremely sophisticated in understanding its dependence on the sun--something that we still have to learn.

AN OVERVIEW OF WORLD ENERGY PROBLEMS

G. V. Subba Rao
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December 5, 1973

AN OVERVIEW OF WORLD ENERGY PROBLEMS

G. V. Subba Rao

Thank you, Dean Pierre. It is my intention to give you a brief picture of the emerging world energy problem. It is also my intention to give you a context in which you can examine the problems faced by many countries.

I think it is evident to all of you how important the use of energy is. It is an integral part of the growth process of any economy, whether it is a highly industrialized country or a struggling developing country. The continuing increase in world population and the progressive rise in the world per capita income have resulted in a rapid growth of energy demand exerting an inexorable pressure, particularly on the conventional premier fuels, namely, oil and natural gas.

The burning issue at the present time is how to meet the burgeoning world energy requirements during the decades ahead. At the United Nations we have several offices looking at the problem of trying to project world energy requirements and I have left with Dean Pierre's office a bibliography of some of the materials that relate to this particular issue.

Questions are repeatedly raised by concerned publicists as to the long-term adequacy of energy resources to sustain the increasing growth rate of energy consumption. According to statistics, the world energy consumption rate has been doubling every 14 to 15 years and, at this rate of five percent per annum, it is easy to calculate that the cumulative energy requirements by the year 2000 will exceed by four times the presently proven reserves of petroleum, and roughly by seven times the present proven natural gas resources. However, the potential world hydrocarbon resources, on land, offshore and deep sea are still a very big multiple of the presently estimated proven reserves and call for further exploration and development. Furthermore, the results of several studies in the United Nations and outside sources (and perhaps this exemplifies a certain viewpoint which may not be fully shared by everyone) indicates that the world is not going to suffer from shortages of other energy resources such as lignite or coal, oil shale, and tar sands. There are additional potential energy resources in the form of hydropower--unutilized vast potential sources which are awaiting further utilization--tidal power, geothermal, solar, as well as nuclear power.

.Now, having said this, one must reflect on the fact that while on a global level, the energy resources look formidable despite the protestations of the "limits to growth" thesis, etc., you could still have the situation of particular shortages arising in particular fuels in particular locations for certain periods of time, and we have seen some of this recently, too. Now, I do not want to discuss this much further--I have a number of statistics to which I can draw your attention as I go along. I would like to call your attention to one particular problem.

It is that which relates to the growing disparity in the level of consumption between the developed countries--the rich, industrialized nations, on the one hand, and the poorer, developing countries, on the other hand. And here, I would come back to some of the other issues connected with the skewed distribution of world energy resources as they are estimated and presently known. This imbalance can be illustrated by giving you some statistics of the share of the developing countries in world energy consumption which was only nine percent in 1971, and that part of the world constituted about 48 percent of the world population. Here, I must tell you my definition, or rather the definition in terms of United Nations' statistics of developing countries. We classify countries into three groups, into three socio-economic systems: the developed market economy which means the industrial private enterprise economies: Western Europe, Japan, North America, Oceania, South Africa, and several others; the centrally planned economies, by that we mean Socialist countries, and the developing economies of the Third World. You will see that China is generally included in the centrally planned economies.

The developed market economies which constitute 12 percent of the world's population, with a per capita income on the average in 1971 of around $2,000, consumes 62 percent of the world's total energy consumption and their per capita consumption is something like six tons or 6,000 kilograms of coal equivalent. I just wanted to give you these broad order of magnitudes. Before I go further, I'd just like to mention that the developed countries have 19 percent of the world fossil fuel reserves according to certain definitions which will be available to you. If you were to calculate this on a per capita basis, they can sustain a consumption of only two tons--that is per capita consumption, whereas their requirements on a per capita basis is six tons. Now, the centrally planned economies which constitute one-third of the world's population, with an average per capita income of $500, consumes an average of roughly 30 percent of the world's energy consumption--the demand exerted by them. They possess, if you were to look at the fossil fuel reserves, 78 percent of the world's fossil fuel reserves. Now, here again, you have a measure which is quite interesting in that they are

quite comfortable with respect to their fossil fuel reserves. Now, coming back to the developing countries, as I mentioned to you, if you include China with more than two-thirds of the world's population, they consume only a fraction of the total energy produced although taken as a group they showed a surplus of primary energy production far in excess of their aggregate requirements. However, on an individual basis, substantial surpluses are limited essentially to fifteen countries who are the main exporters of petroleum and natural gas. On the other hand, there are about seventy-five developing countries, or more perhaps, with an energy deficit, and in some cases a very critical energy deficit. By critical, I mean those countries which depend on imported energy to the extent of more than 50 percent of their total consumption.

I come now to a second feature of this problem. I'm only describing the problem which may arise because of these imbalances of both consumption and production, and in the possession of the reserves at the present time, and perhaps in the future. The international petroleum industry, as you all know, clearly rivals all other industries on a global basis both in size and in its vast performance, and because of the opportunities in view of increasing growth of worldwide petroleum demand. Therefore, the petroleum exporting and importing countries continue to surpass the state to a much greater extent through their national companies in the exploitation of, and the development of their energy resources.

I would now like to discuss the structural aspect of this imbalance. This imbalance is partially illustrated by the fact that a high proportion of the world energy demand is satisfied by petroleum--approximately two-thirds of the demand--and therefore petroleum is a premium fuel (if you add natural gas to this, it's perhaps a little more). So, if I refer to the structural aspects of this, I think it is very integral to the question of the world's energy problems. It is here that you find again that the control and disposition of the resources of production, refining, transportation, and marketing and distribution. I don't have the exact statistics--but a very small number--I expect a dozen or so countries, have large reserves at the moment. Less than a dozen or so perhaps of the multinational oil companies have control over 70 percent--or have had control to a great extent, I must say--of 70 to 80 percent of world production, 70 percent of refining. These are just impressionistic figures; they are not accurate as to degree, but they are of the broad order of proportions that I have described.

Perhaps more than half of the world tankerage indirectly is controlled. Now naturally, this is a situation of imbalance which is unlikely to last too long because there will be counter-active or counter forces which will be put into motion, and I think you must understand this. Therefore, we have inequality in the distribution of reserves-- wealth, you

may call it--this particular type of wealth, the premium fuels, the fossil fuels, and above all, the hydrocarbons. Then you have the imbalance in the control mechanism, in the integration of the mechanism, and, of course, in the supply mechanism. This is the kind of situation which is likely to come under great stress for change.

Now, I just mentioned the growth of the role of government and governmental intervention which is likely to become more of a factor with respect to this particular problem. The exporting countries will continue to try to maximize their revenue through exports as well as diversification of their economy. These countries, in the face of large accretions of foreign aid exchange reserves, will face the option of leaving some of their oil resources in the ground for future uses because of their certain absorptive capacity, etc., unless sufficient investment opportunities and guarantees are provided to defer the use of their present incomes.

Another issue of growing concern is how, in the process of meeting these energy requirements, the harmful and deleterious consequences of increased global energy use on the environment and quality of life can be minimized, since the use of energy pollutes the air we breathe and also results in massive thermal pollution.

Yet another energy-related issue is how best to insure the flow of vital energy supplies from the dozen or so energy surplus countries to the energy-deficit countries which constitute the overwhelming majority of the world's nations--rich and poor alike.

These issues pose great challenges but also opportunities for the drive to develop less polluting energy sources, to discover new hydrocarbon reserves and to give an impetus to research and development aimed at the efficient utilization of energy by devising improved energy conversion processes.

It poses also the need for some conservation of energy and the development what one may call an "energy ethic" designed to avoid wastage of energy for extravagant and super-luxury uses.

These growing energy problems demand solutions and approaches at the global level before they overwhelm us and take on the dimensions of a global energy crisis. The interdependence between the developed market economies, the socialist countries and the third world of developing countries on the one hand, and the mutuality of interests between the energy-surplus countries and the energy-deficit countries on the other hand will, notwithstanding the political overtones, hopefully result in a harmonised interplay of forces for solving the looming energy problems ahead.

The following discussion is presented to highlight some of the existing, as well as emerging, global problems and issues, many of which result from the interaction of the energy-deficit and surplus countries on the one hand and the present set-up of the international energy economy on the other.

A review of the global energy situation reveals a serious imbalance in that the share of the developing countries in world energy consumption was only nine percent in 1971, in petroleum consumption only thirteen percent and in electricity only seven percent. The developing countries with more than two-thirds of the world's population consumed only a fraction of the total energy produced, although taken as a group, they showed a surplus of primary energy production far in excess of their aggregate requirements. However, on an individual basis, substantial surpluses are limited essentially to fifteen countries who are the main exporters of petroleum and natural gas. On the other hand, there are about 75 developing countries which are energy deficit, and in some cases, critically so.

In response to the soaring world energy requirements, particularly since World War II, the pace of exploration for hydrocarbons has increased considerably. A new era of offshore exploration and development has begun. Today, about 20 percent of world petroleum requirements come from offshore and the quest for further exploration and development will almost certainly continue in view of the overwhelming dependence of world economy on fossil fuel. This share is expected to increase to about 40 percent by 1980. Progress in the techniques and design of equipment for offshore exploration has been rapid and exploration work can now be undertaken in depths of water up to 350 metres, even though the initial cost of such offshore activity is probably three times that of comparable inland operations. However, recent statistics indicate a higher ratio of reserves discovered per unit of investment in offshore exploration than for inland.

The international petroleum industry rivals nearly all other industries in size, past performance and beholds opportunities in view of the increasing world-wide petroleum demand. Therefore, the petroleum exporting and importing countries will continue to participate to a much greater extent, through their national companies in the exploitation and development of their energy resources. In so doing, the former countries will strive to maximize their revenues through exports as well as diversification of their economies. These countries in the face of large accretions of foreign exchange reserves will face the option of leaving some of their oil resources in the ground for future use, unless sufficient investment opportunities and guarantees are provided to defer the use of their present income.

A great majority of the energy-deficit developing countries is expected to remain net importers of crude petroleum and of petroleum products during the seventies. At present, these countries produce only about one-third of their crude petroleum requirements; the remaining is met by imports at the 1970 level of about 120 million tons of crude petroleum and 35 billion tons of petroleum products. These imports which entailed a foreign exchange cost of $2 billion in 1970 are expected to reach $7 billion in 1974.

Many of the petroleum importing developing countries have not shared fully in the general decline of petroleum prices in the 1960's, and there is little reason to believe that competitive prices will be charged for their imports during the 1970's, unless ways and means can be found to minimize their foreign exchange costs by gaining "a most favoured" access to competitive sources.

The rising petroleum imports of industrial countries will mean heavy pressures on their balance of payments with repercussions on the present world monetary system.

Increased oil import costs are likely to accelerate the pace of exploration for indigenous energy resources in both the developed and the developing petroleum importing countries. Where oil prospects may seem unpromising, efforts will be made to develop alternate sources such as nuclear, geothermal, or coal. These are not mutually exclusive. This will entail vast new investments in comparatively high cost alternate sources of energy. Considerable changes in the energy policies of energy-deficit developing as well as developed countries may therefore be anticipated. In view of national security considerations, most countries have undertaken the building up of stockpiles equivalent to 15 to 60 and now to 90 days of their petroleum requirements. These emergency stocks require additional investment for oil purchases and storage facilities.

The demand for energy in the form of electricity has been growing faster than any other form of energy. This trend is most likely to continue during the 1970's; therefore the significance of alternative energy sources such as hydropower, nuclear and geothermal from which electricity can be produced will be enhanced. This is an obvious statement; it is derived from the present situation to some extent. Of these three, the prospects for utilizing large-scale hydropower are, however, restricted though not necessarily limited. Nuclear energy prospects are overshadowed by the long lead time, high capital costs, hazards of radiation and the fact that nuclea. costs are predicated on the assumption that a nuclear station will

operate at near-peak capacity most of the time. Geothermal energy which, though being a relatively new entry to the world energy scene, offers many advantages. The overall relative costs for geothermal-based power generation have been shown to be less than either the nuclear-based or fossil fuel-based power generation, more so if the fuel has to be imported. In addition, geothermal energy is perhaps less polluting and offers multi-purpose applications such as desalination of water and recovery of minerals. Far more important, perhaps, will be the contribution of coal to increased world energy supplies, particularly in substituting for hydrocarbons through coal liquefaction and gasification.

The location and structure of industries often becomes specially adapted to the availability and prices of the available energy resources. This aspect of energy utilization is particularly relevant with regard to the non-energy uses of energy source (e.g., petrochemicals and fertilizers), which have steadily increased in the recent past with the demand and consumption, and their continued growth may lead to locating energy-intensive and other supplementary industries in the petroleum-rich developing countries.

The substitution of one fuel for another is technically possible in many cases, especially for the generation of electricity in fossil-fueled thermal plants and large-scale industrial processing. (There are many instances of electrical generating plants being built with dual-firing equipment so that advantage can be taken of fluctuations in the relative prices and availability of primary fuels.) The principal factor which determines the choice of fuel is the final cost of a unit of heat energy to the consumer; such cost calculations must make allowance for the cost of conversion equipment, cost of handling and storage facilities, actual purchase price and intrinsic factors such as convenience and safety and environmental impact. The pace of substitution will depend on the scale of reserves of the alternate source, the lead time required for commercial scale production and above all, the new investment costs entailed by it.

A number of environmental problems have appeared. The unprecedented concern about environmental quality extends not only to obvious pollutants such as smoke and toxic gases from various energy processing and production facilities, but also to a range of economic and aesthetic issues such as the use of prime-value land for siting power plants, transmission lines, petroleum refineries, etc.

There is also the related issue of conservation of resources in general, and energy resources in particular. Some of the major issues requiring conservation in one form or another are: inefficient means of

energy production, transmission and storage, planned obsolescence of consumer goods, superfluous packaging, industrial waste heat, private transport, inefficiently operated public transport, non-recycled materials, restoration of mining areas both above and below ground, etc. Whereas it is being recognized that at least some portion of the increasing energy demand in the developed countries may be extravagant, there will be felt increasing need for energy conservation, particularly in the large energy consuming nations.

International agreements dealing with exploration, development, supply, refining and marketing of energy resources (notably petroleum and gas), are generally concluded on a long-term basis. However, during the 1970's, several international petroleum agreements will be nearing expiration and are giving rise to profound and radical structural changes in the international energy industry. Also, both developed and developing countries are taking steps to intervene directly in regard to the ownership, supervision and management of their energy economies.

In response to increased world energy needs, the pace of energy-related research and development will further quicken resulting in the accumulation of a vast amount and wide variety of technical knowledge and means for massive technology transfer to the developing countries will have to be found.

In the light of the foregoing discussion of energy-related problems and issues, the need for international cooperation will be increasingly felt, particularly by those developing countries who will be striving to develop and manage their own indigenous energy resources and by the adoption of more rational policies in the rich energy-consuming countries. When viewed from a global perspective, the prospects for coordinating national efforts in developing the energy resources may not always look promising. However, such efforts could take the form of mutual cooperation in energy exploration of both conventional and non-conventional sources, energy processing and producing facilities, reduction of environmental pollution, development of high voltage or super conductive transmission systems and large scale exchanges of electrical energy. What is required in essence, is a global cooperative approach for the use and management of the energy resources of the world on a fair, equitable and just basis.

The views and opinions expressed in this paper are those of the author and do not necessarily reflect those of the United Nations.

INTELSAT - A GLOBAL COMMUNICATION SATELLITE SYSTEM

Sidney Metzger

In this talk I would like to describe what the Intelsat system is, give you some idea of its extent and also, by means of slides to show you the various types of satellites which have been used by Intelsat since the initial launch of Intelsat I in April 1965. In particular, in addition to presenting the various types of satellites, what they do, how they work, their capacity, their cost, and their problems, to emphasize the extremely rapid growth by their telephone traffic capacity (a twenty-fold increase in a short period of six years). The next part of the talk will cover the earth stations, which together with the satellite provide for a complete system. And finally, to present some considerations involved in establishing communication satellite systems in the developing countries.

The first slide shows the approximately 85 member countries of Intelsat. Over 50 of these countries, involving 69 stations, operate 85 antennas today. The 85 member countries, which have grown from the dozen countries which started the Intelsat system in 1964, share the ownership of Intelsat in proportion to their share of international telephone traffic. The earth stations are wholly owned by the particular country. The Intelsat organization is divided into various layers. The first involving the government themselves; the second layer consists of the operating entity within each country; the third layer (The Board of Governors) consists of some 18 organizations, either countries or groupings of countries which each have at least about 1.5 percent of the international traffic. The Board of Governors has several committees including those on technical matters, on finance, and on operations. These groups meet about a half dozen times per year in order to work out the various details involved with the global operation of the Intelsat system. This year a Secretary General started operation, assisted by Comsat who not only is the U.S. entity, but also performs the technical and operational management for Intelsat under the Secretary General.

As part owners of the system, each country contributes a certain amount of money each year in order to keep the system going. As users of the system, each country pays a certain amount for each voice circuit. At the end of the year a profit is turned back to the various owners. Over the years the cost per one-way voice channel charged by Intelsat to its member countries has decreased from $32,000

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December 19, 1973

in 1965 to $9,000 in 1974. It is anticipated that by 1977 the cost per channel will decrease to approximately $7,000 per year. In 1972, Intelsat's gross income was approximately $90 million. For 1973, it is estimated to be about $95 million (a larger number of circuits but a lower price per circuit).

The next slide (#2) shows the growth of the number of circuits carried by Intelsat from 1965 to the present time, and also the growth in the number of antennas. Note that we started in 1965 with 60 circuits and at the present time the global system is carrying approximately 4800 circuits. The traffic varies; about 5/8 of the total is carried in the Atlantic satellites; 2/8 in the Pacific; and 1/8 in the Indian Ocean satellite. The number of antennas increased from the two stations which were used with our first satellite to about 85 at the present time.

The next slide (#3) shows the number of paths. A path shown here by a line between two countries, indicates one or more telephone circuits between those two countries. At the present time there are more than 280 such paths around the world. Our first satellite, Intelsat I, or Early Bird as it was known (Slide #4) was launched in April of 1965 over the Atlantic and it had a capacity of 240 two-way telephone circuits. In principle, the satellite operates similarly to the radio-relay stations you see on the highways. The unique feature, though, is that rather than using a steel tower of some 100 to 200 ft. we use, in effect, a tower 22,300 miles in height. At this altitude above the earth, in an orbit around the equator, the satellite rotates once in 24 hours just as the earth does, so that the satellite appears to stand still with respect to us here on earth. It is this unique so-called synchronous orbit which has been used for all of Intelsat's satellites. The purpose of the satellite is to receive radio signals from the ground, amplify them, and re-transmit them so that they could be picked up at stations far beyond the optical horizon from the sending station. With three such satellites, essentially global communication could be obtained except for the northerly latitudes. This particular satellite weighed 85 lbs. and is powered by solar cells. The radio tube has a power output of 6 watts and yet with the large antennas, which we will discuss in more detail later, has a capacity of 240 telephone circuits simultaneously. Only one satellite of this type was launched. A second was built but was never launched because it was superseded by our Intelsat II shown on the next slide.

In 1965, the National Aeronautics and Space Agency asked Comsat to provide communications for the ships at sea which were needed to track the forthcoming manned space program. This program included the Gemini and Apollo satellites. These satellites circling the earth require line-of-sight communication over all parts of the earth. In some areas there are no land masses from which the satellite could be seen and it

is necessary to provide ships in the Indian and Pacific Oceans in order to permit constant communications with the manned satellites. The problem then arises of how the signal being picked up at the ship can get back to the mainland, and for this purpose it was planned to use a communications satellite so that signals would go from the manned spacecraft to the ship, from the ship to the communications satellite at 22,000 miles out, and from the satellite back to the mainland. During the year which passed between the launch of Intelsat I and Intelsat II (Slide #5), the capacity of the Delta rocket had increased so that the 85-lb. payload of Intelsat I could be more than doubled to 190 lbs. which was used for Intelsat II. This satellite also had a capacity of 240 telephone circuits but the antenna beam permitted communication with both the northern and southern hemispheres as compared to Intelsat I which could only communicate between stations and the northern hemisphere. Four such satellites were launched. The first one failed due to a failure in the apogee motor which was of new design.

The next three were successfully launched and were all used for period of 2 to 3 years. They were superseded in 1968 by Intelsat III shown in the next slide (#6). This satellite, launched by the 1968 version of the Delta rocket, weighed approximately 300 lbs. The additional weight permitted us to increase the equipment on board so that it had a capacity of 1200 two-way telephone circuits, or alternatively, some of these circuits could be removed and replaced with one or more television signals. The unique difference between this satellite and its predecessors lay in the fact that whereas the earlier satellites radiated power in all directions from its antenna, giving in effect a doughnut type of pattern, the Intelsat III, through its directional antenna radiated power only toward the earth. This increase in effective power permitted the use of 1200 telephone circuits. Eight of such satellites were launched, three of the launches failed due to rocket failures including a first stage, third stage, and an apogee motor. Of the satellites which were successfully launched, several experienced trouble due to bearing problems. In order for the antenna to remain pointing at the earth while the satellite itself is spinning, it becomes necessary for the antenna to spin at an equal speed but opposite in direction. One of these satellites, launched February 1969, and still operating, is almost five years old. Its antenna has never given trouble, indicating that the design of the shaft and the bearing in this particular type satellite is rather critical. About the time we learned the nature of the troubles, the satellite became technically obsolete. The demand for increased traffic was such that we needed a satellite having about four times the capacity of Intelsat III, and after a design study, a contract was awarded for the Intelsat IV shown in the next slide (#7).

This satellite is approximately 8 ft. in diameter and about 9 ft. high excluding the antennas. The two reflectors are 50 inches in diameter and provide a beam about 1/4 of the diameter of the earth. The antennas can be remotely steered from the ground to illuminate any part of the earth. The smaller antennas at the top provide a beam which completely covers the earth. The satellite weighs about 1600 lbs. and the solar cells which cover the surface generate approximately 500 watts of D.C. power. There are 12 amplifiers or repeaters. Collectively, they can handle from 3,000 to 6,000 two-way telephone circuits. Alternatively, a repeater can be used for a high quality television picture or two television pictures simultaneously of somewhat lesser quality. To give you an idea of the cost of such a project, to develop a satellite of this type including to build the various structural, thermal and electrical models, to build eight flight spacecraft to be launched by eight Atlas-Centaur rockets costing $16 million each, gives a total project program cost of approximately $250 million. Roughly, half is due to the rocket cost and half due to the satellite cost including development. Five such satellites have now been successfully launched--three over the Atlantic (two in use and one spare); one over the Pacific; and one over the Indian Ocean. Three remain--one to be launched January 4, the next in the summer of 1974, and the last at the end of the year. These will provide spare satellites in orbit over the other oceans. The first Instelsat IV was launched at the beginning of 1971.

It is estimated that the satellite will be filled by 1975, therefore a contract was let for a satellite with even greater capacity, the so-called Intelsat IV-A shown in the next slide (#8), which provides approximately twice the capacity of Intelsat IV. This increase is obtained by providing twice the number of repeaters as in Intelsat IV, half of these operate with an antenna beam which covers South America and the eastern part of North Africa, and the other half operates with a separate antenna beam which covers Africa and most of Europe. The two beams use the same frequencies but they are sufficiently separated so as to minimize the effects of interference on one beam against the other. It is anticipated that this satellite will become saturated in 1978, and studies have been underway for the past year to decide what type of satellite should be launched in 1978, so that the expected traffic at that time could be handled.

The next slide shows (#9) still another way of providing increased traffic capacity. This is a picture of the satellite we have under construction for use by AT&T. This satellite is to be launched by Comsat and to be used by AT&T solely for domestic traffic. It will have a capacity of 14,400 two-way telephone circuits for each satellite, three of which use the same frequency band twice--one set of repeaters operates with a vertical antenna, whereas the second set of 12 repeaters using the same frequency band, operates with a horizontal

antenna. At the earth stations, corresponding antennas are used. It is found that at these frequencies, antennas can be designed so that signals from one polarization are essentially ignored by antennas having the opposite polarization, thus permitting a doubling in the use of the spectrum. These satellites are now under construction and are to be launched in 1975.

We now focus our attention on the earth station part of the system. The next slide (#10) shows our earth station located in Brewster, Washington. It consists of a building housing transmitters, receivers, and multiplex equipment similar in principle to the equipment used in radio-relay stations but differing in the power of the transmitters and sensitivity of the receivers. For example, whereas a typical radio-relay transmitter might have a power output of 5 to 10 watts, in our stations we have transmitters having an output of 8,000 to 12,000 watts. Also, because the weight of a satellite must be kept to a minimum due to the high cost of rockets and satellites, great pains are taken to decrease the noise of earth station receivers providing sensitivities of about 100 times better than that used in radio-relay stations. This great improvement in sensitivity is obtained by using receivers which are kept in refrigerators operating about 15° above absolute zero. Finally, whereas the antenna of a typical radio-relay station varies from 6 feet to 10 feet in diameter, the Intelsat antennas are usually 97 feet in diameter in order to provide a much greater area and thereby use signals of exremely low power received from the satellite. One can appreciate the magnitude of these signals when you consider that the 12 repeaters on board an Intelsat IV have a combined radio frequency power output of 72 watts, or smaller than the usual 100 watt bulb found in our homes and yet these signals must travel 22,000 miles from the satellite to the earth station. The resulting power at the output of the antenna is typically in the order of a millionth of a millionth of a watt.

The first antenna was that in the earth station at Andover, Maine (#11). This was built by AT&T for experiments with the Telstar satellite in 1962, and was bought by Comsat in 1965 for commercial operation. The basic design is in effect a 60-foot version of the 8-foot horn antennas used by AT&T in their terrestrial microwave links. This antenna was used because its theory was well understood and several thousand of them had been made for terrestrial use. The disadvantage was the high cost and the fact that a radome had to be used to avoid the effect of snow falling on the large structure.

The next generation of antennas is shown in the following slide (#12). These antennas were based on designs used for military and by the National Aeronautical Space Agency (NASA). They weren't well adapted to our 24 hour per day service since, for example, attempting to maintain equipment located in the feed cone of the Hawaiian antenna

(elevation angle of 48°) required that the technician tie himself in with a rope.

The next generation of antennas (Slide #13) included an elevated equipment room which remained horizontal regardless of the antenna elevation angle. Also, this design improved on the electrical performance (gain, bandwidth, and lower noise) of the previous generation, but was more expensive.

Finally, the current generation is shown in the next slide (#14) wherein the antenna is located atop a 50 foot diameter concrete room which houses practically all of the equipment, except those which, for electrical reasons, must be located in the elevated equipment room. Future designs promise to extend the antenna feed into the main room by a periscope arrangement, so that the elevated equipment room can be eliminated. This design not only had the desired electrical performance, but at a reduced cost.

Slide #15 shows how the cost of these stations has decreased over the years, from a range of $6 million to $12 million in 1965, to $4 million, to $8 million in '68; to $3 million to $6 million in 1970. By 1972, the range is down to $2.5 million to $5 million. The decrease is due to the emergence of standardized designs, thus eliminating development costs and larger production quantities. However, the sequence of a first design not meeting expectations; a second design meeting the performance but at a higher than desired price; and finally a third design achieving the same performance but at a lower cost is typical of most complex engineering projects.

The procedure for a country considering whether or not to build a station would be to get pertinent cost information from Comsat, and to compute expected costs and revenues from its predicted telegraph and telephone traffic. Assuming the result is favorable, a consultant is engaged to prepare specifications, recognizing that each country usually has its own problems and that such specs must be tailored to the specific requirements. Comsat, not being a manufacturer, has been asked to act as a consultant by over two dozen countries in the last five or six years. In addition to preparing specifications, the consultant may also help in the technical evaluation of the proposals received in response to the request to bid; to follow up on the selected contractor during the production phase; and also to assist in the installation test phase. Finally, he may also be called on to prepare training methods for the operating crews. One desirable approach is for the future crew to participate during the testing of the equipment by the manufacturer, including lectures at the manufacturer's plant by his men.

Depending on the experience of the crew, they might take over the running of the station right after acceptance testing; or in some cases have the manufacturer run the station for some fixed period of time--perhaps 3 months, 6 months, or even a year, meanwhile giving the crew on-the-job training. At this time, most countries of the world operate their own earth station, and with quite reasonable results, viz., in 1972, the on-the-air percentage time for all stations of the world was 99.94 percent. Considering that these stations are using very complex, modern equipment with green crews, this is quite an accomplishment. (AT&T's objective for their latest cross-country microwave relay system is 99.98 percent.)*

The attached section "What Satellite Communication Means to Kenya" was prepared by a member of the East African External Telecommunications Co., Limited, to describe their reasons for going to communications satellites and the result. This company provides communications for Kenya, Uganda, and Tanzania.

The last ten years has seen communication satellites grow from an experiment to an international system carrying the major share of the world's transoceanic telephone traffic.

*AT&T's objective for their latest cross-country microwave relay system is 99.98 percent.

WHAT SATELLITE MEANS TO KENYA

Introduction:

Kenya is a partner state in the East African Community which is an organ of economic cooperation between the independent states of Kenya, Uganda and Tanzania. A number of services and institutions are run jointly by the three states under this treaty of cooperation and one of these is the East African External Telecommunications Company Limited. The main objective of the E.A.E.T. is to provide and maintain telecommunication links between East Africa and the outside world. Our links to the outside world have exclusively been via H.F. radios until 1970 when we started communication via satellite.

It may be a better approach to start off by briefly outlining the development of external telecommunication in this part of the world. There are various factors entering the need for the establishment of international telecommunication media but the most important one is the improvement of understanding between the different peoples of the world. The results of such understanding are many and in most cases mutually beneficial to man; move towards peaceful living, improvement in international trade, international exchange of cultures and traditions, are a few of them.

In the case of East Africa, the initial pressing need for setting up telecommunication system was trade. In the early 1920's the only means of transport from Europe to East Africa was by ship. The ship to shore telegraph link was, therefore, the first telecommunication service to be employed. The system was installed by the Eastern Telegraph Company at Mombasa and soon after this a pair of two hundred mile submarine telegraph cables were layed to join Mombasa with Zanzibar.

During the Commonwealth Prime Ministers Conference in 1948, it was decided to embark on a world-wide telecommunication network. As a result of this decision, a number of long distance submarine cables were layed. It was, however, thought uneconomical to include E.A. in this expensive network at that time so we had to rely on H.F. radios which adequately met our traffic demands then. The volume of traffic continued rising and with such a state of affairs, we could not rely on H.F. radios for too long. We started following with interest the tests that were being carried out between America and Europe using passive and active satellites for communication over the Atlantic Ocean.

Why We Joined Intelsat:

I mentioned earlier that our primary objective is to provide and maintain telecommunication links between East Africa and the outside world. In pursuing this objective, we have to realize that high performance standards, reliability, and efficiency, of our services will be expected by our customers. In light of steadily growing traffic and the fact that some of the distant administrations we communicate with began diverting their attention from H.F. to satellite communication, we had to begin thinking likewise.

The objectives of Intelsat are commensurate with ours. Intelsat is a body set up "to provide, through the most advanced technology available, for the benefit of all nations of the world, the most efficient and economical service possible consistent with the best and most equitable use of radio spectrum." East Africa cannot achieve, in siolation, her main objective as given in the treaty of cooperation, i.e., economic development. We have to buy from and sell to other people. Business transactions require fast and e efficient means of communication; this needs readio communication. The decision to join Intelsat was therefore sanctioned as being in the best interest of the community. With E.A. negotiating an association with E.E.C. in Brussels, our role is clear.

The Cost of the System and Financing Arrangements:

The E.A.E.T. operates on a commercial basis. The Company finances its own running costs, expansion and other liabilities from the profit it makes or through a loan agreement with other financiers. In appraising a new project, therefore, the questions of profitability and improvement in the standard of our services have to be compromised. The construction of an Earth Station was a very big project requiring proper appraisal. It took two years of discussions and negotiations (1966-1968) before the final decision was taken to construct the Earth Station at Longonot in Kenya. To add to the significance of this investment, the Heads of State of the partner states had to give the final approval.

The Earth Station was constructed by Marconi Company to the standards set by Intelsat. As part of the contract, Marconi met part of the capital cost on agreed loan terms. A number of local firms were sub-contracted to carry out different phases of the work; the station was ready in two years (1968-1970).

The Earth Station is situated 40 miles from the Head Office of E.A.E.T. in Nairobi, where the International Transit Switching

Center (ITSC) equipment International Maintenance Center and International Telephone Exchange (IMC & ITE) are housed. The link between the Earth Station and the ITSC is a microwave system installed by Fujitsu of Japan.

To cut the maintenance cost, we normally include a training programme as a part of a major contract. During the construction of the Earth Station and the installation of the ITE, some of our Engineers (local staff), were sent for training to prepare them for work on the equipment once commissioned. We are proud to say that we are using largely the skills of our local engineers and technicians to maintain these relatively new systems.

How the Satellite Is and Has Been Used:

Our use of Satellite Units has grown steadily since August 197.. We operate direct links with five Earth Stations via Intelsat IV (F5) in the Indian Ocean Region, namely, Goonhilly (United Kingdom), Fucino (Italy), Ceduna (Australia), Vikram (India) and Buitrago (Spain).

The Unit Utilization has grown from an initial 20 telephone channels in 1970 to 49 at present. Most of our circuits are working to London (Goonhilly). Buitrago has so far been used by NASA on lease circuit basis during the times when they are constructing and launching their satellites at San-Marcos near Mombasa. Since the last launch, we have closed the circuits to Buitrago.

The services are mainly of three types, namely, telephone, public telegraph and telex (most of the telex channels are leased). Occasionally, we receive and transmit pictures and quite often, we handle voicecasts. We are not equipped for television service but, were able to modify our standby path to receive some events live from Munich during the last Olympic Games. It is not an economic reality at the moment to include extensive TV service. Our next priority is to be able to have another system facing the Atlantic Ocean Region. When Pan-African Telecommunication network comes into operation, we will definitely have our services expand and feel our role in the acceleration of inter-African trade.

Our Earth Station acts as an international gateway for those African countries that work H.F. circuits with us. It is so satisfying to feel that we are playing this important role to our friends.

GENERAL MANAGER

E.A. EXTERNAL TELECOMMUNICATIONS CO., LTD.

DCO/FPN

STRATEGY FOR THE DEVELOPMENT OF THE TECHNICAL INFRASTRUCTURE OF DEVELOPING COUNTRIES

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January 8, 1974

STRATEGY FOR THE DEVELOPMENT OF THE TECHNICAL INFRASTRUCTURE OF DEVELOPING COUNTRIES

Kenneth S. Julien

Mr. Ambassador, Dr. Walker, Ladies and Gentlemen, I bring you greetings from my own university, the University of the West Indies, and in particular, the Faculty of Engineering at St. Augustine. We in Trinidad and the West Indies obviously have had many contacts and continuing relations with Howard University. I think we stole a professor from here and made him a Prime Minister, and more recently, we also managed to steal one of the professors from the School of Engineering and he is now on my faculty.

It is indeed a pleasure to be asked to address you as a participant in this series of topics, and when I saw the list of previous speakers, I realized that I was in quite distinguished company. This afternoon the plan of my talk is made up of four parts which I will contribute, and possibly a fifth part, which I hope shall be contributed from the floor.

First, I will deal with the whole question of the definition of terms, and particularly the terms that I will use in my address. These are terms that are very much overworked and I think that it is very important that we spend a little time looking at them. Second, I'll talk a little about the general terms, about the problems of development and the role of technical infrastructure in that development and the solution of that problem. Third, I will focus on a particular region, obviously the Caribbean, on which I feel competent to talk and spend a little time identifying some of the structural weaknesses in the Caribbean, that mitigate against development. Finally, for my part of the contribution, I will identify and expose some of my ideas about what strategy is needed to overcome these particular problems for the Caribbean. Fifth, which may or may not come about, the question of relating what I have said and its application to other developing countries is something which I hope can come out of this discussion.

First, dealing with terms, a very impressive title has been given to my talk--"The Strategy for the Development of the Technical Infrastructure of Developing Countries." I think it is important that we spend a little time on these critical phrases: "development" and "developing countries." As an engineer, I find it easier to talk in terms of objectives, and I would like to apply that thinking to the word "development." I would like to raise questions to you about what I feel are the objectives behind development of developing countries as distinct from the actual meaning of the word "development." Further, and to start this off, I think perhaps it is easier to get an idea of what I'm getting at if we take some time to consider what these objectives are not.

What Development Is Not. Development of the less developed countries is not a guarantee that they will choose any particular ideology or value system. In fact, since development involves profound changes in national behavior and sometimes creates threats to national unity and cohesion, it may, in fact, result in upheavals in pragmatic policies and some changes in the old behavior. Development is not a guarantee of political stability or an alternative to violence. Change is in itself, disruptive, and since the associated development usually leads to drastic changes, some form of disruption should be expected. Development is not an assurance of peaceful international behavior. History holds too many examples of highly developed and rapidly developing nations which behave both aggressively and irresponsibly towards their neighbors. These examples are still with us, and there is no guarantee that smaller and developing countries would not adopt them. Having dismissed some of the cliches of what development, or what the objectives of development are sometimes thought to be, let us look at another approach--the ideal. The ideal is often stated that the major objective behind development is to bring together all groups and to eliminate all inequality within the society. This is an ideal that I think is an impossible one, and perhaps even meaningless, and therefore let us dismiss that as well.

A definition which is not my own, but which I've recently come across in a publication entitled Partners in Development -- the one that attracted me most, says simply that development is, and I quote, "to reduce disparities and remove irregularities. It is to help nations to move forward in their own way into the industrial and technological age so that the world would not become more and more sparsely divided between the 'haves' and the have-nots' both on a national, as well as on an international scale." This simple statement of global objectives is the one that has impressed me most of all the literature that we refer to

in development. This, therefore, is the major objective that I have in mind when I talk about development, and the one that I will ask you to address yourself to in this seminar.

Let us now have a look at "developing countries" -- a very popular phrase these days. The temptation to speak of "developing" and "third world" countries is always there, and too often, I, as have you--as you are now here this afternoon--have sat through learned discussions or read published papers on "developing countries," emerging countries," "transitional economies," "underdeveloped countries," and more recently, the most overworked phrase--"third world countries." Profound general conclusions have been arrived at, pronounced upon, recorded, and sometimes even acted upon. I, as you may have gathered from my preliminary remarks, have become a little bit skeptical of any general conclusions arrived at about this fictitious group of countries, whether they are "less-developed," "developing," etc.; and in the words of a recent study, "there is no satisfactory way of describing these countries as a group in terms of one of their most important resources, namely, human resources." Therefore, it would be useful to examine some of the features that tend to characterize or distinguish this resource--that is, the human resources--the people of developing countries in this context.

Two key words come to mind to anyone who is familiar with people in the developing countries. The key words are: dependency and lack of confidence. The environment in which they live, the structural arrangement, the institutions, the decision-making processes in most third world countries have eroded and continue to erode the confidence of the people insofar as the mastering and control of technology is concerned. There is lack of confidence, and sometimes none at all, in the people of these countries. The impression is common that science and technology is some mysterious gift given by God to the developed countries which will be doled out in small and harmless quantities to others. We keep hearing of transfer of technology, adaptation of technology, technological aid, technical assistance programs, etc., and if these are explored in any depth and are actually experienced on site, you will find that invariably they aggravate this situation of continuous erosion of confidence.

Dependence. We have some concept of economic dependence, but something that is becoming even more critical in these developing countries is the question of technological dependence. Before I am accused of preaching isolationism for developing countries--which I'm totally against--before I'm accused of that, allow me to develop this point further. It is of greatest importance to distinguish between interdependence and dependence; and I think I can do no better than quote from Willie Dumas:

> The dominant feature of the contemporary world economic order is interdependence among nations, particularly in the field of trade, technology and capital inflows. In particular, a small country, with a limited range of national resources and a small domestic market, must depend heavily on foreign trade, on both exports and imports. But, interdependence can only be meaningful for a country if the dynamics of economics change, or reaction to external change in the world economic environment are internal and under its own control. If such dynamism is not internally located, interdependence turns into dependency.

These words are as true for economic and political activity as they are for technology, and unfortunately, it is rarely recognized. In a nutshell, so far as modern technology and science are concerned, the majority of developing countries are convinced, in fact, that: (1) they do not know; (2) they will never know, and (3) they will always have to be helped by some other nation. These words perhaps may sound harsh and perhaps may be queried, but I am prepared to back this conviction, if need be, by critical examples of this sort of conviction. It is this conviction that makes the development and the revolutionary development of technical infrastructure a critical area of activity for most developing countries. This leads to my final definition.

Technical Infrastructure. The word "infrastructure" itself is of some interest. In true loyalty to my basic education which is very much British, I resorted to the Oxford Dictionary and found a precise and somewhat strange definition for infrastructure. It defines infrastructure as a "system of airfield, telecommunications, and public services forming a basis for defense." It would appear, therefore, that the origin of the word was based on a concern for defense, and today it could be argued that it conveys something somewhat different. I contend, however, that in many countries, in fact in the greater part of the world, the original basis still holds, i.e., it is a form of defense, although the enemy is now hunger, poverty, disease, illiteracy and complete dependence and lack of confidence. It is against this background that one can, with justification, introduce the additional adjective--technical--and from this we get the phrase, "technical infrastructure," which, in my definition, means the provision of technology and technology in the fight against these many problems that are common to all of the developing countries. Simply, it is the creation of an environment, an atmosphere in developing countries in which technology is the servant, not the master; in which the mystery has been removed from technology in that it has some indigenous qualities; in which technologists are constantly harassed; in which they are rewarded for meeting these challenges successfully, and in which they can reach the maximum

potential in their respective fields. These are high-sounding phrases, and if you examine them more carefully, you can see that they cut across the entire structure of the society; they cut across the entire educational system; and they cut across all forms of major economic activities. These three elements, economic activities, educational systems, and the social structure cover such fundamental areas that I cannot pretend to be competent in dealing with any one, much less three of these in the broad context of developing countries. I will, therefore, with your permission, restrict myself to a region. with which I am familiar, and perhaps with which most of you are familiar, namely, the Caribbean. I'll utilize my knowledge of conditions there to demonstrate the weaknesses I've identified, and suggest a strategy for immediate action.

The Caribbean region does have some attraction as a laboratory model. It is small enough to provide a simple model, complex enough to make it interesting, and possesses enough common features of both the developed countries and the less developed countries to allow comparisons and comments to be fully understood and appreciated. A further restriction which I will have to place is that of restricting myself to the English-speaking Caribbean, although most of my remarks can be applied to all territories in the Caribbean and Guyana, with the possible exception of Cuba.

First, I'll give you a description of the region of the model. I am not going to bore you with details and statistics of the region. These are probably well known to you. They are certainly easily available. However, consistent with my emphasis on human resources, some facts should be highlighted which provide common areas for this model. Human resources are very young. Over forty percent, or just about forty percent of the population generally is under eighteen years. Some sixty percent are under twenty-five. Employment: There is basic structural under-employment which averages between 15 to 25 percent of the total labor force. Education: This is a plus. On the whole, the population is literate and numerate, averaging some 95 percent literacy and some territories are approaching 100 percent. The people are capable and accept training easily. They are also, on the whole, ambitious. It may be the wrong type of ambition, but they are ambitious and exposed as we are to the mass media--to television, the movies, the press--whether one likes it or not, the aims, the value system is very much oriented to the metropolitan countries, whether it is the United Kingdom, or more recently, the United States. In other words, they see very clearly and very well what other people in the North have, and they, rightly or wrongly, want it as well.

I would like now to take a look at economic activity, and review three major factors: economic, educational and social before going on to a description of the strategies.

Economic activity: agriculture. Agriculture has been a traditional mainstay of the economies of these developing countries, and bear in mind, I'm now talking about my small model of the Caribbean region from the days of colonization. Agriculture has maintained its renowned low productivity . What is even more significant about agriculture is that it has tended to typify in social and economic terms, the plantation system--about which I'm sure you've heard a great deal from Dr. George Beckford, whom I saw gave an address here last year. It is a favorite term these days in the Caribbean, and I certainly do not intend to get involved in the arguments around it; but agriculture certainly typifies what George Beckford and Burke refer to as the plantation system. Let's look at it a little more deeply.

In Jamaica it is almost a two-crop agricultural situation: sugar and bananas. In Trinidad, sugar. In Guyana, rice, etc. In Jamaica, sugar and bananas account for some $41 million Jamaican dollars in export, compared to a total of only $56 million in total exports in agriculture. In Barbados, some 60,000 acres of land are being devoted to sugar cane cultivation. This probably has no meaning in a country like this where you have millions and millions of acres; but 60,000 acres of land devoted to sugar cane cultivation in Barbados represents sixty percent of the total land area. In Trinidad and Tobago, some 50,000 people are directly or indirectly employed in the cultivation and processing of sugar, and this in a work force of 360,000. These are but a few of the disturbing facts which identify a serious weakness in the whole economic system insofar as it relates to agriculture in the region. The next form of activity that is of major importance in these territories is tourism.

Tourism, in many of these islands, is ahead of agriculture in its importance to the economy. The Bahamas, which is an extreme example of a tourist-dependent economy, had over one million visitors per year in the past three years. Its own population is just over 200,000. It is estimated that these tourists spend some $235 million (U.S.). The total national revenue of the Bahamas in 1971, was just over $100 million. The total exports of the Bahamas in 1967 amounted to less than $20 million.

The other major weakness of an economy which has tourism as an important base is the sensitivity of that economy to changes in world situations, as well as to the fickleness of the average tourist. Rumours of recession or any instability in the monetary situation affects the tourist industry almost immediately. Normal restrictions on travel

and the use of foreign exchange can affect the tourist industry dramatically. An increase in fares in one direction and a decrease in fares to another part of the world has an immediate effect. Any internal difficulty, whether from a health hazard or some spasmodic political activity can lead to substantial cancellation of bookings as the tourist is likely desirous when leaving his own country to want to forget the struggles and troubles in that country and not to replace it by those of another. Again, you can see the obvious weaknesses when tourism is a major part of an economy.

Manufacturing, although appearing on the scene rather late, now seems to have established some part in the economic activity of these countries. In Trinidad and Tobago, which has the largest manufacturing sector, the contribution for manufacturing to the total output was 18 percent in 1971. This is compared to 15 percent in 1966. So the growth is not very dramatic. It is also compared to the contribution of thirty-five percent from the oil industry.

In Jamaica, manufacturing contributes about 13 percent of the GNP, compared to the 15.6 percent coming from the aluminum industry. What is more important, however, is not these facts and figures, but rather the type of manufacturing. With the exception of the food-processing industry, manufacturing in this particular region takes the form of assemblying of partly finished goods. This is justified either on the basis of a protected market, so-called "import substitution" or from the benefit of comparatively and reasonably cheap and productive labor. It can be argued that this is one stage of development, but after a period of some twelve years, proposals for new activities still tend to be thought of as simple assembly operations, as distinct from true manufactures. This is a serious weakness in the whole growth, and hence results in the slow growth that has taken place in manufacturing activity.

For those of you who may not be too familiar with what this means, I can give you one extreme example. This particular one is the manufacture of radios for the local market. These radios are shipped from Japan in kit form--complete kit form, and they are assembled. And one may say, "well, there's nothing very wrong with that." If you follow this back, however, you will find that what in fact has happened is that the radios are first made completely in Japan, tested, and the brand name put on; they are then completely disassembled and repacked and shipped out to be reassembled and sold in stores on the local market. One may argue, "Well, this sounds very ridiculous." It is on the one hand, but on the other hand, if these are the conditions for the so-called transfer of technology; if this particular firm says, "the only way you can use my brand name is if you allow me to do this," then obviously this is the price one has to pay, and the price is paid by the consumer.

There are no serious attempts to embrace the other activities of manufacturing, namely, planning, sorting of material, inventory control, design, production and marketing. It is relevant that of the 400 engineers in practice now in Trinidad and Tobago, less than five percent of them are involved in any type of manufacturing operation, and the few that are involved, have accepted positions in this field as a last resort. A similar situation exists in Jamaica, where there is a complete absence of any true manufacturing operation. Finally, dealing with the other important economic activity in these islands--mining and associated professions occupies a major place. Jamaica continues to be the largest exporter of bauxite in the world with contribution to the GNP from this activity of some 16 percent. In Trinidad, petroleum occupies even a stronger position. The petroleum sector accounts for some 30 percent of their GNP and over 80 percent of their export earnings. It employs over 20,000 workers directly, and supplies 27 percent of all government revenues. If anything, this activity is beginning to grow even further and to dominate the scene in Trinidad and Tobago even more so.

The difficulty that affects this important sector of the economy, and it is one that has been recognized internationally, is that both in Jamaica and Trinidad, these important centers of activity with one exception are fully owned and managed by multi-national corporations. The advantages and disadvantages of this arrangement are well known and have been fully debated. It is not my intention to get into that subject, but merely to state that the problems that have been identified in manufacturing where the activities in the islands are restricted to mere processing, is even greater in the case of these industries. The planning of production, the planning and design of new plants and modification of existing plants, the marketing, hiring of key personnel, are all handled centrally in some foreign head office with few major decisions being left to the local operations. This form of decision-making machinery is an obvious weakness in the economic system. So, this covers the major aspects of the economic activities.

What about the social structure as it relates to all of this? I am sure you've heard at length from George Beckford, or if you haven't, you should read his study on Resources and Underdevelopment in the Caribbean. In this paper he explains the plantation system and its effect on various activities in this system and his thesis is that this system contributes to a persistent resource underdevelopment. He defined the plantation system, and I quote, as "the totality of institutional arrangements surrounding the production and marketing of the plantation staple." He goes on to describe the plantation system as a type which brings labor, capital and enterprise from elsewhere and establishes production on some new territory with relatively open resources. I do not intend either to agree or disagree with the remedies proposed by

Dr. Beckford, and I'm sure he has explained the remedies he has in mind to rectify these situations, but I am more concerned with the facts as they exist now. He identifies, and I agree with him, the three major reasons why the plantation systems face persistent underdevelopment. They are: (1) that the plantation system denies the majority of the people of the plantation society a real stake in their country; (2) that a chronic dependency syndrome--you hear the word dependency coming up again--is characteristic of the whole population because the locus of decision-making concerning fundamental economic issues resides outside the plantation society; (3) that the majority of people are not sufficiently motivated toward the development effort because of the first two reasons.

What about the educational system which is of concern to me, as I am sure it is to you. The educational system has for some time contributed to the lack of development of the technical infrastructure. It has always been a system which in the first place was imposed upon us by our colonial masters, and second, adopted by the newly independent states. In any event, it continues to be the pattern of all levels, from the primary to the university level under the British system to the extent that even now secondary education examinations are set and marked by English institutions, and up until recently, the university examinations followed a similar pattern. As a result, the relevance of education to meet the social and economic needs of the region would have been met only by accident. All of you recognize that education is one of the key factors in the development of the technical infrastructure and any strategy must deal with this problem. The identification of these basic weaknesses in the structure of the economy, the structure of the society, and the system of education, should have convinced you that a strategy is needed. One cannot wait for normal evolution to rectify the situation. A positive effort calling for solution and adoption of solutions must be made. What, then, is the strategy?

Obviously, the long-term removal of these weaknesses must come from major political decisions on both the national and international front. These weaknesses, which I've described at length, have been recognized by most governments in the Caribbean. Some of them have taken positive steps to remove them, and a perusal of the development plans now floating through the islands will confirm this. We read in the most recent Trinidad and Tobago plans that a process of self-consistent and internally generated development can only be set in frame if the following problems are overcome:

1. A diversification of the structure of production so that the economy can continue an internally generated

process in the following industries: agriculture, fisheries, manufacturing and tourism, irrespective of adverse or favorable development in the petroleum sector of the economy. This is from the five-year development plan for Trinidad and Tobago, 1968-1973.

2. The elimination of structural unemployment.

3. A removal of the center of decision-making in investment, production, employment, management and marketing from overseas control to locally controlled interest conditions. Again, at a more fundamental level, Trinidad and Tobago is busy rewriting its constitution and has taken positive steps towards its major resources. Guyana has taken similar steps, and noises of this are being made in Jamaica.

The recent establishment of the Caribbean common treaty with its harmonization of physical incentives is another step towards rectifying the serious damage done by the very generous fiscal incentives so readily adopted in the '60's. The expansion of educational facilities at all levels, including the university level, with specific objectives, as distinct from the mere copying of what is taking place elsewhere is another contribution to the overall strategy in the removal of these weaknesses.

These are long-term measures and are the continuing measures which must come from political solutions. However, I contend that a major area has been completely ignored by these countries and these governments, and it has been ignored because, on the whole, scientists and technologists and educators have not actively participated in prescribing these remedial measures--and again for very good reasons--it stems again from this lack of self-confidence which generates lack of confidence in each other. The area which has been ignored, the area to which I refer, is the development of the technical infrastructure. I see in any major improvement of the technical infrastructure, a generation of self-conifdence and confidence in each other. I see the creation of an environment which encourages innovation; an environment in which technology is controlled and in which the technologists are constantly challenged and allowed to reach their maximum potential. In addition to having available a pool of trained manpower at all levels, I see a body of progressive entrepreneurs, a well-staffed, confident and efficient civil service with respect developing between the public and private sector. There is one major ingredient in the achievement of all this, namely, human resources, and it is for this reason that this

strategy can be the simplest, as well as the most complex.

What are the keys that could lead to the strong motivation of this human resource towards its achievement? It is simply the expansion of educational facilities. It is simply the raising of wages in agriculture and manufacturing. It is simply the nationalization of key industries, allowing major participation by all. It is obvious that it is not as simple as that, and I see two categories of action in addition to the more fundamental and long-term political processes which are slower. The two categories are: one with a medium-range response, and I'm thinking of between five to ten years; and the second with a much shorter response--under five years.

Let's deal with the first category and look at the sectors of activity that I've previously identified. Education: a major revision of curriculum at all levels is needed. The systems must be diversified to bring in not only general academic training but also specialized training in agriculture and commerce. There must be a greater awareness of science and the possibilities of science. The role of science in life, in everyday needs, in food, in health and in leisure, must be clearly identified and brought home, possibly through education. In this connection, the public media has a critical role to play and one that they have tended to ignore. In the Caribbean, as in the other developing countries, the written word is a powerful weapon. It can be a weapon that can be used in this defense. Again, in line with education, I see the writing, the acceptance, and the implementation of a well-thought out science policy from which we could plan and produce the number of scientists and technologists that we need and the type of research results that are needed for the country.

Agriculture. A virtual revolution must take place in the attitude towards agriculture and methods used in agriculture. In spite of its importance in each island and each territory, without exception, it is also recognized as one of the least productive sectors in the economy. One recent development plan makes the profound statement, and I quote, "So long as the greater part of the agricultural sector remains with its existing low level of productivity, the country will continue to be underdeveloped." If any statement calls for a revolution, that one does. What sort of revolution? Perhaps a massive expansion program with the university, with its many resources in the forefront; the introduction of demonstration farms with results available through all channels, including the public media. The public sector participants, initiating, promoting and financing fruit and vegetable processing facilities in order to end the chicken and egg situation.

I haven't mentioned the university yet, and perhaps the whole attitude here could be demonstrated by a crisis problem that we are now having at the University insofar as it relates to the Faculty of Agriculture. There is a very large unit called the Regional Research Center (RRC) which is associated with the Faculty of Agriculture which is staffed by full-time professional scientists and agriculturalists whose major activity is research in the crops that are important to all the territories of the Caribbean. Recently, because of a shortfall in the subventions to this program, there has been talk of retrenchment of some of these professionals. In the verbal battle that has been going on between these professionals and the government--a very significant attitude has developed. These professionals are all very well-qualified, very experienced, and perhaps form a center of some of the leading agriculturalists and scientists in tropical agriculture in the world, however, some of the governments are claiming that the results are not forthcoming from this center after all these years of support.

The scientists and agriculturalists, on the other hand, are claiming that their terms of reference were not so much to produce the results towards any ultimate objective but that their terms of reference were to do research; and if anybody wants to find out how to use this research, well, that aspect really doesn't concern them. This attitude, strange though it may sound, in fact--if you read recent newspapers, you will find it has been headlined--is an understandable attitude if one were dealing with a research insitution located in the United Kingdom, France, or somewhere like this where they are, in fact, involved with fundamental research and it really doesn't matter whether these results are used by the farmers or the government. That's the sort of situation that I refer to which calls for an immediate resolution.

The professions of management, engineering, architecture, accounting, should take on a national identity. The creation of national entities to embrace these various professions should be undertaken and top priority be given to their organization for public projects.

Contracting. A similar situation should be instituted in this sphere of activity. The many and scattered, small contracting firms should be encouraged to work under a single, or at the most two, umbrellas to allow competition for major project works; and under that umbrella, skills of all levels could be attracted and rewarded. Similarly, with respect to architecture, accounting firms, auditing, the same situation can be repeated. With regard to manufacturing, again I'm talking of very short-term measures - pilot industries--which will form the basis of true manufacturing enterprise should be established by public sector agencies. I'm suggesting public sector agencies because I simply feel that the private sectors won't do it. Whether

it is electronics, metal works, tool or dye work, woodwork, what have you--these industries should work in close collaboration with the universities and research institutes.

A word about research institutes--a word which many people consider taboo in developing countries, but which I consider to provide one of the keys. They preferably should form part of the university activity, provided that the work is problem oriented and we do not run into the sort of problem I described previously. This sort of problem-oriented research should be encouraged by the university. I have had the good fortune, or otherwise, of being involved in preparing a number of research proposals and seeking external aid and aid within the Caribbean for various research projects. And the most recent example after all of these years of doing this came as a real shocker, when having spent some six months preparing a fairly substantial program request for research money, the representative of the foundation came to Trinidad to see us, and was very impressed by the program we were doing, etc. This was his very first visit to Trinidad--but at the end of it all, he prescribed a solution: that we really didn't need to do research; that we were not quite ready for research; that research really is something that has to be done elsewhere; that it would be a waste of his foundation's money to invest any money in research. After all, we could buy or license technology. Needless to say, there were a few warm words of exchange between us.

To support all these various activities and to encourage and get some of the people with these skills to return to the Caribbean--and again I'm referring to short-term measures--to support this and to provide at the same time a well-recognized machinery--I am proposing (and I do this in all seriousness) that these countries either collectively or individually set up, for want of a better word, "human resources agencies" with authority for manpower planning, manpower placing, manpower utilization and recruitment of Caribbean professionals, technicians, craftsmen and those with ties in the Caribbean.

We, in the Caribbean, have spent millions of dollars and continue to do so to attract foreign investment and foreign technology, but, to the best of my knowledge, except for the efforts made by our offices of the embassies and the High Commission officers here and elsewhere, not a single cent has been spent to attract our own nationals who have skills and experience that are badly needed. It has been completely ignored that, in addition to foreign investment and technology, the major and probably the more important ingredient is the question of people--the human resources. Anyone who has studied the recent brain-drain study will be amazed at the number of skills at the professional, technical and crafts level that are scattered throughout the world and I feel certain that some major unorthodox effort has to be undertaken to attract some of these people back.

Hence, I want you to consider with all seriousness, so far as the model of the Caribbean is concerned, this proposal of a human resources agency. My further dream is that this would be done on a regional scale, regional in the sense of the Caribbean.

And so to summarize, therefore, the strategy as I see it. First, there are the long-term and fundamental changes that are coming about, that will come about, and are in a continuing process. They derive from political decisions that have been made, that are being discussed, and that presumably will be implemented. They affect national policies and extend internationally, and for this reason, they take a long time but are needed. The second need is for medium-term measures in the following fields: (1) Education: we need a new attitude; (2) Agriculture: we need a virtual revolution with all sectors that are peripheral to agriculture playing a part; (3) Manufacturing: in addition to pilot efforts under government sponsorship, a complete review of the scope of manufacturing of various proposals should be done and the depth of the manufacturing should be rewarded; or put another way, the superficial approach to manufacturing should not be encouraged. The question of value-added now become important, not from the point of view of fiscal benefits, but from the point of view of improvement of the technical infrastructure.

Third, under the short-term heading, I see the creation of national professional organizations to attract and to undertake the practice of the key professions which are critical to both the social and economic development of the nation. In this regard, I see the creation of the pilot industries which I referred to before, initially sponsored by governments, but leading to viable enterprises that can be spun off to the private sector. And finally, the creation of a human resources agency, where the whole question of people, the question of bringing people back, ensuring that when they do return to the Caribbean, that they are rewarded and that they are allowed to meet their maximum potential.

Some of these things are being done and I don't have the time nor the inclination in a short address like this to go into any details. Afterwards, I'll be prepared to answer and give some examples if you like. If this model is useful, that is, the model that I've used of the Caribbean, if only in understanding the problem, my contribution will be worthwhile. A serious and frightening problem does exist. Developing countries are either going to grasp it in the sense of taking unorthodox steps in order to narrow that gap, or, as some of them have already done, just relax and learn to live with it.

May I end with a quote from one of your former professors? "But the fundamental question is this: Can a tiny country with a clouded and unpropitious history rise above its past and assure to each and every citizen his or her full measure of human dignity by building a humane and equal society with a political, economic and cultural identity of its own? I have no doubt about the answer."

You must have recognized the stamp of Eric Williams in that quotation. He ends by saying he has no doubt. I have serious doubts unless a very unorthodox approach is adopted to solve this problem. I thank you.

WATER SUPPLY AND WASTEWATER DISPOSAL IN DEVELOPING COUNTRIES

The Honorable C. B. Ramkisor

January 23, 1974

WATER SUPPLY AND WASTEWATER DISPOSAL IN DEVELOPING COUNTRIES

The Honorable C. B. Ramkisor

Ladies and gentlemen, first I would like to express my appreciation to the School of Engineering at Howard University for inviting me to speak on water supply and wastewater disposal in developing countries and to share with you some of the experiences I have had in my own country which may be important for students at Howard for use in their own countries when they return. I would like to again thank Dr. Pierre, Dr. Walker, Dr. Varma, and of course, the whole staff of the School of Engineering.

My speech won't be very technical. It will be addressed more to policy-making issues. In thinking about the topic, we should first ask, "Why should we worry about this problem?" As you know, human beings cannot exist without water, and you have to dispose of used water properly. It is also well known that water carries a variety of diseases to human beings. Thus, there is the possibility of various infections being transmitted to human beings through their drinking water. Also, the water should be of good quality and of great enough quantity to meet the health needs of the people of your nation.

The diseases which human beings can contract from water-related diseases and water-borne diseases are bacterial , parasitic, viral, etc. You probably have read about some of these diseases and the fact that thousands of people die every day because of poor water supply. In developing countries, especially, it is very important to supply safe drinking water. The developed countries also have problems, but those are different. They have enough water, but because of heavy industrialization, their waters are polluted.

In developing countries, there is another problem because you have to be careful in those areas where you do not have pure water or enough water for the population because of the effects of urbanization. This is because the people will go where they can have better living conditions and cities provide many and varied facilities. Now, if all these people come to the cities, you have to have enough water. You will also need electricity, roads, schools, and of course, jobs for these people. You have to plan carefully in these developing countries not only for water supply and wastewater disposal, but also to have all the facilities that are needed in an area to stop the trend towards urbanization. There must also be a program to create jobs in the rural areas.

There is not only the problem of finding jobs for people who move to the city, but there is also a social problem. There are economic problems, and later there will be health problems if the city grows very quickly and the water supply and wastewater disposal system do not keep pace. Therefore, I would stress again that you need well thought out plans for the growth of developing countries.

Often these developing countries try to solve their problems without realizing that they can get help from outside their own countries; and we know that there are not enough professionals in these areas to design good long-term plans. In Surinam, with 160,000 square kms., and a population of about 400,000, you see that about 90 percent of the population lives on the coastal area. Ten percent of the population lives in the interior; and of these 400,000 people about 200,000 live around the city of Paramaribo, and the other 160,000 live along the coast.

At the beginning of 1952, we obtained information about water projects underway in other countries and we learned that the U.S. Agency for International Development could give us some assistance. We applied for this aid and A.I.D. officials came to Surinam and began a program called "Shallow Dig Wells Water Supply Program." They traveled all over the coastal area and obtained information about Surinam's geology. When they had collected all this information, they started the shallow dig wells projects; and similar projects are being carried out in many developing countries which are financed by international organizations. There are projects going on in Africa financed by the European Common Market especially for shallow dig wells. The specialists we had in Surinam from the United States Government looked ahead to think about what could be done after the program was completed. Specialists were needed in this field so it was decided to send some people from Surinam abroad to specialize in these fields.

The "shallow dig wells program" is not so technologically advanced that specialized help was needed, but as you go further along and plan water supply systems and wastewater disposal systems, then you need skilled labor. You could, of course, import technicians who would come and do the job and then go away without teaching the people anything, but this is not the way to do it. Local people should be trained in these programs as we are doing in our program.

A few students went to other countries to study this special problem of water supply and wastewater disposal which is called sanitary engineering. I was one of them. I went to the University of Oklahoma where I studied for two years. There I met Dr. Varma, and now I meet him again here after ten years.

Beside the shallow dig wells project, we had an adequate water supply in the Paramaribo area and in two other small population centers. We currently have about eleven water supply systems and we need about fifty-five to supply the whole coastal area--about 70 percent of the population with good water. We tried to get help from organizations outside the country.

We knew that the Pan American Health Organization was carrying out a number of programs in this field in different parts of the world so we applied to get assistance from them, and in 1969, they agreed to work with us in Surinam on a coastal area program dealing with water supply and wastewater disposal. It was important to know about the quality and quantity of both the ground water and the surface water. The program lasted about three years and we drilled about 150 wells to find out where the water-bearing sand was located and to ascertain the quantity and quality of the water. Surinam has a number of rivers and more useful data was obtained about these. We also have built a man-made lake in Surinam and we see today that, because of the energy crisis, we have to build more of these kinds of lakes. A hydro-electric power dam was constructed and we obtain a great deal of energy for aluminum smelting for a bauxite company located nearby. One water plant is treating water from this lake.

The drilling program took about three years, and when we obtained the information we needed, the Pan American Health Organization also helped us to design the plan and to train local people. This was just recently completed. We are now in the construction phase of this program. Of course, it cost a great deal of money, but the pre-investment money--50 percent of it came from the government and the other 50 percent came from the UNDP. We are now constructing about five plants. One of them is financed by the five-year plan from the Dutch government. We have four small plans financed by UNICEF on a 50-50 basis. Unfortunately, in developing countries, people sometimes do not know that there are a a number of organizations which can supply financial aid. In our country, we have attempted to get as much aid as possible from outside sources.

For a developing country, the design of the plan is most important. In Surinam, we asked the Pan American Health Organization to help us to design the plans. Normally, when you receive aid from another country, then the country that provided the aid will ask you to give these jobs to engineering firms from their country. However, the engineering firm will design a costly plan because they will get a percentage of it. The plans should be designed so that they are simple to operate and to maintain. In our country, we tried to use materials which were available in our own country first, and then to import whatever we did not have. We

were fortunate in that our ground water supply did not require a complicated treatment process. In various places, the ground water we have available needs only to be disinfected by chlorination. In these cases you only need a well; a pump to draw the water out of the well; chlorinate the water; pump the water to an elevated tank, and then you have your distribution system, house connections, etc. Most likely, the pumps and the chlorinator will have to be imported, but you must buy a pump for which you can get parts in your country. Other countries might require a complicated treatment of their ground water which is also required in some places in Surinam. There is a significant concentration of iron in some of our ground water, and this has to be removed which is accomplished by aeration, filtration, and then chlorination. We attempt to build these aerators with materials available in our own country.

Concrete bricks are used extensively for the aerators. After aeration, the water goes through a rapid sand filtration system and then the water can be chlorinated. In developing countries, the population centers are built along rivers. We have tried to build wells, shallow wells along these rivers, using the sand that is between the river and the well as a filter and pump the water from well and then it needs only to be chlorinated.

In Surinam, we had three pieces of rotary-type drilling equipment from the Westinghouse Air-Brake Company, which was formerly George E. Failing Company of Enid, Oklahoma. These rotary-type drilling machines can only be used in areas where you have sand and clay layers. In the United States, for example in the Minnesota area, where you have a lot of pebbles, it is better to use percussion-type drilling equipment. Drilling by the rotary system is faster, of course. If a country cannot afford this expensive equipment, then the jet-type equipment can be used. This equipment is far cheaper for drilling water wells up to 100 feet.

We have drilled wells in Surinam up to 300 feet deep by jetting. Of course, the jetting system takes more time and, of course, the possibility of losing drilling pipes is greater . Drilling by this rotary equipment system goes very fast, it is very effective, and we completed about 150 wells in two years. They were mainly 1000, 500 and 400 feet deep, with most of them being about 400 feet. Another important factor is the kind of casing which is used. In general, steel pipes are used because in Surinam and in many countries you will have water-bearing layers that are very corrosive. The steel pipe casing lasts about six years, and after this period you will have to drill another hole. In our country, we

have been drilling the holes and casing them with PVC--plastic--pipes. These pipes are very durable. The wells cased with PVC piping are still being used after fifteen years. We have also been using asbestos cement pipe casing but because of the heavy weight of asbestos cement, we couldn't finish wells deeper than 50 or 40 feet, but with the PVC casing, we have finished wells three, four, five hundred feet deep. There are also other parts that a well requires--e.g., a screen. Generally you must use a material for this screen that cannot corrode too quickly. Especially in developing countries, it is important that a well be inexpensive to construct and that it have a long-life. In this case it is advisable to use both PVC screening and piping. So, we have been using a lot of PVC piping and have had good results, and therefore, I would suggest that PVC be used in most countries.

Our present program is planned through 1981, and the government has decided that by that time, about 70 percent of the total population should have good water. At this time, about 45 percent of the population has water available, and in seven years, the figure will be about 75 percent. The water supply plan is a good one, and we also have a plan for the disposal of wastewater.

We will still have to estimate future demand. In developing countries it is difficult to say how much water will be needed after five years. The water demand in Surinam during the coming ten years is estimated to be about 150 to 200 liters per capita per day. Many plants have already been built, other plants are under construction, and we have used a great deal of local materials in their construction.

As I mentioned before, it often happens that an outside engineering firm will design a plant for you which will be quite complicated and expensive, but in our case, the Pan American Health Organization designed the plant together with engineers available in our country. Also, as I mentioned earlier, we have been using PVC pipes extensively and we have gained a great deal of experience with PVC pipes. It is a good material--it lasts long, is easy to handle, and cheap to lay down.

As far as house connections are concerned, in our country we have found that if people want to have house connections, they have to be metered. If the water is not metered and you have to calculate usage, the actual water consumed will usually be much higher. However, we use two systems --one with meters, and in the case where people do not want water in their house, we do not use a meter. However, the government would like to see everyone with water inside their house, but there are a number of people who want a tap outside their home. In that case, it is too costly to install a meter because with a tap outside the house, most

people do not use a great deal of water. We have discovered a faucet of a special type made by a company here in the United States--The Fort Meter Box Company which has proved to be very practical. You have to push on it to open it, and even when you continue pushing on it, it stops after having delivered a certain amount of water. Very often faucets are designed so that you can continue pushing on it or by placing a heavy object on it, it will continue to stay open and deliver water. This particular faucet which we have been using will stop after delivering a certain amount of water. It is a good system and it is working well in Surinam and I would recommend its use in developing countries wherever taps are installed outside the house.

With regard to the rates charged for the water, we have different rates established depending on the value of the property or its size, but for one faucet outside the house we have a fixed price. In our country, the poor people pay only two guilders (about one dollar) a month. All the pipes used for the distribution system are made of PVC material that is manufactured in our country.

I would like to talk a little now about wastewater disposal, and if you have any questions about water supply and you want to discuss it further, we can do so afterwards. First, I'd like to discuss wastewater disposal in our cities. We have one large city--Paramaribo--about 120,000 people live there. Here, we have a combined sewer system and each house has its own septic tank, the overflow goes to the sewer system and from there it goes to the Surinam River. Until now we have had no problems, however there exists a certain danger because the septic tanks are located near the water supply pipes and the water supply is not chlorinated in Paramaribo. I am sure that it will not be very long before it will be necessary to chlorinate the water.

At the present time we are planning a new collection system for sewage for Paramaribo. The plan is ready, but the system is not yet under construction although we anticipate that it will begin very soon. We have planned for Paramaribo a separate system for rainfall and for domestic sewage. We do not require treatment at the present time because there is sufficient water in our rivers for dilution. The Surinam River has a high flow rate and thus the sewage is easily dispersed in the river. We also have centers which are further from the rivers and in that case the wastewater is treated in sewage lagoons. As you know, in developing countries, if there is plenty of available land, sewage lagoons are the easiest and cheapest way to handle wastewater, especially in tropical countries. It has been our experience that sewage lagoons in our country, and in many developing countries, are working very well.

In Surinam, we presently have one in operation and another one under construction. I can tell you a little of our experience with the one that is under construction. We had an engineering firm to design this one for us, and they designed a very expensive plant, a complicated one. It was an activated sludge system with coagulation and sedimentation. The equipment had to be imported from the United States or Europe. We were finally able to prevail upon them to design a much simpler plan using an oxidation ditch and it is now under construction.

So, the one thing I would like to say to you is that you must be careful about the design: any plan designed for wastewater disposal and a water supply system must be designed as simply as possible and you must insure also that you have people that can operate the system. It often happens that when a foreign firm designs the plant, they don't train local people, and when their experts leave after a few months, the plant is not operating any more and then you have real problems. So, try to have your own local people trained. This is most important for developing countries. Before I stop, I think I should mention that you have to have a good organization for planning water supply systems and wastewater treatment plans.

THE BREAKDOWN OF SAHELIAN ECOSYSTEMS: ECOLOGICAL DEMOGRAPHIC AND SOCIO-CULTURAL FACTORS IN THE WEST AFRICAN DROUGHT AREA

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February 20, 1974

THE BREAKDOWN OF SAHELIAN ECOSYSTEMS: ECOLOGICAL DEMOGRAPHIC AND SOCIO-CULTURAL FACTORS IN THE WEST AFRICAN DROUGHT AREA

Elliott P. Skinner

Thank you very much, Dean Pierre. It's a pleasure and a challenge to have been invited to speak before an audience in the School of Engineering, but since anthropologists are a very arrogant breed, and believe that they can address themselves to any subject pertaining to man--anthropos--I thought I would welcome the opportunity to see whether or not some opinions of an anthropologist about the basic ecological, demographic and socio-cultural factors in the West African drought areas could be placed into a local computer to the end of facilitating an output conducive to the elaboration of a schema for the resolution of some of these problems.

An ecosystem is currently defined in anthropology as a dynamic interrelationship between a human society, and the plant and animal species within a specific physical environment. Thus, we see an ecosystem as having three important aspects: a physical aspect, a biological aspect, and, of course, a societal aspect. As we look at ecosystems, we note that over time they achieve some kind of equilibrium. An equilibrium is achieved as a function of human beings recognizing the limits of their environment, and learning how they can exploit the biota in these environments so that human societies can continue.

We also note that ecosystems undergo change. They are changing all the time. However, these changes are so structured that ecosystems persist in some kind of equilibrium, and unless these ecosystems are challenged or threatened, they tend to persist. One challenge to ecosystems is climatic, and when climatic changes do occur, human populations attempt to adapt by utilizing the landscape in new ways, moving outside the landscape, or using the biota in novel ways. Many human populations have survived climatic changes by changing their culture in order to adapt to their new environment.

One of the most difficult challenges to ecosystems is, of course, conquest of an ecosystem by another human population. If the local population is exterminated, then of course there is a fundamental change in that total ecosystem. In most cases, however, the local society is incorporated into a larger ecosystem, or what I've been calling an ecosystem network. There is a linking of the local system with a wider system. Depending on the links between the local system, and the now

superordinate system, there is a possibility of viability, but not always. For many reasons, local ecosystems cannot tolerate being drawn into larger systems; they simply disappear as functioning systems.

What we've seen over time in the Western Sahel is a whole historical process in which local systems have flourished, have tried to expand and have contracted. Today, we are experiencing the latest in a whole dynamic series of events that have marked the history of the Western Sahel. Seen in archaeological perspective, the Western Sahel, or the Sahel, the Sahara, and the Sudan have not always looked the way they look today. We find that in the waddis of the Sahara the remains of stone tools, engravings, and other artifacts indicating that during the Neolithic period, the area was inhabited by pastoral populations and even agricultural populations. We know also that during the arid period that marked the end of the last glaciation that it was no longer possible for human beings to live in this area. True, a number of agricultural populations did retreat to the oases. They are still to be found there, and their numbers have been augmented periodically from the south. But, by and large, the populations that lived in this area during the last phase of the Würm glaciation left the area. On leaving the area, many of them retreated to the north, and many of them retreated to the south, into the area around Mauritania. These later migrants probably created the ancient kingdom of Ghana.

We know about Ghana because of the work of El Bekri in the 11th century. Ghana probably arose around 300 A.D. and played an important role in the Western Sudan. Lying athwart several trade routes, Kumbi, Ghana's capital, became an important entrepôt, in which populations from the north and from the south were able to trade, develop sociocultural systems, and synthesize what was local with what was foreign.

But Ghana, like many of the emerging Sudanese kingdoms (and the later empires) had ambitions of conquest and moved into the desert, incorporating within its social system some of the Berber-Tauregs. Later on, as a result of the introduction of Islam, many of the groups conquered by Ghana revolted, used Islam as a mobilizing weapon and destroyed the society and civilization that was known to us as the empire of Ghana.

The fall of Kumbi was accompanied by a decay in the ecosystem of Ghana so that when another group arose and started to expand, the center of expansion was not in the former Kumbi area, but farther down in the Western Sudan in the Niger area at Niana. Now, here was a dramatic shift. Whereas ancient Ghana profited primarily from trade, the basis of Malian civilization was agriculture and trade. This area

was able to support a very large population. The Malians were able to expand their civilization and incorporate them into their emerging empire numerous populations. They used Islam and Arab culture to expand their horizons and linked West Africa to Mecca by pilgrimages, and to the Mediterranean by trade, commerce, and diplomacy.

The Malians also tried to expand their ecosystem by moving farther south into Mossi country, and farther east into the Hausa states. In the process , they incorporated the area around Gao inhabited by the Songhai. The people of Gao, like the earlier people of Mali, did not willingly accept a subordinate status and taking advantage of the conflict between the Malians in Timbuktu and Jenne, and the Tauregs to the north and other populations to the south, the Songhai were able then to overthrow the Malians. In the process, Sonni Ali and others created a much wider ecosystem linking Gao to Timbuktu and Jenne, and expanding the power and influence of Songhai all the way to the Western Atlantic. This was happening at a very auspicious, or inauspicious period, in the history of Western Africa. It was during the heyday of the Songhai empire that Westerners appeared around the bulge of Africa and started to trade with the Africans along the Gold, Slave, Pepper and Ivory Coast. The nature of this trade ultimately sapped the strength of the ecosystem that was Songhai. And, when in 1590-1591, the Moroccans moved down into the Sudan to find out what had stopped the flow of gold from this area to the north, Songhai fell a victim to two forces: the invasion of the Moroccans on the one hand, and the loss of important trade to the south.

For about 2000 years the Western Sahel was a viable and important social, political and economic entity. When the basic economic foundation that had supported this system was no longer available, the system broke up into smaller kingdoms. The Bambara were independent, the Djerma kingdom was independent, and the Mossi who had been attacked by Mali and Songhai were independent. The Fulani kingdoms began to emerge, so that in the absence of a basic economic structure that supported the political strength of the larger structure which had been Songhai, this area began to break up into smaller warring groups. I suspect that many of these competing groups were in the process of trying to recreate a larger and more viable system.

This process of state-building was taking place when Al Hadj Omar, Mamoudon, and Samoray-Toure, sometimes using guns, sometimes using slaves and trade, tried to take over the whole area. When we look at the history of the world, what we find is the tendency of peoples to form larger and larger entities. During periods of breakdown, there is a reduction in scale of societies and local formations until a new power arises somewhere to recreate a larger and more viable system. The Africans were in the process of doing this when General Faidherbe moved

into Senegal with a policy of "peace or powder" to introduce French power into this area. Gradually, through a whole series of wars, and sometimes treaties, the Western Sahel was drawn into the structure of the emerging French West Africa empire.

What were the French all about? According to their views of empires, the French tried to create basically two systems of colonies: under one system, France sent its citizens abroad, for example to Canada, to create what was called "colonies of settlement;" the second type of colony desired by France was called a "colony of trade." West African societies were incorporated as colonies of trade. This meant that this area was never seen by France, whether by Colbert, by Jules Ferry, or by Albert Saurrat, as an area which could be developed as an entity in and of itself. Almost every kind of development that took place in this area was designed with one aim in mind--to serve the interests of France. This was true when the area was divided into colonies in which there were cercles, subdivisions or posts--the whole political organization of French West Africa was designed in order to make government easier for the French. We hear a great deal about the penchant of the French for Direct Rule. The fact is that because important kingdoms were present in this area of Africa, the French used adirect Rule, just as the British used indirect rule in comparable areas under their own control. As one looks at this area in terms of transportation networks from the point of view of roads and railraods--what does one find? One finds that a railroad extends from Dakar to Bamako; another railroad from Abidjan to Ouagadougou; but no attempts were made to link these railroads across colonies so that internal trade was possible--all of these railroads ran directly to the coast.

In terms of economic development, no systematic attempt was made to develop all the crops in this area. Earlier, around the 1700's, peanuts were found to do very well in Senegal and peanuts then became the center of commercial agriculture in this colony. Later on as textile mills developed in France, cotton became the center of commercial development. This occurred even though most of the people in this area used peanuts only sparingly and used cotton only for making their own clothes. Most of the people in this area grew and consumed millets and sorghum, crops which were very adaptable to the harshness of the zones in which they found themselves.

Indeed, the further north one goes, the more monocultural agriculture becomes. At the edge of the Sahel area, people can only grow sorghum and a few varieties of millet. It is only when one moves further south that there is the possibility of adding maize or potatoes, or

even rice. And given the dryness of the area, rice is only possible as a cultigen in the river valleys or in bottom lands. Yet very little attention was paid to experimenting with different types of crops, especially those crops which the population used as their basic source of food.

The social change that took place in French West Africa came as an afterthought and was very often stimulated by the fear on the part of the French administrators that they would be criticized by the missionaries for permitting the traditional African family organization--circumcision, schools, and other indigenous institutions to remain. Thus, Sister Marie Andre du Sacre Coeur was able to create all kinds of problems for every governor in this area by insisting that the age of marriage be changed; that young women be permitted to marry without the consent of their families, and so on.

Since these basic institutions articulated with the traditional labor organizations, and with the traditional political organizations, the social changes desired by the missions in order to permit people to become good Christians or western in outlook, constituted a basic challenge to the nature of the French colonial system. And I want to emphasize this. The French never really governed this area. To have governed this region would have meant establishing the institutions of the French colonial system in every village, incorporating the Africans into the local sub-system of the ecosystem network which was the French empire.

In many colonies in the Sahel there was only one European ruling or governing 60,000 Africans. What this meant then was an imbalance between the structure on the state level--a structure created to draw men and materials from the local areas, a structure which was not interested in transforming the local base which produced the men, the materials for the super structure and ultimately for the French empire--and the local communities. It was this kind of imbalance in articulation and in development that was to lead to the rise of nationalism which finally brought these areas to independence.

Who were the people who were involved in the nationalist movements? By and large, they were people who were trained in the mission schools--they were what we call the "black white men." They were the ones who knew about the French constitution--many of these individuals had served in the armies, the colonial wars of France. These were the people then who were able to talk to the French and debate with the French about the nature of the colonial system. However, many of these people did not have viable links with the rural masses because in order to become fluent in French, to talk about the plays of Racine and Corneille, to talk about négritude, one had to leave the bosom of one's family by the age of five--one had to become an enfant du père blanc--"a child of the White Fathers." These children of the White Fathers were the ones

whose task it was to move their societies from dependence to independence. These individuals had learned quite well; they had learned from the French that the government of a country should depend upon the will of the governed.

The problem for everyone was that the French never practiced democracy in Africa. True, the people of the four communes of Senegal were citizens, but even they had problems. The Senegalese were black and once outside of Senegal, unless they wore their citizenship on their sleeves they were taken for subjects, and treated as such. Democracy, then, consultation between ruler and ruled was alien to French West Africa. The African elite knew that the Europeans had specific ideas about the nature of democracy and the nature of leadership so in 1945, when given the opportunity to take part in the political process, these Africans moved into the rural areas to bring a message that the local people had never heard. The message was that: "If you vote for me, I can build you schools; I can restore control over your families; I can restore your manhood, and your dignity." This message won the elite the votes and with these votes, the elite were able and willing to move these countries from dependency on France to independence.

The people of the Sahel faced major problems at independence. The French had built a macrostructure. They had created a French West Africa federation with the capital in Dakar, and with regional capitals in eight states, five of which were in this area. During the decolonization period, some Africans contemplated utilizing the existing federal structure as a viable West African entity, but the French feared such a powerful structure. Through the agency of M. Felix Houphet Boigny of the Ivory Coast and the bureaucracy in Paris, the loi cadre of 1956 destroyed the regional unity that had existed in French West Africa since 1896. Thus, a larger system with some advantages, even though it served the interests of an outside power, was broken up. The local states were faced with the possibility--indeed the need--to develop the kind of political infrastructures which could support their presence in the United Nations as modern nation states. Where was the money to come from?

The African statess had only two sources of money. One source, was the local people, but the economies of French West Africa were not developed to the point where they could have supported the nation-building processes that were being demanded by these emerging nation states. The other source of aid, of course, was from outside--initially French. However, as the Cold War developed, these countries were drawn into the orbit of another aid-providing country which had as its raison d'être, not the development of countries needing massive amounts of money to build their infrastructures, but stopping communism from instituting entirely new systems of government, new systems of production, new

ideologies, or what have you. Nevertheless, neither the French nor the Americans (nor the Russians) were willing to provide the amount of capital and know-how necessary to enable these states to create the kind of basic institutions which would aid their people.

In the absence of substantial aid from outside groups, the local bureaucracies, the local elites began to turn to the only other source of funds, the peasants. And since little was done to develop the rural areas of this region so as to produce a surplus for the state, many elite members started to use the limited in-flow of taxes for themselves. Corruption became a byword, and the local military elite which had its own links through the colonial structure to France and the Western world, coupled to an ideology to protect the state, began to move into power. There were coups, riots and more coups as the military attempted to restore some kind of equilibrium within the system. Yet even the military was unable to deal with many factors and problems to which this area was heir.

If the Sahelian countries did loosen their ties to France, they could not remain outside the global village that was becoming increasingly interdependent and smaller due to the speed of transportation and the new technology. Not only were they members of the United Nations and unwilling participants in the Cold War, but they were being increasingly affected by changes or events in other areas, such as changes in the world climatic systems. Climatologists are still arguing whether or not shifts in the polar air masses, or more regional shifts of rainfall having a periodicity of 50 or 100 years have started to affect this area. Whatever turns out to be the case, the fact is that from around 1966, the area became progressively drier. Moreover, this was also the period during which many of the states were instituting new local development schemes, were organizing regional development schemes to increase production of export crops in order to pay for the accoutrements of modernity and so on. It was also a period when the rural people, having been told that independence would bring with it the modern life, were moving to the cities--those places to which their taxes were being sent and which were like islands of modernity in the sea of tradition. So, in addition to climatic factors, urbanization was another factor, and with urbanization there were the other problems of social change. Political change, urbanization, modernization and conflict over scarce resources were all disturbing factors in the Sahel when every year the Sahara spread southward a little more, and every year the rainy period became shorter. Every year, the traditional "hunger period" (between the exhaustion of previous year's harvest and the beginning of the new harvest) became longer until last year when the world was faced with the possibility that unless massive aid were given to this area, millions of people would die.

There are problems here. One problem was: were the stories true? But the facts could only have been verified if these countries had had censuses or if people could get to the rural areas to ascertain how many persons were dying. The truth was that the absence of a basic infrastructure affected the amount of information the outside world could receive about the kinds of problems these areas were facing. Once the news media convinced the outside world that there was the possibility of famine, the outside world then began to move. Why? Human reasons aside, the reason was that these states were no longer isolated--they were part of a larger world system. Newspaper chains, television chains, started to send groups of people into these remote areas, and very often these journalists ran into difficulties because the local leaders were not aware of the implications of being linked to a wider system.

Both foreign nation-states and international bodies had to react to the Sahel disaster. The U.S. had to react, the UN had to react, FAO had to react, UNICEF had to react, and as these major or macro-organizations tooled up to move into West Africa, what did they find? They found an absence of linkages through which major universal or international organizations could deliver food and medicine to the local population. In other words, the fantastic differences in nature and scale of the local societies in contrast to the kind of structures which existed outside of Africa--the only kind of structures that could exist on the international plane--made aid-giving difficult. The foreign structures were quite efficient for dealing with modern societies; they were incapable of dealing with the micro-technology, micro-economics, micro-politics, the micro-sociology, and the micro-ideology of the Sahelian states. The result has been criticism, conflict, contradictions and general chaos.

It seems to me that what this area needs is a massive introduction of the wherewithal to create the kind of structures that would enable them to articulate with a world that is moving to higher levels of integration with the use of satellites, computers and complex technology. In other words, new structures must be created in the Sahelian zone so that the societies there can link up with the modern world. Schools such as Howard can help to train engineers, but this is an easy task in comparison with the major political and social changes that are needed. The people of this area should be encouraged to create larger regional groupings. I know that many of you will say that these are political problems. Yes, indeed these <u>are</u> political problems but we must never forget that the balkanization of West Africa in 1956 was also a political problem and one in which France, because of her own interest, played a major role.

Because of the linkages between many of these countries and France and of France with the EEC, it was difficult (and it is still difficult) for people from Niger to trade legally with the people of Nigeria, for the people of Togo to trade legally with the people of Ghana, and for the people of Senegal to trade legally with the people of Gambia. There are also political and macro-economic procedures and interests that are frustrating the normal tendency of people to create new links or linkages. For example, a great deal of the peanuts of Niger are being marketed illegally in Nigeria. We social scientists see these acts as mechanisms of local people, driven by the market principle, if you wish, or by ties of kinship or adventure, or by a number of basic social factors, to meet the exigencies of a changing situation.

The often spontaneous new behavior of Africans in the face of difficulties suggest that they are not totally resistant to change. If the circumstances are deemed propitious, people will change their ordinary behavior. During periods of disaster, they are more predisposed to change. At this present moment, given drought, and given the realization of many people that the structures which emerged during the colonial period, the decolonization period, and after independence are not working, they are predisposed to change. The problem is that even when local structures can change, the ongoing relationship between this area and the outside world is not as amenable to rapid change as it should be. For example, there is no determination to support a Regional Committee of Six or Seven nations created by the Sahelians with a raison d'être of coordinating all efforts dedicated to helping this area to survive. Instead, groups in the United States, in Europe, in Canada, in many places, are mobilizing themselves in the name of this area, and often forget to invite the Africans to talk about the basic issues.

The problems are even more serious than that. The attempt on the part of groups in the U.S. to create new types of links with the Sahel and ones based on new concepts are being frustrated by the present aid-servicing institutions which see the emergence of new constituencies for Africa as a threat to their own operations. To give an example: As a result of my background, and limited knowledge of how these states operate, a group was formed with me as co-chairman along with Congressman Diggs (Relief for Africans in Need in the Sahel - RAINS) dedicated to the principle of helping the Africans but not telling them what to do with our aid. We planned to give them the money and let them do what they wanted to do with the money we had collected. Once the news of our organization was bruited about, RAINS was seen as a threat to such groups as the American Freedom From Hunger Foundation, which did everything, or almost everything, to prevent our group from coming into

existence. The Freedom From Hunger people promised everything--promised free television time, and promised to give 101 percent of all the money donated to it in the name of RAINS to Africans.

The Freedom From Foundation people could not and would not understand that we were trying to create a new kind of organization to articulate with the Africans in a novel way. We were not planning to deal with the individual states; we were planning to use the organizations created by the Africans themselves to deal with the problem. In other words, we were trying to create a new structure to deal with a new African structure. The existing organizations although dedicated to aiding Africa did not want to see the emergence of a new structure because it threatened their interests. Our feeling was that new structures had to be created. We were trying to help these new structures to emerge because given the macro changes needed to deal with this new reality, the pre-existing ones were inadequate.

There is a need for a new approach to the problems of the Sahel and the brightest people at such institutions such as Howard should attempt to help. It has been suggested that the climatic factors in the present drought are worldwide in scope and may be the result of technological developments in the West. If indeed what is happening here in the U.S. is creating changes in the global climatic system, there is little the Africans can do about that. But the physical scientists can tell us if this is true. If that is indeed the case, then the West may have to modify its technology, or barring that, give this area the help that would enable it to survive. If the problem is due to local climatic factors then the area may have to be abandoned in the same way as those early agriculturalists abandoned the Sahara during the arid period. But, if on the other hand, the disaster is linked to how these states are organized politically, economically, socially and ideologically, then it seems to me that there is a possibility that physical and social scientists could help. We could help to provide the means whereby new structures could be developed in the Sahel so that these people can save their ecosystem and link it creatively to the global ecosystem which I believe is the only kind of ecosystem that is viable in the contemporary world. Thank you.

THE INTERNATIONAL AGRICULTURAL RESEARCH NETWORK

Clarence C. Gray, III
Deputy Director, Agricultural Sciences
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March 6, 1974

THE INTERNATIONAL AGRICULTURAL RESEARCH NETWORK

Clarence C. Gray, III

Thank you very much, Dean Pierre. As an old college professor, the first thing I'd like to ask is that you all move down to the front. There is a reason--these slides I have prepared may not be clear to those sitting in the rear. It's always nice to talk at a university where you have a captive audience. I spent ten years of my life teaching at Virginia State so I know something about these things.

The following headlines appeared in the New York Times on February 26, 1974: "Wheat Stocks Are Depleted by Huge Exports--Outlook on Price Is Uncertain Before the New Crop Comes In." The opening paragraph went on to state:

> For the first time in a generation, American wheat supplies have been depleted so low that the bottom of the barrel is almost in sight. And there are some who say, or contend, that the bottom will be scraped before enough of the new crop can get to market to prevent soaring prices of wheat, then flour, and finally of bread and other baked goods.

Here is another headline that appeared in the same paper on February 28: "Scientist Fears Wide Food Shortage." This was a report of a presentation at a meeting at the Association for the Advancement of Science. Now, such headlines, and the beef shortages of the last year, the general rise in food prices--to say nothing of the oil embargo--these things have brought home to the American public, in very real terms, in very hard terms, the growing interdependence of the peoples of the world. A severe drought in Russia or India can have direct, almost immediate effect with repercussions throughout the world.

Now, if you have experienced some uneasiness or discomfiture over food shortages, and rising prices, you can imagine what the impact of food shortages and high prices is in developing countries where the per capita food and income are less than $300 annually. For the less affluent, often food-deficit developing nations, largely in the tropics,

the long-term outlook is bleak and grim if they are forced to continually compete for fluctuating, often inadequate, and poorly distributed food supplies.

During the 1973 food crisis, severe dislocations and disruptions occurred in several hard-pressed nations of South Asia. In India, for example, there were reports of food riots in various sections of the country and the government had to divert scarce, hard-earned foreign exchange away from economic development projects for the purchase of high priced foods.

Now, although the situation varies from year to year, the solution for most poor nations is likely to be within the country itself, and it is for this reason that the Rockefeller Foundation has pioneered and supported institutions which can help poor nations realize the food supplies that they need.

The International Agricultural Institutes and the networks they form is the topic for my discussion this afternoon, and I propose to do several things. First of all, I'd like to present some background information with respect to the situation, the population resources, and food production prospects. In other words, the situation and the rationale for the institutes. Then, I'd like to present information on the institutes--the origin of the institute concept, the several institutes and the way they function, and their accomplishments to date. Finally, I'd like to comment on the significance of the institutes and the implications for engineering and other professions and disciplines which are necessary and critical in the development process.

First of all, let us talk about the situation. I'd like to share with you a series of slides. Here is a map of the world and the main thing I want to show are these two red spots here because this is where most of the people of the world live--China, India, Pakistan, Bangladesh, Indonesia and Japan. It shows that the mid-year population of the world in 1973 was 3,860,000,000 people. In Asia, there are 2.2 billion. So, you see that of the 3.8 billion people in the world, most of them live in this section. The projection for the year 2000 is 6,494,000,000, of which 3,999,000,000 will be in Asia.

This slide shows the developing nations--1940-1970 is right here; and here is the projection for the year 2000. You can see that the population in the developed nations is holding fairly firm. It will be increased, but it will not be a substantial increas. That will happen in the developing nations, so here is where the problem will occur. This graph shows it in more dramatic terms. Since 1900, there has been a gradually

accelerating increase in world population. This increase has been in Asia. You can see what will happen unless population increases are gotten under control. I put this particular slide together late the other night. The only thing I want to show you here is what resources are available for food production throughout the world. This is a map of climatic zones in the world. Most of the developing nations are in zones four and five. The colors on the map, the greens and blues, indicate humidity, and the reds and browns indicate degrees of aridness and semi-aridness. The point that I'd like to make here is that in the developing world--that is, in the tropics, you have a weather constraint on food production because of the weather conditions. Now, most of the rainfall that the tropics receives is of a monsoon nature. Usually, you have periods of high humidity, heavy rainfalls, and then lengthy dry spells. The next slides will show this.

Here is a nation in South Asia--Vietnam--and you can see that this picture was taken in the middle of the monsoon. There is more water here than one would know what to do with. Fortunately, God made rice and rice does very well in this kind of environment. There are varieties of rice that grow twenty feet tall. Their stalks elongate this sort of a climatic situation.

This is the Katmandu Valley of Nepal and I wanted to show the beginning of the monsoon and the rice that is growing on these terraces. This is what happens to rice in the monsoon. In the beginning you get a small amount of rainfall and then it picks up. This was going to be a very good rice crop but unfortunately the amount of rain, and because the rain comes down in such torrents, the rice is just beaten into the ground. This slide shows the same valley, but in the dry season--the peak of the dry season, about February or April 1959.

In this next slide I want to show you the problem of soil resources and population. This slide was made in 1965, and at that time the world population was 3.3 billion. This shows the number of acreas of land in the world. The total amount of land in the world comes to something like 32 billion acres, of which a total of 7.8 billion is potentially arable. That is, that is the amount which can be used for crop production. Here we have the cultivated land as of 1965, which is about half of the total--3.4 billion acres. But most importantly, I want you to see the amount of land that is being cultivated relative to that which could be cultivated. Take a look at the figures here--in 1965, 83 percent of the land in Asia was already cultivated. Here in Europe, we have a very high ratio also, i.e., population pressure on the land in Europe. About 44 percent of

of the potentially cultivatable land is under cultivation. Now, what this says to me--should say to us--is that there is still a great deal of land left in the world. Only about half the cultivable land is now being cultivated. The problem is distribution. It is in the wrong place. It is in Asia. Look at the situation in South America where there is quite a bit of land and very little is being cultivated. Look at Australia and New Zealand. Only two-tenths of the land is being cultivated in Australia. So, again we have the age-old problem of distribution of resources.

In this slide, I want to show you the major crops of the world. Wheat, by and large, is the most important crop in the world in terms of acres devoted to its cultivation--217 million hectares. Rice is the most important crop in terms of numbers of people who eat rice as a major component of their diet--134 million hectares. Now, what is the situation with regard to food supply in the world at the present time?

Well, if we go back, say twenty years, you will see that food grain production at that time was about 600 million bushels. In 1971, it was something like 1.3 billion. So, the point is that food production has kept increasing in that twenty-year period. Population has gone up only about sixty percent. So, we have to conclude that food production has kept pace with population growth. The problem then is affluence in developing nations and affluence in developed nations. High income in America attracts food from developing countries.

In this next slide, you will see the difference in productivity of various crops in different parts of the world. These data from 1968 have not changed much since then. Look at the yield in metric tons per hectare of these various crops as compared to North and Central America. This kind of data leads us to the conclusion that there is a great deal of room for improvement in the productivity of food production in developing nations. This is basically the rationale for the International Institutes. These kinds of yields clearly show that there is room for improvnement. This particular chart reflects gross national product, and in turn, incomes in developing nations.

Here is where the problems are--in Asia, in Africa. where the per capital gross national product is around $300 (U.S. equivalent). The ability to buy food is a very important factor in the lives of the people. This is the per capita income in developing countries, and this slide shows selected developed countries. You can see, for example, what has happened in the United States. The point is that the gap between the rich and the poor is getting wider. Now, all this adds up to how well off the people are, and one of the measures of the well-being of mankind is the food that they eat. Food is one of the basic necessities

of life. You can see in this chart where the excess food is going. This is taken as the caloric intake as a percentage of established standards by major regions and countries in 1959, 1961, projected to 1970. You can see that in the U.S.A. we eat a little bit more than our share.

It became clear that if one wanted to get at the problem of food production and improving food production in Asia, the place to start was with rice. This slide shows an aerial view of Burma. It shows two things. First of all, it shows very definitely to the agricultural scientist that this rice is suffering from nitrogen deficiency. It also shows that even without any nitrogen fertilizer, the rice tends to lodge, i.e., fall over. This is the result of the monsoon nature of the weather. Strong rains beat the rice into the ground and so the yields here will be very low.

This is a slide taken in the Philippines. This rice is grown in the deltas, tidal lands up to 10,000 feet above sea level, and all the land in between. Here is a scene in India. The temples indicates that man has been here for a long time--these are old temples, perhaps 1,000 to 2,000 years old. Here is another slide showing rice growing in Eastern India where it is the major crop.

About the mid-1950's, it became very clear that the technologies that had been developed in the West-- a highly productive agricultural technology in wide use in North America and Europe--was passé in terms of transferring its benefits to the tropics. President Truman in 1945-46 announced the Marshall Plan and we all thought that it would be a simple matter. All we had to do was to go abroad and tell the farmers how to farm American style--use seeds, fertilizers and insecticides. But nothing happened...the rice plant, particularly, did not respond to such technologies. Most of the people lived on rice which is the major crop that they grow in the tropics--it's a monoculture, and the people use the rice for food and the grasses for brooms and to build their homes. This particular crop just did not respond to U.S. technology. When we used fertilizer on it, it grew too high and the insects preyed on it. Fertilizers created an environmental situation which permitted diseases and insects to thrive. Diseases spread like wildfire. So, what were we to do? Here we were with no technology to apply because most of the scientists were working on peanuts, cotton, bananas and other plantation-type crops which were in great demand in the West. No attention had been given to the food crops of these tropical countries. The lack of technology created a kind of a dilemma because we were faced with a situation where we did not know how to proceed.

Well, fortunately, about that time the Ford Foundation suggested that we organize a research effort. The Rockefeller Foundation had been involved for about twenty years in programs to improve agriculture in Mexico, and other countries in South America. We had a small corps of experienced agricultural scientists, soil readers, soil scientists, entomologists, biologists, and micro-biologists. Fortunately, surveys also had been made and the conclusion had been reached that the crop to start with was rice. That's why I showed you those slides of rice being grown in various parts of South Asia under different conditions. In that part of the world rice grows under such a wide range of conditions that it is difficult to develop a technology that would be locally suited to all of those conditions. One also has to consider the fact that in India alone, there is something like 4,000 different varieties of rice. Almost every village has its own variety. In many areas, the people are very selective about the kind of rice they eat--sticky rice, dry rice, aromatic rice, etc. Thus, there were consumer problems, biological problems, physical constraints and human constraints--a whole array of factors which had to be considered.

As I said earlier, fortunately the Rockefeller Foundation people had looked at the situation and decided that an unprecedented research effort was necessary to break loose those constraints. The previous history of the Rockefeller Foundation had been with work on hookworm in the American South, and work on parasitic diseases in Egypt and South America. The best scientific talent that existed in the world was brought together to focus on the problem. They were adequately supported with respect to the things they needed. The goal was to make a production breakthrough, particularly if some scientist had done research and disovered something that perhaps suggested the way for improvement.

Fortunately, about this time, the Rockefeller Foundation people working in Mexico, and Dr. Borlaug who received the Nobel Prize for his work on wheat, had developed something that was needed. Dr. Borlaug who was working in Northern Mexico wanted to breed varieties of rice that would step up the number of generations rather than waiting for the seasons to come around. By going from Northern Mexico down to some of the warmer Southern states in Mexico, he got another generation; and the next year he had the two generations he needed. In the process, he went from one altitude to another and he developed a plant that was photo-insensitive. If you were noticing those slides, you probably noticed that certain trees drop their yield at certain times of the year. Most of the plants are photo-periodic sensitive. Some plants mature when the days are long--some plants mature in warm weather, some plants mature when the days are short.

Corn, for example, matures in the fall because the days are short; wheat when the days are long, in the spring and summer. But in the process of moving the germ plasm back and forth--bringing it back to Northern Mexico, then to Southern Mexico-- Dr. Borlaug was able to develop varieties which were photo-insensitive.

Then someone said, "If we can develop some photo-periodic insensitive varieties of rice, we can double up the rice crop in Asia, we can grow rice at different periods of the year, irrespective of the day limits." Also about that time, the biomedical scientists were beginning to realize that the variabilities that existed in the germ plasm of various crops was such that if you could manipulate the germ plasm, put a combination together in such a fashion that it could be peculiarly adaptable to a particular environment, we would get something that was workable. So, the Foundation went to work and established an institution. They established what was the first of the international institutes thirty miles south of Manila at the College of Agriculture at Los Banos.

This slide shows one of the new kinds of rice varieties that was developed in the Philippines. On this side, you see one of the new varieties of rice. Over here you see the old variety, and here the new one. You see that the new variety is still standing which means it will give a very high yield. By crossing several varieties of rice, the scientists developed a very short rice with a stiff straw which does not fall over. They also selected a nitrogen fertilizer. This is what we call genetic engineering. The consequence was a substantially increased yield.

Nepal and Pakistan also have new varieties of rice. This slide shows the pay-off. You can see the difference in height between the new and old varieties. This is the traditional type of rice, the indicant type. This is the kind of yield we could get without any fertilizer, without any nitrogen. As soon as you apply the nitrogen fertilizer, the rice grows straight up and then falls over. As you can see, the new rice developed by the International Rice Research Institute stands right up and from 120 kilograms of fertilizer, you get something like nine tons of rice.

It is these kinds of results that have emerged through the establishment of other institutes. We now have a whole network of these institutes. The first was established at Los Banos in the Philippines to work on rice. About the same time that IRR was producing the new plant type for rice, Dr. Borlaug and his associates had produced a wheat that was also widely adapted to the tropics. By the mid-1960's, both rice from IRR and wheat from CIMMYT had spread like wildfire throughout Pakistan and India, showing very conclusively what the potentials were for increasing food production in the wet tropics.

That last slide showed that you could increase yields of rice up to nine tons per hectare. That was the potential and hope and promise for food production in the tropics through scientific activity and engineering of plants as I have indicated--changing the architecture of the plant by making it smaller, making it more resistant to storms, more responsive to inputs, and thereby opening up a whole range of possibilities for increasing food production in the wet tropics.

Based on the results of IRR and CIMMYT located in Mexico, a whole series of institutes have been established. We have one in Columbia (CIAT), one in Nigeria (ILRAD), one in India (INTERCEPT), and the International Laboratory Research in animal diseases, and another institute is being established in Kenya. Another livestock institute is also to be established in Ethiopia. There is a vegetable institute in Taiwan and an institute in Lebanon doing research in dry-land farming, a Mediterranean type of agriculture, and a potato institute in South America.

On this last slide I want to show the kinds of funding available for the international institute system. Look at the bottom line -- $32 million. These various donors came together through the actions of the Rockefeller Foundation and Ford Foundation because it soon became apparent that the two foundations could not establish enough institutes and keep them going to solve all the problems of food production in the tropics. It was therefore imperative that something be done. So, here was an opportunity for the world donors to come together to pool their resources and establish institutes that would function in the tropics. As you noticed on the map I showed you, all of the institutes were located in the tropical zones of the world and directly in areas where they could carry out their functions. Well, you can see the kind of money that has been mobilized in support of this international institute network.

At the present time, as you can see from the hand-out that I gave you, if you look at the column of the world's major crops, you will see that all are now covered by some international institute. You may well ask what kind of activities are carried out by these institutes. The first thing they do is to become the world center for a particular crop. That is, they have the responsibility for collecting all of the world's germ plasm. In other words, corn grows all over the world--up in the Himalayas, in Mexico, Central America--and what has happened over time, even though crops originated in a particular climatic zone of the world--what has happened over time through the influence of the environment is that we have expressions of different characteristics of genetic qualities that have come to the fore. Thus, there is a wide variability in the genetic make-up of a particular crop.

After collecting the world's germ plasm, the first thing that the institute does is to screen it and find out what are its attributes and what qualities the germ plasm possesses that can be used and manipulated to increase food production. Their next task is then to act as a sort of clearinghouse for information, and as they collect the germ plasm, they can make it available to the nations who need it. The institutes also engage in training which is a very heavy component and of vital importance to most developing nations which are faced with manpower problems. Training is conducted at all levels--the production level, Master's degree, Ph.D. degree, post doctoral work--for scientists who wish to come to an institute to work on a particular problem.

The other thing we must remember is that the tropics are different--they are different both culturally and socially. When we begin to develop technology for the tropics and the developing nations, one must take this into consideration. What are the implications of all this? In the case of agriculture, there are countries that may be faced with the same kind of problems after they have spent several generations doing the same things we did--trying to transfer Western temperate zone technology, the developed countries' technology to the tropics. It doesn't work, and therefore we had to take a different approach. This is certainly one of the implications. The other implication was that the problem was so large and so complex that no one institution can handle it. It would have to be a combined effort of institutions and individuals pooling their talents and through some mechanism, the very best talent had to be brought together to solve some of these problems.

As I travel through developing countries throughout the world, I see all sorts of monstrosities. I see engineering technology which is poorly suited for developing nations; I see big machines; I see computers, and I see all sorts of advanced technology in societies where you have great numbers of people who are unemployed, where you have income distribution problems. We're not going to get around this problem by transferring technology. Here in the United States, agricultural technology has made food very cheap. But look at what has happened here. It has displaced a number of people, and I'm sure that the social costs when you add them up are more important than cheap food in the supermarkets.

I can see the need for institutions such as Howard getting involved in establishing, first of all, closer points of political strength in developing countries, perhaps with another institution. I can see opportunities for a network of these strengths to be fostered. I can see opportunities for developing training courses that deliver a technology that is suited to people of developing countries in their present circumstances.

As I was telling Dean Pierre just before this lecture, I am absolutely disgusted with agricultural technology in America, but more

in terms of what it does to developing nations. I just finished putting together a paper in which I say that it is almost worth a solution to start all over again because students come to the United States with a completely different background and set of experiences, etc. The things that we teach have little or no meaning for them. All we do is reproduce American problems and solutions. I can see where an institution such as Howard could have a very prominent role to play in Africa, in Anglophone Africa.

A MORPHOLOGY OF TRANSPORTATION IN DEVELOPING COUNTRIES: A CASE STUDY OF AFRICA

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March 13, 1974

A MORPHOLOGY OF TRANSPORTATION IN DEVELOPING COUNTRIES: A CASE STUDY OF AFRICA

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The objectives of today's discussion are first, to define the role transportation plays in developing economies and second, to share information with you regarding the state of transportation in independent Africa, both from a physical and organizational standpoint. Basically, my expectations are coincident with the expectations of this seminar series, i.e., for a deeper appreciation of tactical and strategic importance of transportation infrastructure. I also expect that as a result of what we are going to talk about today, some vigorous discussion will follow the formal presentation.

I decided to go the mode of a slide show. I am not so sure of the merits of this, but it certainly makes it easier to remember what you want to say--by putting it on a slide. First, I want to orient us all to what we mean by transportation. I know that most people think there is no problem in defining transportation but I want to do it anyway. A very simple definition of transportation is: "the movement of persons and goods from one point to another as quickly, as cheaply, as comfortably, as safely, and as reliably as possible, within the limitations of the resources available." I think that this last phrase - "within the limitations of the resources available"-- is very important when we talk about transportation in developing countries. What do we mean by resources? When we talk about resources, basically what we are talking about is some combination of the following things:

(1) The guideway, that is, the kind of facilities that are available, whether a road or rail, a channel in a river or a channel approaching a harbor, and the network over which these things are spread. In other words, is it just one road between two points or is it a number of roads between two points or is it a number of roads connecting a number of points, etc.? So the facilities and the network are important when we talk about the technology available.

(2) The vehicles that ride on that facility. For example, if you have a roadway, is it a truck, a tractor-trailer, an ordinary little car; what kinds of trains do you have running there, what kinds of boats do you have running in the channels, what about the pipeline size, etc.?

(3) Maintenance is a very key problem especially with respect to developing countries--what is the maintenance technology that is available?

(4) Operational policies. In other words how do you route the vehicles that are available to you, how do you schedule them, etc.?

(5) The personnel available to operate all of these facilities.

So we talk about resources with respect to providing transportation for the movement of people and goods in some efficient manner as defined by whoever the decision makers are. We have to talk then about some combination of technology involving guideways, the vehicles, the maintenance, the operating policies and the personnel involved.

Now, when we talk about these guideways, one of the things that has to be dealt with is the comparison of technologies available. I want to discuss very briefly some of the technologies that are available.

Waterways. Why opt for waterways if you can use them? Waterways provide low-cost movement of bulk commodities for both long and short hauls, all things being equal. If waterways are available, then low cost movement of bulk commodities will be facilitated. This is very key especially in the south central part of Africa because there are a lot of natural waterways that are totally unexploited to date.

Railways. It is an economical means of moving bulk material over long hauls, and where there is a very high traffic density. Again, I think this is a very key thing because one of the problems today is that if one looks at all the developing countries, railways are definitely on a decline. How does one justify railways being on a decline against the fact that it does provide an economical means of moving bulk a great distance and over high traffic density? There is an advantage there, but I think the problem here is the competition with roadways, and, of course, the institutional mechanisms that exist in the countries themselves.

Roads. Very reliable and economical for truck hauling. This transport means has definitely improved over the years. It is a feasible form of mechanized transport where traffic is light. Perhaps one of the most

important selling points for roadways is that it does provide flexible routing in that it can go to a number of dispersed points much more easily than a railraod and service is fairly fast. One of the problems with a railroad, of course, is that one has to allow a lot more time for delivery than for truck haulage. Another comparative advantage of a roadway is that it does provide access to land and resources throughout the entire length, i.e., you can get off at any point. It is accessible at an infinity of points along the roadway for all practical purposes, whereas with a railroad, that is not true. In other words, if one must stop every few hundred feet, it becomes much more uneconomical to operate a railroad in that mode than it is to operate a highway with trucks running over it in that mode. Another very important thing, too, is that a roadway can accommodate all kinds of traffic. What do we mean by that? Well, if a roadway is constructed, a guy with his donkey cart, if he has been accustomed to hauling things with his cart, can still use that particular facility or he can walk on it, or he can haul things like a rick-shaw. So the roadway can facilitate both the movement of mechanized transport and the existing so-called primitive means of transport. Thus, it is no accident that a lot of money and investments in developing countries are now going into roadways. It is because of these comparative advantages.

Air. Air is a very important travelway over extremely rough, very difficult terrain. That is all we want to say about that, except for the fact that within a developing economy what would be desirable, are air carriers that can provide very high hauling capacity, but at the same time permit operation on very short runways so as to minimize investments in building runways, etc.

Pipelines. Very low unit cost transport for liquids and gases. Perhaps one of the most important advantages of pipelines is that it is relatively unaffected by the weather. When we talk about roadways or any kind of transportation facilities in developing countries it is very important to consider weather in the design, maintenance and operation of their facilities, because of the fact that many times, weather is the key problem. There might be x thousand miles of roadway when looking at the total account, but perhaps nine months of the year, only 1/3 or 1/5 of x are possible, and therefore weather conditions are a very important factor to be considered.

Now, when we talk about the choice between these things--how to make a choice between these technologies given these comparative advantages, as we said before, one has todeal with the cost characteristics and the service characteristics--what are the levels of service one can get from employing a particular technology? How cheap is it to operate, how fast is it, how reliable, how safe, etc; what about the economics of each of these modes? One has to worry about the input of capital, a very critical thing because one might well have to expend a lot of foreign reserves in order to invest in a very sophisticated system that results from attempting a wholesale transplant of technology from a so-called developed country.

What about the whole problem of managerial talent? The more sophisticated the transportation system, the more demands there will be for and upon managerial talent. Technical skills will have to be mobilized, and that could be an extremely critical constraint upon the system that can actually be utilized.

One of the things that one has to keep in mind in any developing economy is that a transportation system is not an end unto itself. It has to fit into the total overall development objectives. So, therefore the time constraint might in fact require one to pull back on what might appear to be a real nice looking system, to something that can operate within the given time constraint for operation. What about the requirements for maintenance and operation? I do not know of any vehicles that have been designed in developing countries to meet the conditions of the developing areas. It is usually a case where one comes up here, buys a truck, and takes it back someplace and hopes that it functions efficiently in a different environment. What happens is that the requirements for maintenance and operation of those vehicles and those facilities can, in fact, get you into trouble. What about the ability to create capital? If one cannot produce the capital, where does it come from? How does it affect foreign exchange and how does it, in the long run, affect the entire economic activity? One has to consider very seriously, from an economic standpoint, not only in terms of engineering economics, but in terms of the economics of the countries involved, what should be the alternative technologies, and what should be the mixture of technologies that should be utilized in order to meet some transport objectives.

Now, we said that transportation is not an end in itself, that it has to tie in very closely with the overall development objectives. So, I just want to list here some of the things that transportation ought to serve. Now, I am not saying that this is particularly unique to developing countries. I am simply stressing this to point out that certain stages of development require that particular attention be paid to the effect that transportation can have on these different things. One cannot afford to build transportation networks for transportation's sake. You cannot afford that luxury as you can in the United States, for example. I will just list some of the things that have to be taken into consideration when one attempts to put in a transportation infrastructure.

Getting land into production: Obviously, if there is no way to get the produce out, you are not going to develop the land, except maybe for bare subsistence farming. One has to talk about marketing these agricultural commodities. That is a very critical thing because we are all aware of the distribution problems; and one of the problems over there is, in fact, transportation. Even if you did produce the goods, how do you actually get the goods over the network to the people who need them? The lack of transportation becomes a very important constraint.

Making forests and mineral wealth accessible. If you cannot get in to move it in and out where it is needed, then you might as well not have it. It is useless. So you can have a rich continent with poor people because you have no way of getting those goods out. Now, keep in mind the fact that I am not suggesting that just putting transportation there that every one will get rich. I am just simply pointing out that one has to have the transportation infrastructure in there to allow you to do these other things. So, you do not do this unless you are prepared to follow up with the other things that will increase the economic activity in the region.

Developing industry. If your transportation system is unreliable, then industry is going to have a tough problem in planning its supply schedule. How does it get the fuel to meet the needs of the machinery to be worked, etc?

Expanding trade. That should be intra- and international trade. Without the transportation system, you cannot move the goods from one point to the next, and between one country and the other to stimulate trade. I think you will see that it is very true of Africa that the transportation system was never designed to facilitate either intra- or international trade. It was only designed to get things out to the port so you could move raw materials to the mother country.

Conducting health and education programs. Once again, you can have the best doctors in the world but unless you have some way of getting them to where the people are who need their help, then you might as well not have them. So again, transportation helps to meet these developing objectives.

Exchange of ideas. This is also very important. In other words, if you have isolated villages or isolated communities throughout the country, then it is not very easy to exchange ideas unless they can somehow communicate and move around. Now, that might be good or bad. You just might want to not put in a transportation system to deal with that because one of the objectives may be not to exchange ideas, because you can see that on an international scale or on an "across-the-ocean" scale that this could be a problem--the fact is that you can come here and get infected or stimulated by ideas which might be totally useless to the economies that you say you want to return to. So transportation does facilitate that exchange of ideas, too.

National political unity. How do you get around when you have to campaign and so forth?

Now, that we have said all that as a very lengthy introduction, we could probably summarize it all into what you might call a Transport

Problem. Available transportation was developed primarily to facilitate movement from points of resource to the coast, so that one finds that, especially with respect to railroads, that they are all oriented towards the coast, not to allow any intra- or international trade. As a result, growth occurred in port cities. There is poor maintenance of rolling stock. There is inadequate exploitation of waterways, where possible. There is a lack of well-trained personnel for planning, management and maintenance of an efficient transport system and the question is how much of the scarce resources should be allocated to transportation in order to achieve development goals.

The independent states of Africa are attempting to alleviate these problems via the creation of a new rational system of transport lines. I refer you to the Africa Regional Plan of the UN World Plan of Action which was published just recently. This rational system has divided the transport links into three types: (1) penetration lines which will connect each country with the outside world, providing access from ports to areas where there is some economic activity in the hinterland; (2) axes of integration, which will facilitate international trade and cooperation; and (3) national networks which will in effect develop in each country itself but then serve as feeder lines to the axes of integration and penetration lines.

There is also the problem of standardization of transport networks in terms of the geometric design of the links, and capacity by volume and weight. This is a very critical problem, because, especially with respect to railroads, it is not uncommon to find in Africa, two railroads of different gauges coming together because they were built by different colonial powers at different times to serve different needs. A trans-shipment is artificially created which in turn introduces inefficiencies into the system for moving goods around. To appreciate the capacity problem, imagine you are driving forty-thousand gross-tonnage trucks on one road which links up to another road which can only carry ten tons. Then there is the operation of transport networks with respect to personnel management, maintenance and what appears to be a big problem, customs and immigration laws and practices. Because if you are going to facilitate international trade on the same continent, that does become a problem and it is being addressed on a joint basis by all the African countries.

Now I want to show some slides to give an overall feel for what is happening with respect to the plans that are being made to deal with the problems that I have just outlined here. Before I do that, however, I want to define Africa. I think that is important because when I talk about Africa here I am talking about the 41 independent member states of the Economic Commission for Africa. That excludes Azania, Angola, Mozambique and Zimbabwe. Independent Africa is divided into four regions. North Africa consists of Algeria, Egypt, Libya, Morocco, Sudan and

Tunisia. That land area is 8,244,718 km squared with a population of 90.83 million. West Africa includes Dahomey, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, and Upper Volta. This region has an area of 6,141,207 km squared, with a population of 105.4 million estimated for 1972. Central Africa is made up of Burundi, Cameroon, Central African Republic, Chad, People's Republic of the Congo, Equatorial Guinea, Gabon, Rwanda, Burundi and Zaire, with an area of 5,377,042 km squared and a population of 44.4 million. Then there is East Africa made up of Botswana, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Somali, Swaziland, Uganda, Tanzania and Zambia. Note that Mauritius and Madagascar are islands off the coast of Africa which are defined by Africans to be part of Africa. East Africa has a combined area of 4,868,246 km squared and a population of 84.79 million. I mention these statistics because it is going to be important as we look at a set of statistics and attempt to interpret them because as you well know, statistics can tell anything. So, to make this a little clearer, what I will do is compare these statistics with developed countries. In order that we can get an idea of the order of magnitude we are talking about I will present some information with respect to the areas and populations not only of Africa itself, but also with respect to the so-called developed countries. When we look at the areas and populations, I just want to point out that this is supposed to be the number of persons per square kilometer. Note that Africa (41 member nations) have 13.2 persons per km squared, and here we have France with 91.5, Germany with 240 approximately, Japan with 277 and the United States with 20.8. So that just gives you an idea of the demographic-geographic characteristics of these areas we are talking about. You might want to raise some questions of that 13.2 versus 277. I will leave that up to you.

Let us now take a look at some statistics on the amount of roadway kms. in each of the different regions of Africa. For example, take Algeria, with 95.83 thousand km of roadway. However, permanent roadway is only 18.46. That is critical. Why? It is critical in terms of having a roadway or network system that is available for use at all times of the year, the critical thing is what's permanent as opposed to what is so-called improved. So, if we look at the percentage of all weather roads (incidentally, an all-weather road could also be a gravel road; it does not necessarily have to be paved; however, when I attempt to break the statistics down, I distinctly look only at the paved), it turns out that North Africa has the highest percentage of permanent roadways of 191.25 thousand km. with 31.2 percent of it paved. If we were to look at the density of paved roads per unit area, we will see that Africa as a whole, has 4.2 km of permanent roadway per thousand km squared, compared to the United States with 270 km per 1000 km squared. Now, I am not suggesting that 270 is an ideal to which Africa might aspire; it might or might not be. I am simply presenting this so you can get a feel for what we mean and what those numbers mean. Let us take a look at Germany with 1168 km per 1000 sq. km of territory--fantastic density. On the other hand we see that it only has 290.27 thousand

x 100 km of roadway. So what is reflected here is the density. Germany has fewer route kms, but very high density. Take a look at the amount of permanent roadway in each country. The United States, very interestingly has only 42.7 percent of its roadways permanent. I thought that interesting because some of you might have thought that everything around here is paved. In other words, 57.3 percent of U.S. roads are gravel or earth roads. Notice that with respect to density of roadways per 100 per square km, the U.S. is below France, Germany and Japan with respect to density. With respect to population, however, notice that the United States has the highest rating of route km per population unit. So you might say to yourself as a decision maker in an African country, "Well, look, these developed countries have the word on everything and if they are our standard--we might want to get to at least 1/2 their density in so many years, and what does it take in terms of the commitment of resources in order to get there?" That is an example of the way you might want to use the statistics presented here.

Let me quickly tell you what is being done to deal with some of these problems. I think perhaps the most exciting thing that is going on right now on the continent with respect to transportation is the Trans-Africa Highway which is planned to go from Mombasa in Kenya to Lagos in Nigeria, a distance of about 6,375 km. This highway will connect East to West, something that does not exist right now. Six countries will be linked directly by this highway--Kenya, Uganda, Zaire, Central Africa Republic, Cameroon and Nigeria. The feeder links to the Trans-Africa Highway will link up an additional twelve countries--Somalia, Ethiopia, Tanzania, Zambia, Sudan, Ruwanda, Burundi, Chad, People's Republic of Congo, Gabon, Niger and Equatorial Guinea. Now, a lot of these roads already exist in some form or another, either as paved roads, unimproved roads, dirt or gravel, etc. So one of the things that has to be done is to upgrade those roads so that they will be all-weather roads and meet certain standards of link geometry and carrying capacity.

Another exciting and ambitious project is the Trans-West African highway network, a very large percentage of which has already been completed. Nearly 55 percent is all-weather. It consists of two main routes--a northern route and a southern one; a system of feeder routes will link up all the countries throughout the area. The northern route goes from Senegal to Fort Lamy and Enjamina in Chad; the coastal route goes from Senegal to Lagos. Sixteen countries will be linked up via the Trans-West Africa highway network to facilitate international trade and cooperation. The total length of that network is 17,511 kms and already 13,512 kms is operative as all-weather roadway, but only 7,842 kms of it is bitumen-surfaced. So things are well on their way. A key observation here is that if we now super-impose the Trans-African highway onto that network, we would note that there will be a continuous roadway extending from the West to the East of Africa. With respect to timing, the Trans-West African Highway is slated for completion in five years.

There is also a Trans-Saharan highway being planned that will link up to the Northern route of the Trans-West African highway, going from Elgolea through Tamanrasset in Algeria to Mali and Niger. The idea is to link North Africa with the rest of Africa via this highway network.

With respect to railroads, it is again useful to view some comparative statistics. Independent Africa has a density of about 2.2 km per 1000 km squared, and 16.6 km per 100,000 population. This compares with 38.0 and 175.4 respectively for the United States. What is important at this time, however, is what the railway network looks like. This is a classic example of just what the transport system was designed to do. Note that everything is oriented towards the coast with the exception of Azania.

The Tanzam railroad is being built by the Chinese to get copper out of Zambia. I will just mention in passing that before the Chinese came in to do this job, an American-British-Canadian consortium did a feasibility study of the Tanzam railroad and said no to the idea, the reason being that there already existed an economically viable alternative. Which was what? Well, if you look at Zambia here, you will note that there are rail links to the West via Lobito in Angola, and to the East via Beira in Mozambique. A political decision was made, however, and a correct one in my opinion given the volatility of the situation in Southern Africa.

There is also a new Trans-Gabonese railway which serves a deep-water port. One of the reasons for that is because the interior of Gabon is rich in timber and mineral deposits. Note the coastal orientation of this railroad. It is to get the raw material out because there is no manufacturing industry that can transform the raw materials into finished goods there.

I said that the Tanzam railroad was giving Zambia a route to the sea. However, Tanzania itself is also reaping or hopes to reap other benefits from this. There are a lot of coal and magnetite ore deposits in Tanzania and there are lots of areas with potential for sugar cane and wheat ranching in the Southwest portion of Tanzania, which will be made more accessible by the railroad. I also want to point out that there is a road that is almost parallel to the Tanzam railroad. It is called the Great North Road which is not an all-bitumen surfaced road but it does serve as a means for going from the port of Dar-es -Salaam cross-country into Zambia, and it has been used for some hauling of bulky raw material.

Now, with respect to organization, we mentioned that especially with railroads that there is a problem of standardization. There is now a Union of African Railways on the continent, which was established in September 1972 and had the first assembly meeting in June of last year. This union has as its objectives, standardization, expansion, coordination

and improvement of railway services of member states. So something is being done about those problems that mitigate against an efficient system.

Let me, in closing, mention something about ports. There is now a Port Management Association in Eastern Africa that was established last year in April, comprising Ethiopia, Kenya, Zambia, Uganda and Tanzania. They have listed as their objectives: "to foster cooperation in operation and administration of ports and harbors for the benefits of their countries; to cooperate, collaborate and coordinate activities in the harmonization of their related laws, procedures, activities and policies and to provide the means for achieving this; to improve the operational and financial efficiency of their ports and harbors within the context of the old communication and distribution systems of their respective countries and to achieve the foregoing by the mutual study and discussion of problems a rising in these fields." All ports, from Sudan, all the way down to, but not including, Mozambique are invited to be a part of this association. Simultaneously with that, there is now a Port Management Association of West and Central Africa. So African people are trying to get together to deal with the problems that would lead to disunity with respect to the laws, operations, standardization from one place to the next, immigration and k customs laws.

So, let me just close by saying that I hope in this brief period of time I have been able to give some feel for what is happening on the continent, based upon the information that I have to date. I hope that it has stimulated some of us to go into the area. I think that it is a very exciting thing. Transportation as an infrastructure is very critical to development; not that transportation itself will cause development, but development certainly could not occur without transportation.

Thank you very much.

IX - BIOGRAPHICAL SKETCHES

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PETER E. GLASER

Dr. Glaser, Vice President and Head of Engineering Sciences at Arthur D. Little, Inc., has directed a number of advanced engineering projects in thermodynamics, space and lunar science instrumentation, technology transfer and the utilization of solar energy.

Dr. Glaser received his undergraduate training in mechanical engineering at Leeds College of Technology, and Charles University, Prague. He obtained his M.S. and Ph.D. degrees in mechanical engineering from Columbia University in 1955.

Since joining the Arthur D. Little staff in 1955, he has directed research on: methods of generating high temperatures including the construction of solar and arc imaging furnaces, thermal insulation systems, properties of postulated lunar surface materials. He was responsible for the development of scientific experiments for all Apollo lunar landing missions, including measurements of the heat flow from the lunar surface, lunar gravity and the earth-moon distance. He is directing projects on the feasibility of the concept of a satellite solar power station, and the potential of solar climate control systems for buildings as a new industry.

Dr. Glaser is a past President of the Solar Energy Society and is currently serving as Editor-in-Chief of the Society's Journal. He serves on the NASA Task Force for Terrestrial Applications of Solar Energy. He is a member of Committees of the National Academy of Sciences, the American Association for the Advancement of Science, the New York Academy of Sciences, the American Institute of Aeronautics and Astronautics, American Society of Mechanical Engineers, the American Society of Heating, Refrigeration and Air Conditioning Engineers, the Society of Automotive Engineers, American Ordnance Association and Sigma Xi. He has over sixty publications, books, and patents in the fields of solar energy applications, thermal insulation, thermal properties measurements, thermal imaging techniques, lunar surface characteristics, extraterrestrial resource utilization and technology transfer.

G. V. SUBBA RAO

Mr. G. V. Subba Rao holds the position of Chief of the Energy Section, United Nations, New York, and has been associated with the United Nations for a number of years. He was educated at Madras University, but did post-graduate work at Columbia University. A development economist by education and training, he has specialized in energy economics over the last five years. A senior official of the United Nations, he taught as a professor of economics in India, later joined the United Nations as a development economist in the Economics Research and Policies Division, and also served in the Economic Commission for Asia in the Far East in Bangkok. Prior to his assignment to U.N. headquarters, he worked as Senior Planning Advisor for Asia in New Delhi.

Among his several publications, the following recent contributions may be mentioned: "Future World Electricity Supplies," in Environmental Aspects of Nuclear Power Stations, I.A.E.A, Vienna, 1971; and "World Energy Resources and Requirements to the Year 2000," in Volume I of Peaceful Uses of Atomic Energy, Proceedings of the Fourth International Conference, Geneva.

SIDNEY METZGER

Mr. Metzger has been with Communications Satellite Corporation since June 1963 and is now Assistant Vice President and Chief Scientist, working on technical aspects of the satellite communication system including its earth stations and satellites. Previously, he was with RCA from 1954 until 1963 and was in charge of the Communications Engineering Department of the RCA Astro-Electronics Division. During this period he was responsible for the communications system and equipment for satellites SCORE, TIROS and RELAY.

From 1945 to 1954 he was Manager of the Radio Relay Department for IT&T Federal Labs reponsible for commercial and military microwave relay equipment.

Mr. Metzger received his B.S.E.E. from New York University in 1937 and his M.E.E. from Polytechnic Institute of Brooklyn in 1950.

Mr. Metzger is a Fellow of IEEE and an Assoicate Fellow of AIAA. He is a member of the Joint Technical Advisory Council (of the IEEE and EIA): the Panel on Telectommunications of the National Academy of Engineering; Tau Beta Pi, and Sigma Xi.

KENNETH S. JULIEN

Dr. Kenneth S. Julien has been the Dean of the Faculty of Engineering of the University of the West Indies at St. Augustine, Trinidad, since 1964.

He is the Deputy Chairman of both the Trinidad and Tobago Electricity Commission and the Industrial Development Corporation of Trinidad and Tobago. He is also Chairman of the National Scientific Advisory Council of Trinidad and Tobago, and Chairman of the Urban Redevelopment Council.

Among his other research activities, Dr. Julien is presently conducting research into solar energy, food technology and power systems under a grant from the Science and Technology Programme of the Organization of American States. His report "An Industrial Research Institute for the Caribbean" was the basis of a $1.2 million grant from the United Nations Development Program.

Dr. Julien received his B.S. in electrical engineering with first class honors from the University of Nottingham, England, in 1957; and his Ph.D. in electrical engineering in 1962 from the University of British Columbia, Canada. The author of numerous scholarly and technical publications, he was President of the Association of Professional Engineers of Trinidad and Tobago from 1962-1968, and is currently a member of the O.A.S Committee of Experts (a group of seven individuals) on Science and Technology.

C. B. RAMKISOR

Until November of 1973, the Honorable C. B. Ramkisor was the Minister of Rural Development and Decentralization of Surinam. His previous position was that of Chief of the Rural Water Supply Section, Komma Ministry of Public Works from 1965 to 1969. He received his Master's in Engineering in 1964 from the University of Oklahoma at Norman.

CLARENCE C. GRAY, III

Dr. Gray is the Deputy Director for Agricultural Sciences at the Rockefeller Foundation in New York City. He received a B.S. degree in Agricultural Education from Virginia State College in 1943 and earned M.S. and Ph.D. degrees in Soil Science at Michigan State College in 1947 and 1952, respectively.

In 1948 he was a Graduate Council Fellow at Michigan State. In 1963 he received specialized training in economic and social development at the School of Advanced International Studies, the Johns Hopkins University. He was Assistant Professor of Agronomy at Virginia State College from 1948 to 1950, and Associate Professor from 1952 to 1958. From the latter date until he joined the Rockefeller Foundation in early 1970, Dr. Gray was with the U.S. Agency for International Development, serving in Nepal, Egypt, Jordan, and India and including an assignment in Washington as A.I.D. Officer-in-charge of Ceylon-Nepal Affairs. At the time of his Rockefeller Foundation appointment as an Associate Director for Agricultural Sciences, Dr. Gray was serving as Chief of A.I.D's Agricultural Inputs Division in New Delhi. He was appointed Deputy Director for Agricultural Sciences in 1971.

Dr. Gray is a member of the Soil Science Society of America, the International Soil Science Society, Crop Science Society of America, and the American Society of Agronomy, and Sigma Xi.

ELLIOTT P. SKINNER

Dr. Elliott P. Skinner, distinguished Africanist, anthropologist and former diplomat, is presently the Chairman of Anthropology at Columbia University.

Dr. Skinner received his B.A. from New York University, and his M.A. and Ph.D. (1955) in Anthropology from Columbia University. He became the first Black tenured professor at Columbia in 1963. In 1971 he was named Franz Boas Professor of Anthropology at Columbia University.

He has been the recipient of numerous fellowships and awards including the John Hay Whitney Opportunity Fellowship, the Ford Foundation Fellowship, Foreign Areas Fellow (1955-1957), and he received a Guggenheim Fellowship in 1972. Dr. Skinner was appointed U.S. Ambassador to Upper Volta in 1966 where he served until 1969. While he was Ambassador, he received the country's highest decoration, Commandeur de L'Ordor Nacional Voltaque which was presented to him by the President of Upper Volta.

NEVILLE A. PARKER

Dr. Neville A. Parker is an Assistant Professor in the Department of Civil Engineering, and the Urban Systems Engineering Program, at the School of Engineering, Howard University. Prior to joining the Howard faculty in 1971, he was with the U.S. Army Corps of Engineers, and prior to that he was with the Federal Highway Administration. Since 1965 Dr. Parker has worked on transportation related projects and research.

He received his B.E. (Civil) from the City College of the City University of New York in 1965; his M.E. in 1966, and his Ph.D. in 1971 from Cornell University.

Among his other professional affiliations, Dr. Parker holds membership in the American Society of Civil Engineers, the Highway Research Board, Operations Research Society of America, and the Association of Professional Engineers of Trinidad and Tobago.

Dr. Parker was one of the principal organizers of the Sixth Pan African Congress to be held in Tanzania in June 1974, and is a member of the Congress' Committee on Science and Technology.