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SUMMER WORKSHOP ON PARTICLE PHYSICS
21 June - 31 July 1982

RESEARCH WORKSHOP IN CONDENSED MATTER PHYSICS
21 June - 10 September 1982

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AUTUMN COURSE ON GEOMAGNETISM, THE IONOSPHERE AND MAGNETOSPHERE
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F O R E W O R D

Due to the intense scientific programmes of the Centre, every year a large number of scientists from all over the world, and in particular from the Developing Countries, come to the Centre participating in various activities mainly in Physics and Mathematics.

It was decided to take advantage of this situation and to start a regular programme aimed at making our guest physicists and mathematicians conscious of how Physics and Mathematics are relevant to the development of their countries.

In this content some outstanding experts in the subject will be invited to give lectures. In addition some participants of each activity as well as the Associates of the Centre are asked to give a talk on this subject with particular reference to their own countries. These talks will then be issued regularly after each ICTP activity in the form of an internal report.

G.C. Ghirardi H.R. Dalafi

LIST OF CONTENTS

			Page No.
INTERNATIONALIZATION OF SCIENCE IN DEVELOPING COUNTRIES			
Abdus Salam			
SUMMER WORKSHOP ON PARTICLE PHYSICS			
B.A. Baaquie	-	Bangladesh	11
Asghar Qadir	-	Pakistan	30
RESEARCH WORKSHOP IN CONDENSED MATTER			
I.H. Adawi	-	Morocco	42
N. Collings	-	Lebanon	47
R. Engin	-	Turkey	51
M.K. Gbordzoe	-	Ghana	55
H. Ghassib	-	Jordan	78
J.O.A. Idiodi	-	Nigeria	95
SUMMER WORKSHOP ON FIBRE BUNDLES AND GEOMETRY			
S.A. Elsanousi	-	Sudan	113
O.P. Singh	-	India	120
AUTUMN COURSE ON GEOMAGNETISM, THE IONOSPHERE AND MAGNETOSPHERE			
E.M. Aquino	-	Philippines	134
D.M. Fubara	-	Nigeria	142
D.K. Kitpui	-	Kenya	156
E.M. Twesigomwe	-	Uganda	176
WINTER COLLEGE ON NUCLEAR PHYSICS AND REACTORS (25 January - 19 March 1982)			
Kh.M. Mannan			182

INTERNATIONALIZATION OF SCIENCE IN DEVELOPING COUNTRIES

Address by

Abdus Salam
International Centre for Theoretical Physics, Trieste, Italy,
and
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to the Board of Governors of the IAEA, 4 March 1980,
on the Celebration of the Award of the Nobel Prize in Physics (1979).

Mr. Chairman of the Board of Governors, Mr. Director General,

I cannot describe to you how honoured I feel by your very kind invitation for me to speak here to-day. As Scientific Secretary to the Geneva Conference in 1955, I witnessed the deliberations which led to the creation of IAEA and briefly as member of this Board in 1963, I had my first experience of how this Board wisely guides the Agency. Since 1964, Mr. Director General, I have had the privilege of working as a staff member of this great organization, as part of your team and under your dynamic and inspiring leadership.

The Holy Quran enjoins us to reflect on the verities of Allah's created laws of Nature; however, that our generation has been privileged to glimpse a part of His design is a bounty and a grace for which I render thanks with a humble heart.

My first thought on this occasion is with the great European experimental laboratory at Geneva - CERN. This laboratory in 1973 provided the first experimental evidence of neutral currents which are an essential part of the prediction of the theory. My thoughts go equally to the Stanford Linear Accelerator Center in the United States which in 1978, in an epic experiment, provided confirmation of the second aspect of the theory - its very heart - the unification of electromagnetic forces with the weak nuclear force. An experiment at Novosibirsk by a group led by Professor Barkov confirmed the findings of SLAC.

The theory, as well as the experiment, relating to this celebration represent meaningful international, scientific collaboration. Since internationalization of science is the subject of my remarks, in this context, I wish to start by recalling that the history of science has indeed gone through cycles among nations. Perhaps I can illustrate this with an actual example.

Seven hundred and sixty years ago, a young Scotsman left his native glens to travel south to Toledo in Spain. His name was Michael, his goal to live and work at the Arab Universities of Toledo and Cordova, where the greatest of mediaeval Jewish scholars, Musa bin Maimoun, had taught a generation before.

Michael reached Toledo in 1217 AD. Once in Toledo, Michael formed the ambitious project of introducing Aristotle to Latin Europe, translating not from the original Greek, which he did not know, but from the Arabic translation then taught in Spain. From Toledo, Michael travelled to Sicily, to the Court of Emperor Frederick II.

Visiting the medical school at Salerno, which had been given a Royal Charter by Frederick of Sicily in 1231, Michael the Scot met the Danish physician, Henrik Harpestraeng - later to become Court Physician of King Eric IV Waldemarssön. Henrick the Physician had come to Salerno to compose his treatise on blood-letting and surgery. Henrik's sources were the medical canons of the great clinicians of Islam, Al-Razi and Avicenna, which only Michael the Scot could translate for him.

Toledo's and Salerno's schools, representing as they did the finest synthesis of Arabic, Greek, Latin and Hebrew scholarship, were some of the most memorable of international assays in scientific collaboration. To Toledo and Salerno came scholars not only from the rich countries of the East, like Syria, Egypt, Iran and Afghanistan, but also from developing lands of the West like Scotland and Scandinavia. Then, as now, there were obstacles to this international scientific concourse, with an economic and intellectual disparity between different parts of the world. Men like Michael the Scot or Henrik Harpestraeng the Dane, were singularities. They did not represent any flourishing schools of research in their own countries. With all the best will in the world their teachers at Toledo and Salerno doubted the wisdom and value of training them for advanced scientific research. At least one of his masters counselled young Michael the Scot to go back to clipping sheep and to the weaving of woollen cloths.

In respect of this cycle of scientific disparity, perhaps I can be more quantitative. George Sarton, in his monumental five-volume History of Science chose to divide his story of achievement in sciences into ages, each age lasting half a century. With each half century he associated one central figure. Thus 450 BC – 400 BC Sarton calls the Age of Plato; this is followed by half centuries of Aristotle, of Euclid, of Archimedes and so on. From 600 AD to 650 AD is the Chinese half century of Hsiian Tsang, from 650 to 700 AD that of I-Ching, and then from 750 AD to 1100 AD – 350 years continuously – it is the unbroken succession of the Ages of Jabir, Khwarizmi, Razi, Masudi, Wafa, Biruni and Avicenna, and then Omar Khayam – Arabs, Turks, Afghans and Persians – men belonging to the culture of Islam. After 1100 appear the first Western names; Gerard of Cremona, Roger Bacon, Jacob Anatoli – but the honours are still shared with the names of the Spanish Ibn-Rushd (Averroes), with Tusi and Ibn-Nafis – the man who anticipated Harvey's theory of circulation of blood. No Sarton has yet chronicled the history of scientific creativity among the pre-Spanish Incas, Mayas, and Aztecs, with their invention of the zero, of the calendars of the moon and Venus and of their diverse pharmacological discoveries, including quinine, but the outline of the story is the same – one of undoubted superiority to the Western contemporary correlates.

After 1350, however, the developing world loses out except for the occasional flash of scientific brilliance, like that at the Court of Ulugh Beg – the grandson of Timurlane, in Samarkand around 1400 AD; or of Maharaja Jai Singh of Jaipur in 1720 – who corrected the serious errors of the then Western tables of eclipses of the sun and the moon by as much as six minutes of arc. As it was, Jai Singh's techniques were surpassed soon after with the development of the telescope in Europe. As a contemporary Indian chronicler wrote: "With him on the funeral pyre, expired also all science in the East.". And this brings us to this century when the cycle begun by Michael the Scot turns full circle, and it is we in the developing world who turn Westwards for science.

During this century, in the world of physics, we start with the name of Sir C.V. Raman of India – the Physics Nobel Laureate of 1930; then of the Japanese, Yukawa, Tomonaga and Esaki; and of the Chinese Lee, Yang and Ting. During 1979, was also awarded the Nobel award to the great West Indian economist, Sir Arthur Lewis.

As Al-Kindi wrote 1100 years ago: "It is fitting for us not to be ashamed to acknowledge truth and to assimilate it from whatever source

it comes to us. For him who scales the truth there is nothing of higher value than truth itself; it never cheapens nor abases him.". In the spirit of Al-Kindi, let me acknowledge my personal deepest indebtedness to the institutions which have nourished me scientifically – Cambridge, Imperial College, London and the Centre at Trieste.

Now, in this context the question we must ponder is this; are the developing countries to-day firmly on the road to a renaissance in sciences – as the West was in the 13th century at the time of Michael the Scot? Unfortunately, the answer is No.

There are two prerequisites to this renaissance: one, availability of places like Toledo and Salerno for international concourse, where one can light a candle from a candle. Second, the interest in our own developing societies to give the topmost priority to firstly, the acquisition of knowledge and secondly, its dissemination throughout the community. This is what was done, for example, by the Japanese Constitution after the Meiji Revolution.

Regarding the first point, regretfully, the opportunities for international scientific concourse are fast shrinking, with greater and greater restrictions in the traditional countries like UK and USA on acceptance of overseas scholars, including those from developing countries. When I was a student at Cambridge, the fees amounted to no more than £70 a year; next year they will be three thousand and five hundred pounds; an increase by a factor of fifty. As I will discuss later, it is becoming increasingly clear that the developing world will need internationally run – United Nations agency run post-graduate universities of science – not just for research, but also for the high level teaching of modern technology and sciences, both pure and applied.

The second prerequisite for development of science and technology is a passionate, consuming desire on the part of the developing countries and the removal of all internal barriers in its acquiring dissemination of sciences and technology throughout their societies and finally, the application of these towards development. Unfortunately, and I say this with anguish, the prognosis in this respect is not very bright.

Let us consider the acquiring and quality of scientific and technical knowledge. Seventeen years ago this Board pioneered in recognizing that there are two things wrong with science in developing countries; firstly its sub-critical size and secondly, that it was not part of international science. One of the major reasons for scientific brain-drain then, was identified as scientific isolation in developing countries. This Board can take the fullest credit, together with the Government of Italy and with UNESCO, of pioneering the first international centre in a scientific discipline, with a view to increasing the size of high-level scientific manpower and of removing their isolation.

I do not have to tell this Board how the idea of the International Centre for Theoretical Physics has fared since its inception. With UNESCO's active help, and with very generous assistance from the Government of Italy, the Town of Trieste, for which my colleague Professor Paolo Budini was responsible, the Centre was created by the IAEA in Trieste in 1964. UNESCO joined as equal partners with IAEA in 1970. Over the 15 years that the Centre has existed now, it has shifted from emphasis on fundamental and basic physics towards subjects on the interface of pure and applied physics - subjects like physics of materials, physics of energy, physics of fusion, physics of reactors, physics of solar and other unconventional energy sources, geophysics, laser physics, physics of oceans, and deserts, systems analysis - this, in addition to high energy physics, quantum gravity, cosmology, atomic and nuclear physics and applicable mathematics. The shift to the interface of pure and applied physics was not made because we thought that pure physics is less important for developing countries. It was simply that there was not and still is not any other international institute responsive to needs of technological hunger involving the discipline of physics. Perhaps the most important example to-day of this is in the field of physics and energy. Energy is at present the biggest concern of mankind. In country after country, either new departments of energy have been created or the Atomic Energy Commissions transformed to become comprehensive departments of energy. It is, of course, not my station to suggest to this Board and the Agency, that it should recognize this fact and concern itself with energy in all its aspects, so far as developing countries are concerned,

though I wish the Agency did do that. But with the encouragement of the Scientific Council, and the Director General, the Trieste Centre has felt that it should develop and concern itself with physics and energy in all its aspects, that is to say, not only the physics of nuclear power reactors and fusion, but also with the physics of solar energy, including the physics of absorbing and emitting surfaces and photo-voltaics, as well as mathematical studies of energy systems. As a functional arm of the Agency, I am sure we have the fullest blessings of the Board in this programme, and also of the Government of Italy.

But to go back to the Centre, every year around 1200 physicists - half of them from 90 developing countries, these spending on the average, of the order of two months or more at the Centre, participate in research workshops and extended research colleges. We have pioneered an associateship scheme which guarantees that top physicists in developing countries can come to the Centre for a period ranging between six weeks to three months, three times in six years, to work in a stimulating environment of their peers, to charge their batteries and then to return to their teaching and research positions. There are 70 such associates at present, most of them financed by the Swedish Development Agency, SAREC, and some from a special grant from Denmark. We have a network of 52 institutes of physics in developing countries federated with us. The Centre has brought credit to IAEA in the Comity of International Schientific Scholarship - pure, applied and technological - besides meaningfully strengthening physics and physics communities in the developed and developing world. I had hoped that the Agency would create similar centres in experimental physics, in chemistry and reactor engineering, to create and sustain communities in these subjects, but unfortunately, this did not happen.

But over the 15 years that I have been privileged to direct the physics Centre, I have felt more and more strangled, and never more so than now. I used to pride myself on spending half a day, every day, in research, half a day in administration. Progressively over the last five years, this has become impossible. This is not because the task of administration has become more arduous; it is simply because the uncertainty of the Centre's standing in the ecology of international institutes has increased, despite its success, despite its demonstrated need. Its very existence is uncertain from year to year. The Centre functions with no long-term scientific staff; its faculty consists of short-term volunteer committees. It had just one administrative officer and nothing but 18 secretaries looking after the 1200 physicists a year. But even this skeleton staff had to be cut last year.

There is no question that the Trieste Centre still is the model for future international assays in scientific collaboration; particularly for the developing countries. There is no question, but the developing world needs to-day, international institutions of this type, but with requisite stability, e.g. on the applied side, institutes like the Wheat and the Rice Research Institutes, and on the physics side, centres like that at Trieste. Without internationalization, science cannot flourish; such centres, particularly those run by United Nations agencies, guarantee standards, guarantee keeping abreast of new ideas, guarantee a transfer of science and technology by men who created it who come to such centres, moved by idealism, at a fraction of what others would pay them. If such international centres are in developing countries, one may even envisage reverse brain-drain.

My distinguished colleagues on the Board of Governors can take pride in having taken a great step to set up a Centre universally acclaimed and recognized to be essential to the physics in the developing world, but they must also pay serious attention to the Centre's health and stability. Many years back, the Director General launched a special appeal for the Centre; it brought a most generous response of one thousand dollars for three years from Sri Lanka. I understand the Governments of the USA and Japan are contemplating direct help to the Centre on a continuing basis. We need other nations to join them.

The Trieste example is now being copied with the recent setting up of an international centre in mathematics at Nice, by France last year, the creation of a national/international centre for physics in Mexico during February of this year and a centre for fundamental research, announced last week by the President of Sri Lanka. And during a recent visit to Latin America, I was encouraged to learn that an international centre on alternative energy may be contemplated in Brazil, another on

mining - and particularly radioactive minerals mining - technology in Peru, a centre on photovoltaics in Colombia and an international centre on petroleum technology in Venezuela. I am sure similar suggestions for national/international centres will come from countries of Asia and of Africa which I am looking forward to visiting this year. My own feeling is that almost every developing country has a technological problem which needs international scientific expertise. I strongly feel that the United Nations systems, IAEA, UNESCO and UNIDO must take a lead through direct or indirect helping in this legitimate movement towards the internationalization of science in developing countries. I do not wish to imply that internationalization of science through such centres is the whole story, but I do wish to suggest that they are an important part of it.

In sciences, as in other spheres, this world of ours is divided between the rich and the poor. The richer half - the industrial North and the centrally managed part of humanity - with an income of 5 trillion dollars, spends 2% of this - some 100 billion dollars - on non-military science and development research. The remaining half of mankind - the poorer South, with one fifth of this income of around one trillion dollars - spend no more that 2 billion dollars on science and technology. On the percentage norms of the richer countries, they should be spending ten times more - some 20 billions. At the United Nations run Vienna Conference on Science and Technology held last year in this town, the poorer nations pleaded for international funds to increase their present expenditure of 2 billions to 4 billions. They obtained promises, not of two billions, not of one billion, but only one seventh of this. Some observors fear that at the pledging session in New York this month, unfortunately, even this may not be realized.

I would like to conclude with three appeals.

My first appeal is to the developing countries. In the end, science and technology among them is their own responsibility. Speaking as one of them, let me say this: your men of science are a precious asset. Prize them, give them opportunities, responsibilities for scientific and technological development of their own countries. At present even the small numbers that exist, are underutilized. However, the goal must remain, to increase their numbers tenfold, to increase the 2 billions internally spent on science and technology to 20 billions. Science is not cheap; and in addition, we must not forget that technology in the conditions of to-day, cannot, in the long run, flourish without science flourishing at the same time. This was dramatically emphasised recently to me by a Turkish physicist from the University of Samsun who recalled that Sultan Selim III did introduce studies of algebra, trignometry, mechanics, ballistics and metallurgy in Turkey already as long ago as 1799, creating special schools for these disciplines with French and Swedish teachers. His purpose was to modernize the army and rival European advances in gun-foundaries. Since there was no corresponding emphasis on research in these subjects and since the scholarly establishment in the medreses who called themselves scientists, alims, had nothing but contempt for these new technological schools - "funun" - Turkey did not succeed. In the long run, in the conditions of to-day, technology unsupported by science, simply cannot flourish.

My second appeal is to the international community - both of Governments and of my fellow scientists, as well as the United Nations agencies.

A world so divided between the haves and the have nots of science and technology cannot endure; at present an International Centre for Theoretical Physics (with a budget of 1.8 millions) is all that is internationally available for physics for 90 developing countries. Compare this with European joint projects involving physics alone, of ½ billion dollars annually. Compare this with the cost of one nuclear submarine; 1.7 billion dollars. One thousand centres like Trieste could flourish for one year, for one of these and at present there are two hundred and fifty nuclear submarines in the world's oceans. Somehow, somewhere a break must come.

And finally, and in all humility, I wish to make an appeal to the Governors here to-day from the OPEC countries. The President of Venezuela was in Vienna on 14 February. Addressing an OPEC staff meeting, he spoke of the need for an OPEC international centre for sciences. I would like to address myself in this context, particularly to my brothers from the OPEC Islamic countries. To some of you Allah has given a bounty - an

income of the order of 100 billion dollars. On the international norms these countries should be spending 1 billion to two billions of dollars annually in supporting science and technology. It is your forebears who were the great torchbearers of international scientific research in the 8th, 9th, 10th and 11th centuries. It was these forebears who funded the first Bait-ul-Hikmas - Advanced Institutes for Sciences - where concourses of scholars from Arabia, Iran, India, Turkey and the Byzantium congregated. Be generous once again. It is as much our responsibility in accordance with Allah's injunctions, to add to human knowledge as was theirs in their day. Spend the billion dollars on international science, even if others do not. Create a fund - available to all Islamic, Arab and developing countries, so that no potential, high-level talented scientist in the developing world is wasted. My humble personal contribution to this fund has been all I possess - the $60,000 the Nobel Foundation so generously awarded me. Rabbana Taqqabal Minna.

SUMMER WORKSHOP ON PARTICLE PHYSICS

(21 June - 31 July 1982)

PHARMACEUTICAL TRANSNATIONALS IN BANGLADESH *

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It is a commonly known fact that medicines are an essential social requirement, and constitute one of the more important fruits of modern medical science. It also concerns all sections of the society, as drugs and medicines are indispensable commodities, and hence an important issue for the consumers at large. The fundamental demand of the consumers is that there be assured to them, a steady and regular supply of standarad quality drugs at fair prices. The question of fair price cannot be over emphasized in a poor country such as ours, since the price of the medicines often decides whether the consumer can afford the medicine or not, and ultimately poses a life and death question to the consumers.

In this article, we briefly examine the question of pricing, quality and marketing of pharmaceutical products, and assess the problems being faced by the consumers. We will mainly focus on the pricing of drugs, and will briefly discuss the possible protection that the consumers can take.

The marketing quality and pricing of medicines is regulated primarily by the Ministries of Commerce, Industry & Public Health. For any particular medicine to be marketed, it has to be approved by the Drug Administration, which tests the quality and composition of the drug using the Government's Drug & Testing Laboratory. Once the permission to market the drug is granted, the Maximum Retail Price (MRP) is fixed by the Director General of Prices, Supplies & Market Intelligence, Ministry of Commerce. To fix the MRP, the cost of the raw material and packaging material demanded by the manufacturer is approved or otherwise by the Technical Committee; and on the basis of this, the permission to import the raw material and packaging material is granted by the Chief Controller of Imports & Exports, and the allocation of the requsite foreign currency is made by the Bangladesh Bank from the countrys foreign exchange reserves.

Given the above Government machinery for regulating the price of medicines, one would imagine that everything must be in order, and that fair pricing is being assured. However, a closer look at the problem reveals a number of loopholes and ways to circumvent the Government's regulations. We now examine this in some detail. (1 crore = 10 million; 21 Tk. = 1 US$).

In 1980, the total sale of Drugs and medicines in Bangladesh was Tk. 125 crores, of which 8 Transnational Corporations (TNCs) with local factories had a total sale of Tk. 90.50 crore, the local manufacturers sold Tk.19.5 crore worth and Tk.15 crore was imported from the TNCs mostly through the Trading Corporation of Bangladesh. Hence, TNCs were responsible for Tk.105.5 crore i.e. 84.4% of the total sales. Actually, the total sale by TNCs was even higher, since a number of TNCs like Sandoz

* This article appeared in Kretapokkho I (1981) which is the Bulletin of the Consumers Protection Society, Dacca, Bangladesh.

Upjohn, Cynamide, etc. do not operate here directly but instead sell their raw materials and technology to local pharmaceuticals who simply package the drugs in question. *Hence, it can be safely asserted that over 90% of the pharmaceutical market is in the control of the TNCs, and that the pricing of drugs and medicines in Bangladesh is primarily determined by these TNCs.*

The price of drug i.e. the MRP is fixed by Government to be approximately 160% of the Cost and Freight (C&F) value (which includes the value of the raw material and packaging material) of the drug in question. This 60% mark-up on C&F price includes 20% for insurance, bank charges etc, 30% for distributors and retailers commission and only 15% to 20% profit for the manufacturer. Other significant costs that enter indirectly into the price of the drug are labor and administrative costs, the royalty payments, consultants fees, free samples costs, publicity and marketing costs etc. *Although the paper profits of the TNCs is shown as 15% to 20% on the final product cost, it is estimated that they are making between 70% to a few hundred percent actual profit.* We now go into the details of the main factors contributing to the excess prices and eventually to the excess profit being made by the TNCs. We will focus on the TNCs as they occupy an overwhelmingly important position in the pharmaceutical industry. The most important factors in the over-pricing of drugs and medicines are the raw material and packaging materials costs, the marketing costs and finally the financial manipulations of the TNCs.

Note that since the foreign currency for buying the packaging & raw materials is provided by the Bangladesh Government, over-pricing of these causes huge losses of valuable foreign exchange and is a serious economic loss to the country.

1. Raw Material: Most of the TNCs are buying the pharmaceutical raw materials at exorbitant costs at times 100% to 200% higher than the international prices. The TNCs take refuge behind various reasons to justify the higher prices. For example it is reported that a leading TNC, Pfizer has a binding clause in its agreement with the Government that its head office in the U.S. will have to approve of any raw material that is purchased. This allows Pfizer in Bangladesh to buy the raw materials at exorbitant prices from its sister companies abroad and hence transfer profit out in the name of production costs. Most of the TNCs have such binding clauses in one form or another. Another catchword used to justify high prices is quality. We give a table of the different price of an essential drug oxytetracycline which illustrates our point. (See P. 22)

As can be seen from Table 1, ICI has charged over 350% more per kg. for oxytetracycline than the minimum cost in Table 1 of Tk.522 per kg. The claim that the quality of Pliva Pharmaceutical is questionable is also false, since Pliva products have been approved by the Federal Food and Drug Authority of the USA, as being of standard *quality and usable inside the US. (Note also that Glaxo is importing the same chemical from Yugoslavia showing that the quality is of international standards).*

There are numerous other examples of this sort of over-pricing of raw materials. For example, the price of Trimethoprim, which is the main ingredient of Septrin, was put at Tk.9,600 per kg. by ICI whereas a local manufacturer purchased the same chemical for Tk. 3,000 per kg. again showing an over-pricing by 300% by an TNC. The cost of 50 cc of Lignocaine, and anesthetic, is 3 cents, but May & Baker demanded a final price of US$ 1.20, of which 50 cents was the cost of the bottle imported from U.K.

The TNCs usually justify the high price of their raw materials by quoting high cost of labor in Western country's, the high quality, ease of procurement etc. Their logic is false, since quality raw material at a cheaper cost is what we need, and we need not necessarily by these from the Western countries or other costly sources.

As one can see, the main loophole being used by the TNCs to circumvent the Government regulations is to charge exorbitant prices for the raw materials, and given the binding agreements that most of the TNCs have managed to obtain from the Government, they now have a free hand in demanding exorbitant C & F prices. Also, in many cases no back-up material was provided to justify the C & F costs when such was demanded by the Government.

TABLE I

Name of Company (TNC or Local Company)	Source of Supply	Rate per Kg.	Rate per kg. in Tk.
1. I C I (TNC)	Imperial Chemical Industries, London	£ 67.42	2342
2. Pfizer (TNC)	Pfizer Laboratory, Hong Kong	US$ 80.36	1271
3. Glaxo (TNC)	Glaxo Group Limited, (Yugoslav origin)	£ 22.40	784
4. Pharmadesh (Local)	Pliva Pharmaceuticals, Yugoslavia	US$ 42.00	664
5. K.D.H. Laboratories (Local)	Pliva Pharmaceuticals, Yugoslavia	US$ 33.00	522

Most of the binding clauses of the TNCs require that the quality of the raw material be either tested abroad or be approved by the TNCs main office. There is no reason for the quality of the raw material to be tested abroad. It is reported that many TNCs (eg. ICI, Glaxo, etc.) have excellent local testing facilities which can assess the quality of the raw material. Also, local quality control laboratory with modern equipment can be set-up at a capital cost of Tk.50 lakhs and using the existing local expertise. Once the quality of the raw material is locally evaluated, the consumers as the Government can obtain a firm grip over the pricing and the quality of the raw material supply and hence ensure fair practice. "The current practice of allowing the TNCs to assess the quality of raw material abroad should be stopped".

The total import of pharmaceutical raw material was over Tk. 45 crore in 1979, and it is estimated that there was an over costing by 40% in this import. There are three ways of blocking this malpractice of the TNC drug manufacturers. Firstly, to have a centralized import of the raw material to be regulated by the Government, and steps taken to ensure that the lowest price is paid for the standard quality raw material. For example, the Government can decide the acceptable sources of supply and the maximum raw material price, and the pharmaceuticals would then import it directly from these sources at the specified costs. In this manner over-pricing can be stopped. For example, price reductions of over 50% were achieved in the raw

material costs by the State Pharmaceutical Corporation of Sri Lanka who purchased raw materials for some privately owned companies in 1973. Also, all unreasonable binding clauses with the TNCs pertaining to raw material purchase and technology transfer from abroad should be deleted at the time of production licence renewal. *Secondly*, the Government should develop the basic raw material manufacture locally. Currently about Tk. 3 crore worth of raw materials are being produced locally. The experts are of the opinion that at present we should manufacture only some specialized synthetic raw materials, but that for the fermentation raw materials we have sufficient experties to start a multi-purpose antibiotic complex which would among other things produce penicillin, ampicillin, tetracycline and sterptomycin. Presently, about Tk. 20 crore, worth of these antibiotic raw materials are being imported. A multi-purpose plant would cost about Tk. 200 crores, and would be a strategic asset for the country, specially in times of war or some emergency when the import of these antibiotics could be disrupted causing disastrous consequences. Besides the antibiotics, another Tk.5 crore worth of other pharmaceutical raw materials can be produced locally. The Government should make the renewal of the production licenses of the TNCs conditional on these TNCs producing some of the basic raw materials. And *thirdly*, the Government should allow the TNCs to produce only those drugs for which technology is either uneconomical or else doesn't exist locally. For low technology products like toothpaste, vitamins, cough syrups, tonics, glucose-D etc. local firms should be the main producers whereas currently over 80% of the products of the TNCs are of this category. For example in India, the TNCs are allowed to produce Tk. 1 worth of low technology drugs only if they produce Tk.3 worth of high technology products. These three steps, that is centralized procurement of raw materials, the manufacture by local companies of both the raw materials and the drugs involving less technology would bring down the prices of the medicines substantially.

II. ***Packaging Material*** : *About Tk. 15 crore worth of packaging material was imported in 1979, and forms an important component of the medicine's price.* For example, in the price of Dettol manufactured by Robinsons Food, 66./- of the cost is the price of the imported bottle. The Government made repeated demands on Robinson Food to produce or procure the bottle locally, but to no avail. The cost of packaging material is over 50./- for a large number of drugs, and for all the drugs which are bottled or are in vials and ampoules.

The main categories of packaging material are bottle (amber colored, clear glass and plastic), neutral glass vials, ampoules, gelatin capsules and foil packing. Of these categories, only a fraction of the bottle requirement is being produced locally worth Tk.6 crore. *The rest of the packing material is being import at an estimated over-pricing of 30%. (There is also an over-pricing of 10% in the overall freight costs.)*

To stop this malpractice, the Government should enact legislation to closely regulate, or if necessary control the procurement of the packaing material. The Government should also encourage the local manufacture of other forms of packing, all of which can be produced economically and do not involve much capital or technology.

III. *Marketing : There are two main forms of marketing malpractices adversely affecting the Consumers. The first is the creation of scaurcity and the consequent high prices that the consumers are forced to pay. The other is the marketing of drugs under brand names, in which case the consumer pay more for a brand name that is well advertised whereas the same drug is available at a cheaper cost under a different brand name.*

It is a common experience in Dacca that when some medicine is scarce, one has to pay far above the Maximum Retail Price (MRP) that is marked on the medicine, and no receipt for the excess amount paid is given. The production level of the pharmaceutical companies has two aspects, firstly to produce less so as to maintain high market prices, and the other is to produce more than approved amount since the product is more profitable. We illustrate the marketing practice of the TNCs by giving the production figures of Glaxo for 1976-77.

As can be seen from Table II, Glaxo shortfall in the minimum quantity fixed by the Government for antibiotics is 25%. Similarly for ointment, vial and ampoule injectables the shortfall was 4%, 54%

TABLE—II

ANNUAL PRODUCTION OF GLAXO FOR 1976–77

Drug	Approved Annual Capacity	Actual Production (1977)	% of approved capacity
1. Antibiotic Dry Vial	11,640,000	8,280,000	71%
2. Ointment	1,800,000	1,700,000	91%
3. Injectables			
i) Vial	2,500,000	1,160,000	46%
ii) Ampoule	1,600,000	48,000	3%
4. Oral Liquid	1,500,000	2,680,000	179%
5. Tablet	83,000,000	129,000,000	155%

and 97% respectively. This under production adversely affects the consumers as mentioned earlier. On the other hand, Glaxo has over-produced oral liquids and tablets (which includes cough syrup and vitamins) by 79% and 55% because they found its market lucrative and could boost their profits. Of course, the TNCs always have some justifications for their under and over production and only a close monitoring by the Government or a citizens body can regulate supply effectively.

These types of marketing malpractices by the TNCs disrupts the supply of essential medicines, creates artificial shortages and hence causing suffering and in some cases even death to large numbers of consumers. And it negates the Government overall planning for the steady supply of medicines. The Government should take action against these types of contravention by the TNCs and should have well-defined penalties. *The Government should also forbid the marketing of dangerous, experimental and internationally banned drugs as well as drugs with no proven medicinal values, so as to protect the consumers.* The Government should also compile a list of essential drugs and ensure a steady supply of these. The local manufacturer should be encouraged by the Government to produce these essential drugs so as to have a nationally dependable source of supply. On the distribution side, the black marketing and hoarding by the retailers and distributors should be opposed both from below by the consumers, and also from above by Government regulations. The Government should also help the marketing of essential drugs in coperation with the local manufacturers, and establish an alternative retail system using the Rural Health Clinics etc. as possible retail outlets. The Government should also set-up Fair Price Medical Shops to ensure the steady supply of quality drugs.

The marketing of medicines under brand names also adversely affects the consumers. Most drugs have three names a) Chemical name which gives the complete chemical composition of the drug and can be understood only by a chemist. b) Generic name which is the established name and can be understood by a non-chemist. c) Brand name is the designation given by the manufactuer to the chemical.

An important marketing malpractice in marketing under brand names is that the chemical composition of the drug is often not mentioned in the packaging material. Hence, the drug companies cannot be taken to task if an analysis shows that certain harmful or unspecified chemicals are present in the drug. *The Government should pass a low that the explicit chemical composition of the drug must be clearly printed on the packaging material, also all the possible harmful side-effects of the drug must be clearly stated.* The Government should also from time to time do a sample testing of the drugs and check that the drugs composition is the specified one. This testing should also be done by citizens and consumers associations so as to have further protection of the consumers.

For example the generic chemical metronidazole

is being sold under three brand names Klion, Amodis and Flagyl. The current market cost of Klion, Amodis and Flagyl for a 50mg, tablet is 50p, 60p and 100p respectively, and hence the cost of Flagyl is 100% higher than Klion. Since the consumers cannot identify these two medicines as being the same, they are in some cases paying twice the amount for the same drug.

The marketing under a brand name is linked to the high pressure sales tactics being used by the TNCs to convince doctors to prescribe their brand names. The practice of giving free samples to doctors is also a highly questionable way to promoting sales, and also adds to the high costing of the medicines.

The Government should instead introduce the practice of marketing drugs under the generic names, and the manufacturers name can follow the generic name in paranthesis. For example, India passed a law in 1981 that eleven essential drugs can be marketed *only* under the generic name; for the remaining drugs, the generic name has to be given in bold type right next to the brand name. In this way the consumer can choose between the cost of the drug and the reputation of the manufacturer, instead of being helplessly in the hands of the TNCs. It is estimated that if medicines are marketed under the generic names, this would bring down the price by 30%, and would also allow more people to afford to buy medicines.

IV. *Financial Manipulations*: This is a rather technical subject, and needs highly specialized experts to track down the juggling of the accounting figures being done by the TNCs. We will simply give a few examples to illustrate our point.

The most important means being used by the TNCs to avoid Government regulation is in the over-pricing of the imported packaging and raw material. It should be specifically noted that all the foreign currency involved in importing packaging and raw material is provided by the Bangladesh Bank, and the depletion of our foreign currency reserve by the means of over-pricing is a major loss to the country. By doing so, the TNCs besides over-pricing the final product also transfer foreign currency abroad which otherwise would be forbidden by Government regulations concerning repatriation of profits abroad. They also escape paying income tax on their actual profits and hence are depriving the Government of huge sums of revenue.

A common allegation brought against the TNCs, but difficult to prove, is that in importing the raw material, the TNCs do the following: They open a Letter of Credit (LC) in the name of their principal for the given raw material at their quoted (and usually very high) rate, with the condition that the port of shipment is anywhere in Europe. Their head office shelves the intial LC, and opens another LC for the same raw material but from a much cheaper source, and has it trans-shiped to say Chittagong from somewhere in Europe. In this manner they can make upto 300% profit on the cost of the raw material. *In principal, this opening of double LC's can be detected by efficient customs officials by closely inspecting the cargo including the makings on the packing etc. Also, as a preventive measure*

there should be a clause in the LC forbidding trans.shipment and having named port of shipment.

Another type of financial manipulation is to disguise profits as local costs and hence increase the price of the drug, escape income tax as well as circumvent the Government regulation regarding the repatriation of foreign exchange abroad. For example, in 1976-77 Glaxo declared its selling and administrative expenses to be Tk.1.7 crore, and on this basis claimed a 27% mark-up on the factory cost for the overhead expenses in determining the price of the drug. However, on closer examination, it was found that in the selling and administrative expenses, Glaxo had included an amount of Tk.38 lakhs paid for royalty and consultancy fees and Tk.40 lakhs paid as interest on bank overdratts. This amount i.e. Tk. 78 lakhs is not an expense that can be included in the pricing of the drug according to the Governments regulations. Subtracting this quantity out gives for oveahead expenses only a 15% mark-up on the factory cost for the price of the drug. Hence this extra amount of 12% would have been extracted from the consumers by Glaxo as profit and would have gone against the regulations of the Government.

Another example is the manner in which excess foreign currency is being repatriated abroad. In 1975 Hoechst showed short term foreign currency loan of Tk.2.2 crore whereas the Government had sanctioned it a loan of only Tk.0.8 crore. Together with the interest on Tk.2.2 crore, which was Tk.0.7 crore, Hoechst repatriated abroad a foreign currency worth Tk,2,9 crore, well over Tk.1.8 crore in excess of the amount sanctioned by the Government, and hence causing a major drain on foreign currency. The company could have re-evaluated its assests and prevented this drain on our foreign currency reserves. However, in 1976 Hoechst revalued its assests and absorbed a profit of Tk.62 lakhs as capital reserves. It is interesting to note that Hoechst had a paid up capital of only Tk.14 lakhs in 1976, and was doing all this dealing in crores of takas using bank overdrafts etc., the final cost of which was borne by the consumers in the form of high priced drugs.

To effectively encourage the growth of the local pharmaceutical companies, the Government should combine strict quality control of the products of the local companies together with liberal financial assistance to and appropriate legislation in favour of, these local companies. Only by forcing the local pharmaceutical companies to have good quality products can the consumers have confidence in the local companies. Once the local companies can obtain a fair share of the market due to their quality products, the Government can then take appropriate steps to further encourage the local manufacturers and restrict the disprortionate control of the TNCs on the local medicine market.

In summary it can safely concluded that the high pricing of drugs is mainly due to the excessive profits being made by unfair and unethical activities of the multinational pharmaceutical companies starting from the procurement of raw materials and packaging materials to freight costs, and ending

up in dubious marketing practices and legal manipulations. These malpractices of the TNCs cause serious losses of foreign exchange and revenues to the country. The drugs are also being over-priced by at least 40%-50%, and in a poor country like Bangladesh this means increased human suffering, and unacceptable excess profit extraction from the consumers.

It should also be noted that our country has a rich and old tradition of local indigenous medicine mostly using herbs and roots. The Government as well as private medical societies should seriously encourage research into the indigenous medicines by appropriately funding such projects and place indigenous medicines on a sound scientifc basis. By then popularizing these indigenous medicines, a number of common ailments can be cured inexpensively and also will substantially cut down on import of raw material etc. from abroad. The system of using indigenous medicines in combination with Western medicine has been widely practiced in China, with remarkable success. Similar steps should be taken in Bangladesh and specially since the rural population will be greatly benefited by this. However, currently there is no legislation controlling the quality and marketing of these indigenous medicines. The Government should frame appropriate laws for the marketing of these medicines so as to protect the consumers.

Some people try to shift the entire responsibility of fair pricing of drugs onto the shoulders of the Government. They claim that the TNCs are always following Government regulations, and that it is entirely the Governments fault if the malpractices of the TNCs are not detected and eradicated. The weak role of the Government in relation to the TNCs is definitely one of the major causes of the TNCs having a free hand; however, it should not be forgotten that the TNCs form a powerful lobby which is active in unfairly influencing the Government from behind the scene. And also, that the main beneficiary of these excess profits of the TNCs are the TNCs themselves, and hence the main and root cause of the malprctices in the pharmaceutical sectors. Hence, given the weak and concilliationist position taken by the Government, as well as the fledgling state of the local pharmaceutical companies in relation to the TNCs, the only force that can face up to this situation are the consumers themselves.

The fundamental solution to this malpractice of the TNCs is to make the consumers aware of the harm that the TNCs are causing to them. And based on this awareness, to form a powerful consumers lobby to monitor and evaluate the activities of the pharmaceutical TNCs so as to inform, educate and protect the consumers; and also to persuade and pressurize the Government to pass strict legislation controlling the activities of the TNCs. This consumers lobby should also support the local growth of the pharmaceutical raw material, packaging and formulating industries as so to bring prices down by using indigenous resources, and also to make the country free from these manipulation by TNCs which are to the detriment of the national interests.

DUAL SECTOR INFLATION AND IMPORTED TECHNOLOGIES

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ABSTRACT

It has been noticed that economic inflation in Pakistan needs to be described in terms of two sectors rather than by a single inflation rate. The problems arising from this bifurcation in the economy are discussed briefly. A possible connection between this phenomenon of dual sector inflation and importing a technology rather than developing it indigenously is explored.

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I. INTRODUCTION

I would like to discuss here a possible connection between importing a technology and the phenomenon of dual sector inflation [1], which will be explained shortly. The study conducted so far has been limited to Pakistan, but there is some indication that the findings obtained there apply to other countries which have imported technologies instead of developing their own technological base. (The distinction drawn here should become clear later.) Of course, much work needs to be done before the 'indications' lead to a concrete theory. It is hoped that people around the world will check the conjecture for themselves, and I would be happy to learn about its validity from them. In the meantime I am assuming that the conjecture is true and proceeding to discuss policy implications on that basis. Before proceeding I shall briefly review the dual sector inflation model.

As everyone knows, inflation is the self-perpetuating rise of prices. The most complete description of inflation in an economy would be a total time chart of all the prices of all the commodities. Of course, such a chart is of little use in the future. Nor can it be easily used to predict the price of a 'typical' commodity at any time. The purpose of the statistical index called 'inflation rate' is to provide an estimate of the future price of the 'typical' commodity. For this index to fulfill its function the uncertainty of prediction should be substantially less than the prediction itself. If such a situation exists a single inflation rate is a useful index, but if it does not more than one inflation rate must be considered. Since a random break-up of a sample would increase the effective uncertainties, a break-up which reduces the effective uncertainty can be reasonably expected to have some economic significance. If an analysis with two inflation rates gives reasonable predictions where a single rate does not, the dual sector model would have to be used. Even otherwise the dual sector model may give some useful information which is hidden in the single sector analysis. Let us first look at some toy dual-sector models so as to be able to understand the significance of the more complicated, typical situation.

II. SIMPLE MODELS OF DUAL SECTOR INFLATION

In the simplest case (see Fig.1a) where two sectors start at different price levels and have the same, constant, inflation rate, the break-up seems artificial, and the single inflation rate is a better description. However, with the increasing inflation rate (see Fig.1b) the dual-sector model provides new insights, not available in the single inflation rate analysis. One sees that the price difference between the two sectors goes on increasing. However, in real terms (the price difference rescaled by the inflation rate) the price difference does remain the same. The dual-sector effect is most dramatically displayed if we have one sector inflating and the other deflating at the same rate (see Fig.2). In this case the single-sector analysis would give a zero inflation rate. It would not help in predicting that one lot of commodities would have rising prices and the other falling prices. Nor would it predict the crisis that would come when the falling prices hits zero and the other sector continues to inflate. A more typical situation is given in Fig.3 where two nearly equal sectors are inflating at different, increasing rates. The initial single inflation index, may be reasonably good as the 'scatter' between the two sectors is small compared with the inflation rate. However, after a certain stage the 'scatter' becomes larger than the prediction, as the sectors diverge enough. At this stage the single-sector inflation model ceases to be good and a dual sector model becomes essential. Normally economists try to deal with this problem by re-indexing their prices. This 'remedy' has the problem that the re-indexed prices become sensitive to the choice of numeraire. In fact, one should give up any attempt to represent the situation in terms of a single-sector inflation model.

III. DUAL SECTOR INFLATION IN PAKISTAN

The actual situation is that there are a number of different commodities each with its own price variation over time. The average inflation rate is obtained by taking the weighted average change of prices and dividing it by the time interval over which the change is observed. The 'scatter' may be obtained by the standard deviation for a large sample and Δ (the standard deviation divided by the square root of one less than the number of commodities) for a small sample. The reasonable confidence level is twice the standard deviation for a large sample, 2Δ for a small sample, and the average of the two for a medium sample. In the case of Pakistan [1] the single index (over 44 commodities) is $(11.3 \pm 17.6)\%$ (using the standard deviation). The single sector analysis is obviously inadequate. On separating into the sectors of consumption items (16 commodities) and production items (28 commodities) the inflation rates are $(16.9 \pm 14.4)\%$ and $(6.2 \pm 4.0)\%$, respectively (using the standard deviation plus Δ).

We have two fairly reliable predictions instead of one unreliable prediction. If one can place a commodity in a given sector one knows the expected inflation over a sufficiently large period of time. These values are based on Government figures [2] which seem to show lower inflation rates than are believable [3], and thus minimize the dual sector effects discussed above. A more realistic analysis gives even bigger differences showing about 20% and 5% (approximately), respectively.

IV. ECONOMIC SIGNIFICANCE OF DUAL SECTOR INFLATION

A natural question to ask, at this stage, is why there should be more than two sectors. Clearly, too many sectors will reduce predictive power instead of increasing it. However, there is no fundamental reason to prohibit more than two sectors. In fact, if two sector analysis is not adequate for obtaining rates which are greater than the uncertainties on them, one may need to take more than two sectors. The interpretation of the analysis will, though, be much more difficult. If new insights can be obtained using more sectors there is no reason to limit ourselves to only one type of analysis using one, or two sectors.

One of the important insights obtained from the dual-sector models is the discrepancy that arises between the income and expenditure of a worker in an economy like Pakistan's. The expenditure goes up on the steeper consumption sector inflation, but since he is a production commodity himself, his price (wages) goes up on the shallower production sectors. Clearly, at whatever level we set the subsistance level price, the worker will fall below subsistance level at some stage (see Fig.4). At this crisis point he strikes and gets his wages raised so that he again rises above the subsistance level. Due to the increase of the inflation rates the strikes ask for greater wage rises and come out at shorter intervals. The ever-increasing divergence between the two sectors indicates that his is a very poor remedy.

V. IMPORTED AND INDIGENOUS TECHNOLOGIES

On a very rough survey it appears that this phenomenon of dual sector inflation (i.e. the divergence between the sectors to such an extent that they cannot be meaningfully regarded as one sector) is a malaise of the under-developed

countries. I am unable, at present, to provide any concrete suggestion as to how it can be curved, though I do have some tentative ideas which I shall not discuss here. The conjecture mentioned in the beginning is that the dual-sector inflation may be a consequence of importing technologies rather than developing them indigenously. Let me explain the difference between the two. By 'imported technology' I mean a technology all of whose components, or a large portion of them, have to be continually imported. An 'indigenous technology' is taken to mean one in which all, or nearly all, components are indigenously produced. At any time it would be cheaper to import some components rather than manufacture them in the country. However, such a policy probably leads to dual-sector inflation and introduces new problems. These problems may turn out to be more expensive, in the long-run, than the development of the same technology indigenously. I am not saying that the import of technologies is the only cause of dual-sector inflation, but only that I believe that it is one of the causes. Let me now suggest the obvious remedy for this particular cause of dual-sector inflation.

VI. POLICY IMPLICATIONS OF DUAL-SECTOR INFLATION

I would suggest that a conscious choice be made as to which technologies should be developed. The choice must depend on what components of the technology can be reproduced indigenously. Only those technologies which can be mainly developed indigenously should be considered. In the case of a technology which, at the time, requires a few imported components, a programme must be started to produce the component indigeneously, and a deadline given to make the technology completely indigenous. Till such time as a given technology can be largely indigenous, it should not be started for commercial use. Though a static, or short-term, analysis will prefer the apparently cheaper policy of importing the components of any technology, any long run dynamic analysis will prefer the policy of developing every technology which is to be used indigenously. The technologies developed must be used with an intensity that can be supported internally - and no more.

The next step would be to invest new technologies internally. For this purpose one must have a strong base of fundamental science available within the country. It is, therefore, necessary to maintain a core of basic science while developing the technologies internally. For this to be possible equipment for scientific research and teaching must remain available, even when it is not internally produced. Thus the suggestion is, really, that all technologies for commercial use must be internally produced, but the technology to support the science base may continueto be imported for a longer time. It will clearly not contribute to the dual-sector inflation as it is a very small fraction of the total economy. (Similarly, other essential technologies which form only a small part of the economy may be imported.) We need to have basic science to provide the manpower and ideas for developing new technologies, more suited to the needs of the particular economy than the copied technology. Only a society which has this ability, and the desire to create new knowledge can ever hope to compete with other countries. And a country without hope cannot survive. Putting money into basic science may be regarded as an insurance for the future when the country will have dealt with most of its more pressing problems.

To summarize, I have pointed out that there is a bifurcation in the economy of Pakistan. This bifurcation appears to be a general problem for underdevelpoed countries. I have suggested that this problem may be related to to the import of technologies. If this is true the steps suggested above will need to be taken so as to remove at least one of the causes of this bifurcation.

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FIGURE CAPTIONS

<u>Fig.1a</u> - Two sectors of equal weight have prices P_1 and P_2 at some time and an equal inflation rate. The situation is better represented by the single sector at the average price P indicated by the broken line.

<u>Fig.1b</u> - The two sectors now have an increasing inflation rate. Clearly the money difference between the two sectors increases with time. Due to the rising rate of inflation, however, this needs not to be a real effect, but merely a monetary effect.

<u>Fig.2</u> - Inflating and deflating sectors of equal weights. The net inflation is zero. Clearly, much useful information is suppressed by the single sector model (dotted line). In particular, when the deflating sector hits zero price it becomes a sector of free commodities. Apart from the crisis in the economy when half of it becomes free, we see that the average picture shows a sudden rise of prices (after the crisis) which was clearly predictable by the dual sector analysis.

<u>Fig.3</u> - The typical inflation situation. Two sectors start off close together but have different inflation rates. With the passage of time they diverge further and further. The realistic situation would replace the two hard lines by 'fuzzed out' lines to account for the scatter of commodities within each sector. The single broken line would, of course, be spread out much more than the two hard lines in a situation where a dual sector analysis became necessary.

<u>Fig.4</u> - The wages of the workers go up on the shallow production-sector inflation curve, while his expenditure goes up on the steep consumption-sector inflation curve. Notice that if we set some minimum expenditure for the worker at any given time it will exceed his income at some stage. The inevitable strikes at this stage will only provide temporary relief. Due to the rising rate of inflation this temporary measure (denoted by the dotted line) will have to be invoked more and more frequently for larger and larger income rises.

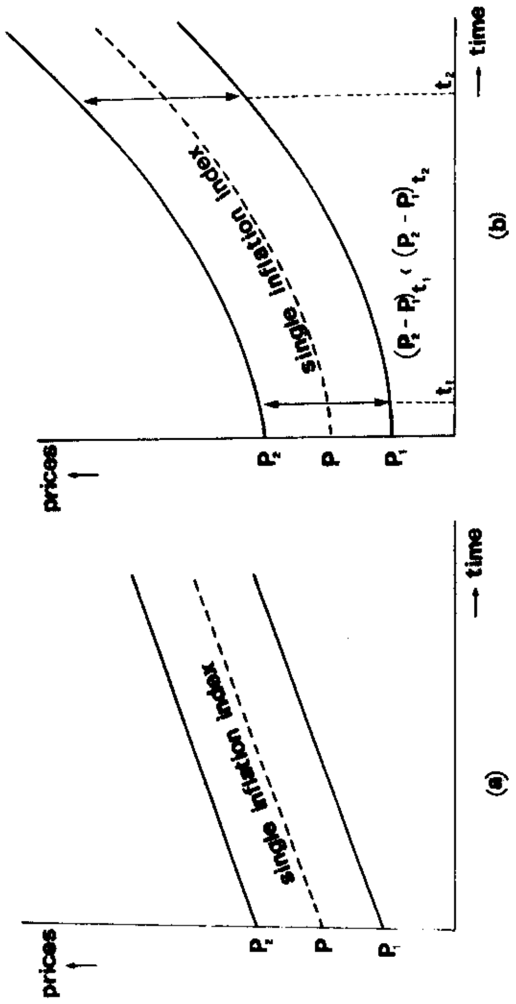

Fig.1

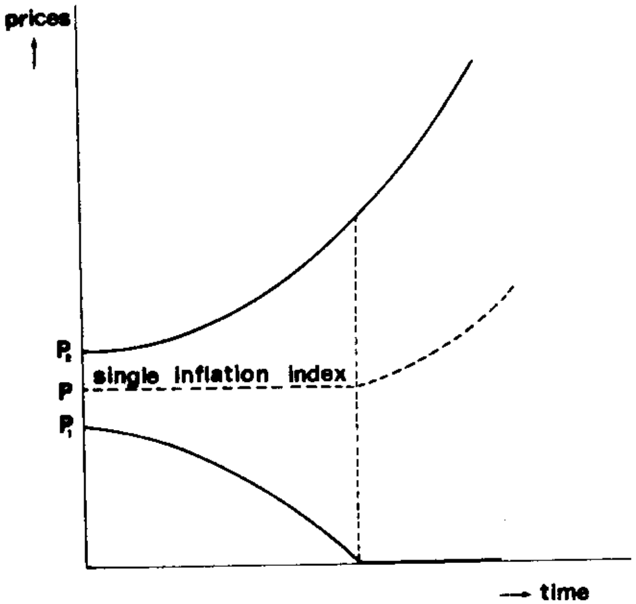
prices
P_2
P
P_1
single inflation index
time

Fig.2

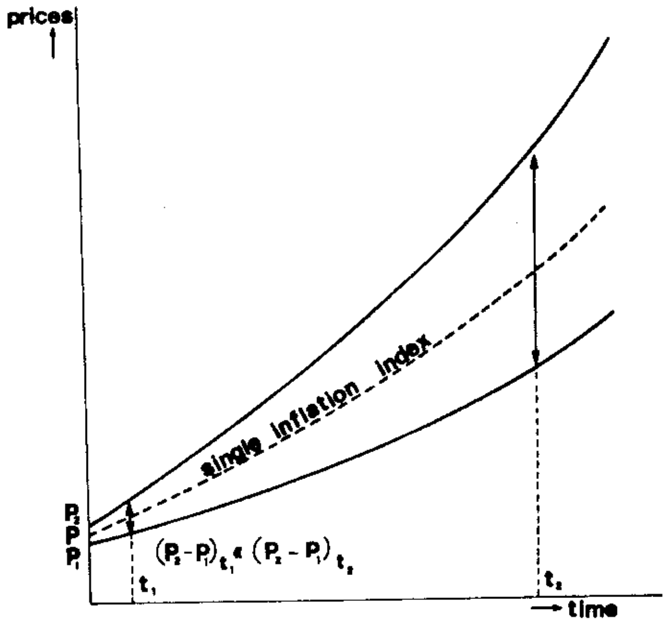
prices
P_2
P
P_1
single inflation index
$(P_2 - P_1)_{t_1} < (P_2 - P_1)_{t_2}$
t_1
t_2
time

Fig. 3

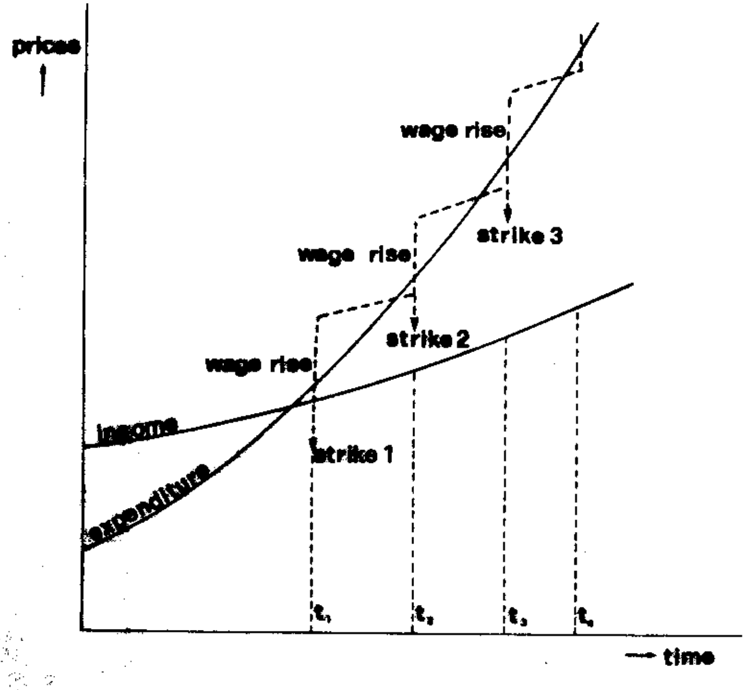

Fig.4

RESEARCH WORKSHOP IN CONDENSED MATTER

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OBSERVATIONS ON SCIENCE EDUCATION IN DEVELOPING COUNTRIES

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Education is not a luxury. It is a basic necessity for the well being, if not the being, of a nation. Nations rich or poor, large or small, must offer its citizens a sound education. The developing nations, in particular, must be fully aware that a good educational system offers the best hope for solving many of the economical, social and cultural problems which these nations face.

I do not claim to be an expert on educational systems in developed or developing countries; but I do have over two dozen years experience in research and education, and strong ties to developing nations. I am a Palestinian Arab by birth and heritage, and an American by citizenship and education. My college days began at the Arab College in Jerusalem and were interrupted in 1948 by the tragic events of Palestine. For two years I taught mathematics and physics to baccalaureate classes in Syria before leaving for the United States to seek an education. After nearly thirty years in the United States which I spent in studying, teaching and research, I returned at the beginning of this year to the Arab World as a Falbright Lecturer in Morocco. I lectured for about six months on Solid State Theory at the Faculty of Sciences of Mohammed V University in Rabat, and visited two other universities in Morocco. I have had many discussions with educators from many countries. In many instances, these discussions confirmed what I believe to be the problems of science education in developing countries. I hope that the observations which I would like to make will not sound too critical. If they should, I trust, they will be taken in the spirit of constructive criticism, or accepted in the Socrates tradition of "know thyself". We must know our ills before we can find a remedy. What are then the ills of science education in developing countries, and what can be done

about them? I will not choose a certain country and discuss its problems, but I will discuss the typical and general problems which seem to be common to all developing countries.

Let us consider the problems related to the integral components of the educational system at all its levels; elementary, secondary, college and university levels. These components are students, teachers, facilities, government and society. We shall later consider the problems of introducing and implementing research and technological programs in developing countries.

Teachers form an indispensable element in education. Most of us remember how a certain teacher instilled in us the love or hate of a certain subject. Ahmed Shawqi, the modern Arab poet, was not exaggerating when he said:

"Rise and give the teacher all due respect.
A teacher is nearly a messenger of God!"

Personally, my love for mathematics was greatly influenced by my mathematics teacher in Jerusalem, the late Jamel Ali. He was a dedicated and enthusiastic teacher. He will long be remembered by many students he taught in the Arab world. There is certainly a shortage of science teachers in developing countries and there is a greater shortage in good teachers. Good teachers can teach, can counsel, and above all can inspire.

There are tendencies to equate learning with memorization especially among the less motivated students. All that a student has to do is to spend a month before the final examination memorizing the lecture notes. The questions are invariably from these notes, and the student who remembers the notes well will pass. Good teachers can remedy this superficial education. They can explain the basic ideas and impart a thorough knowledge of the subject and make memorization unnecessary.

Many buildings for schools and colleges are inadequate. There is hardly space for the increasing numbers of students, let alone offices for the teachers. I know of a college which was intended for six hundred students, houses now six thousand students, and has no room for expansion. As a result the classes are unusually large and both students and teachers are unhappy. I was pleased to visit another college which was erected on spacious grounds with a great deal of room for future expansion.

The laboratories are seldom well equipped. The libraries are usually small and do not meet the needs of the students and the faculty as important reference works are absent. Good teachers with a limited budget can design many good experiments in basic sciences with very little money. A radio set which works, for example, can be built for a few dollars. One can also exercise careful selection in library acquisitions to stretch limited budgets.

Government and society play a vital role in determining what educational system a nation must have. It is important that these bodies act responsibly and place education at the top of the list of national goals. Education must receive generous support, both moral and material from government and society.

I would like to steer away from politics, but I must say that politics does not belong in the classroom. Most utopias picture the heads of state as exceedingly wise, let us hope that the governments will have the wisdom to leave politics out of the educational system. The educational system must be insulated from politics. No high post should be given to political proteges. Political beliefs should not determine whether a teacher or professor is hired or fired. A society which values its educational system (as it should) must strive to make edcuation free from politics. This is vital especially in countries which are still struggling to achieve a stable political system.

Let us now consider the topic which all of you are eager to discuss, namely research, development and technology in developing countries. We all agree on the need for introducing, or improving, research and technology in developing countries. I hope that my observations will be helpful towards this goal.

Technology cannot be imported. It has to be developed locally and sustained locally with the aid and help of developed countries.

Train people abroad and when they return use them effectively. If this is done the "brain drain" will stop. There will always be those who will leave their homeland to live elsewhere for various reasons, but many of the trained scientists, engineers and technicians will stay in their countries and help its research and development programs. Effective use of trained people calls on government and society to give them a free hand and not burden them with bureaucratic duties and excessive number of hours of teaching. The nation must have confidence in its trained sons and daughters who in turn must dedicate themselves to the service of the nation. Not all "foreign" experts are better than the "local" experts. The "local" experts can in time build a tradition in research and technology which future generation can continue. A beginning must be made. The time is now and no force can stop an idea whose time has come.

There is no question that developing nations can train (and in some cases have trained) the necessary numbers of scientists and engineers for the research and the technological programs. Human resources in developing countries are more than adequate and intelligent human beings are born everywhere and not only in developed countries. Material resources, however, are lacking in many countries. It is important for developing nations to cooperate. Despite their long tradition in science and technology, many of the European nations found it necessary to join the Commom Market. There is no reason why there is no Arab or African or Asian Economical or Cultural Union.

The nations of the developing countries face a challenge to unite on two fronts. Firstly, the nation itself must be united in its determination to enter or participate in science and technology. Secondly, the various nations must unite and share their wealths of human and material resources for the benefit of all nations. . They can decide on their needs and develop together suitable research and technological programs to meet these needs. Research and technology can be started in fields such as:

Agriculture in all its branches;
irrigation methods;
reclaiming land from the desert or sea;
desalination, fertilizers
petrochemicals;
electronic components.

By research I mean basic research which might be considered by some a luxury which developing nations do not need. This is not true the above mentioned programs do call for deep understanding of basic scientific questions. One nation might not need or cannot afford to engage in basic research, but collectively the developing nations can and should together create programs in basic research. Basic research once more calls for cooperation among nations to build a nucleus of research workers who will establish a tradition in research and attract future gifted young individuals. The torch will be passed and the blaze of learning will continue to shine as it did shine once before not long ago.

Cooperation among developing nations, which is essential, can take many forms. One country can have, for example, a medical school, another an agricultural school and a third a research centre. These institutions would be open to all students and faculty from all the nations. The developing nations must maintain good communications among themselves and among the developed countries. Visits and exchange programs within the developed and developing countries should be enhanced. The International Centre for Theoretical Physics serves as a shining example. Let there be more centres open to developing nations.

Developing nations must rely on themselves to reach their goals in science and technology. There is no substitute for dedicated local individuals. The attitudes of society must change, or be changed, to allow these individuals to function properly. If I might change a word in Lord Byron's advice to the Greeks

"In native 'minds' and native ranks
The only hope and courage dwells". *)

The problems are immense and the task is nearly impossible. But a beginning must be made. We can easily despair but there is hope. Hope in the noble human spirit which fights against all odds to reach its goals. There are many of these free noble spirits in the thirld world. Let them embark on this holy mission for the service of their countries and mankind.

*) Original words.

L E B A N O N

PROBLEMS OF PHYSICS TEACHING AND DEVELOPMENT IN THE THIRD WORLD

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I shall consider the problems associated with physics teaching and how they become interrelated; then the problems of development and their solution in terms of what technologies could be imported; and, finally, the general problem for the Third World and how it could be ameliorated. I shall distinguish between the problems that are relevant for the developing country, in this case Lebanon, (the specific problems) from the world-wide ones (the non-specific).

Examples of non-specific problems in physics teaching are (1) the teaching standard, (2) student cheating and (3) the null value of a physics degree. A teacher is tempted to direct his instruction towards the brighter members of his class, where his lessons are readily understood. However, he fulfils his role for the greatest numbers of students if he directs it at the average members of the class. This requires a much larger amount of effort on his part in terms of explaining the difficult concepts in a variety of ways until they are understood. Student cheating is a potential problem anywhere in the world, but is particularly rife in countries where corruption is endemic, i.e. those which are emerging from a period of foreign domination. It produces a mistrust between staff and students which is antithetical to good education. Finally, the two professional schools of engineering and medicine lure all the good science students, and leave physics as a 'second best' major. This is related ultimately to employment prospects, and is a more severe problem in developing countries.

The specific problems are that (4) the language of instruction is not the native tongue, (5) the cultural background of the students is not Western, (6) there is a brain drain of indigeneous talented scientists. The language problem is more severe for students from other parts of the Arab World than for the Lebanese, although for the French educated ones it is a minor problem. The attempts which are made to translate Western text-books into Arabic for the rest of the Arab World, would not be relevant in Lebanon. Also, in countries where it is a higher priority for the students to learn English than Arabic, it is superfluous. Since physics has grown up in the West, its conceptual foundations are linked to philosophical movements which are alien to non-Western cultures. Hence there is an added difficulty for the student in digesting these concepts fully. The only attempt to approach this problem has been the movement to islamize science. This would involve, initially, treating science on the same methodological basis, but carrying out phenomenological investigations in order to arrive at an alternative conceptual understanding of the results of experiments. This would, ultimately, generate an alternative methodology. Also the limit between what can be investigated by science and what is inaccessible would be more clearly defined than it is in contemporary Western science. The brain drain has both innner and outer aspects. There is a loss of native talent due to the study of subjects unrelated to the country's needs by scientists working within their countries. There is also the emigration of talented scientists to the West. The inner brain drain has less severe consequences because native scientists can pass on a disciplined methodological approach to their students. This disciplined approach is not entirely individual and contains cultural elements that are valuable for the young student.

The interrelationship of the problems enumerated can be portrayed as follows. (6) will influence (3), since the presence of role models is an important element in the students' interest for physics (4) and (5) will influence (1) and produce a deterioration in the standards which can be attained. This interactive effect is an example of how problems are compounded in the developing world, and, like the spider's web, although individual strands are comparatively easy to break, the web forms a disproportionately more resilient structure.

The non-specific problems of development are (1) a non-equitable distribution of income, (2) lack of employment opportunities, (3) the need for educational programmes in land use, conservation etc. The disparity of

earning power among the population is more readily accepted in the developing world than in the West, but is not more justifiable. The lack of employment opportunities is a greater burden in non-affluent societies because there is the feeling that something should be done. The need for conservation consciousness is particularly relevant for countries about to embark on large scale technological development. A group of politicians trained in conservation measures is especially important in order to ensure importing clean technologies. In addition, the Arab world has a legacy of depleted animal and plant populations which requires a positive action to remedy.

The specific problems for Lebanon are (4) a literacy program, (5) the creation of a working internal communication system (6) improvements in housing, sanitation, garbage disposal etc. Large advances have been made in the last fifty years to make the reading and writing of Arabic general throughout the population, largely, through the creation of good primary and secondary schooling. These institutions should in no way be allowed to erode. A good bus system would improve the noise and exhaust pollution due to traffic in the main cities and facilitate the development of rural areas. Also, an efficient telephone system is a necessity in the modern world. Good sanitation and garbage disposal are necessary to maintain health standards.

Again, the interrelationship of these problems is evident. In addition, the political unrest in the area delays the solution of them, and they seem minor in comparison to the political problems. However, by presenting them, a discussion of viable technologies for the area is facilitated.

The aim of technological development should be, initially, to make the country approximately self-sufficient. In addition, these are the only technologies which a developed country would be willing to export freely, since it does not wish a developing country to become a competitor on the world market. Clothing, glass-making, plastics and furniture industries would be examples of this. These would create employment opportunities and, more importantly, create a more dynamic society. The film and television industries could also be modernized, and port and cargo facilities improved. This should be a moral obligation for the West rather than a philanthropic action. It is true that the West can be seen as, in part, having created the retardation of development in what was the colonial world. But this would place the burden too heavily on individual countries. More importantly, the problem can be viewed as a contemporary problem whereby the technological development of the West overshadows these countries and creates a psychology of underdevelopment. This creates a malaise in the underdeveloped country which is no more important than the material problems, but which is more insidious and penetrates into the backbone of society.

The Third World can be characterized approximately as those countries which lack a national identity; in which food, services and wages are below an acceptable level; and in which there is no evidence of progress (stagnation). Stagnation is the primary problem and can be described more fully as the position of a boy who is being constantly blamed by his parents for no evident reason but, by believing his parents, he ends up in an inactive state or carrying out actions which will gain the approval of his parents but are of no value to himself. The individual in such a society feels that his society is acting wholeheartedly against him. In order to break into this, positive action should be made by the West, and, in modern terms, this means exporting technologies. In addition, the functionaires of the developing countries must show willingness to accept change in their societies, which cannot be guaranteed to be fully beneficial. The strong aspects of religion and culture will stand the test, and the weaker parts will be eroded. However, the vicious circle of stagnation will be broken and the country put on its feet to walk wherever it wishes.

T U R K E Y

SOME REMARKS ABOUT PHYSICS AND DEVELOPMENT OF TURKEY

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1. INTRODUCTION

Turkey is situated just at the junction of Europe and Asia. She has a land area of about 776,000 km^2 and a population of about 47 millions. She has altogether about 20 universities and a few research laboratories which are related to some extent to physics outside the universities. She also has about 250 physics PhD holders, active in research mainly in universities. The country's main export is agricultural products such as cotton, cloth, nuts, wheats etc. and main import materials are machinery, petrol and its products etc. From these very brief remarks it can easily be seen that Turkey is a typical developing country.

2. SOME PROBLEMS AND THEIR EFFECTS ON DEVELOPMENT

The big demand for higher education - There is a big demand for university education in Turkey. Every year about 500,000 school leavers sit for the University Entrance Examination. From them only about 100,000 get places in higher education establishments. The rest either prepare themselves for the following year examination or give up higher education hopes. One of the reasons behind this high demand is the hope of finding a well-paid job. Another reason among others is the ill-oriented secondary school education, since the secondary education is more academically oriented rather than teaching a skill to the pupils.

The right student does not get the right place in University education - One important problem related to the Turkish higher education system is the fact that the right student does not usually get the right place in the university education. This is so because the assignment of a post, say, in a particular department is based on the good scoring marks achieved in the university entrance examination. So a student with an exceptional ability who did not get good marks in the examination may end up in a department which would actually be the last on his preference list.

The bright students do not study Physics - There are substantial earning differences among the various professions in Turkey, and this fact affects the students' field of study. As a result the brightest students naturally tend to study those higly paid professional subjects instead of studying sciences like physics and mathematics. Therefore physics departments do not usually have the bright students.

The shortage of funds for research activities - The world inflationary trends affect Turkey very much. Turkey needs both high technology products and petrol for her development. Unfortunately the increase in these commodities' prices affects the country's balance of payments in two ways, through the importation of these two materials. The industrialized nations overcome these inflationary problems by increasing the prices of their products and likewise petrol producing countries. Hence Turkish universities are extremely hit by this inflationary situation and find it very difficult to get funds for buying research equipments etc. Therefore they cannot carry out efficient research except in theoretical subjects. Even in theoretical subjects researchers cannot obtain the necessary periodicals to follow up the literature in their own specializations. For example, this year the physics department which I belong to has only ~US$ 4,000 for buying small items like chemicals, resistors, capacitors, etc, plus ~US$ 6,000 for buying equipments.

The lack of links between physics departments and industry - Since there is no sound high technology industry in Turkey, industrialists do not usually support research activities in physics departments. Therefore there is almost no link between industry and physics departments. As a result the departments cannot obtain financial supports from industry either.

The lack of well-established research groups - One of the fundamental problems associated with some of the physics departments is the lack of well-established research groups. This is partly due to mis-organization and partly due to the collection of quite different background people in one department. The collection of various specialized people in one department in a way is forced by the intake of students. Since a department needs teaching staff it has no alternative but to employ one without considering too much his particular specialization. Of course in the end you have a number

of well-trained people in hand but their specializations are quite different. This situation creates problems in funding their research. Hence some of them may become just teachers or have to adapt themselves to the new adjustments if there will be any.

The inefficient training of staff members - At the present time some of the physics departments do not have enough staff members. Therefore they usually send research students abroad to do their PhDs in order to fill these gaps. This may be suitable as a short-term solution for having staff members. However, I believe we do not gain much benefit from these researchers. Since they all have specializations in different subjects, on their return home, they cannot find the right places to continue their research. In the end their trainings do not improve the research activities in the department. Another point is that they studied the high technology subjects in the developed countries which are not related to the local problems at all.

I strongly believe that, instead of sending the research students abroad to do their PhDs it is far more important to bring specialists to the country and train the PhD students in the actual location. By this means both the researchers and, more specifically, the technicians and other people associated with the research will be trained more effectively without causing any disturbances in their living environments. I believe that by doing this the research activities in the department will have a lasting character.

The shortage of jobs - Although there is a big demand for higher education the job prospects are not good. Since there are very limited physics related research laboratories in Turkey it is rather difficult for a physics graduate to find a job outside the universities. Moreover, due to the lack of high technology, physicists have very little chance to be employed by the industry either. Hence they cannot use their trainings and abilities in the development of the country. Some graduates may have teaching jobs in schools and some others may have completely different jobs that are not relevant to their training at all. As an example, six students graduated from my department last year. Only two of them are employed by the universities. The other four are still trying to find a job.

The training of physicists in theoretical subjects - Another important point relevant to Turkey is that the physics students were taught topics which are not of much use to them if they work outside the universities. I believe, that the students must be trained on the more applied physics, e.g. electronics or applications of physics, say, in medicine or in industry. By this means I believe that they can find jobs more easily and they can also help to develop the country by applying their particular knowledge in the related field.

The lack of dealing with local problems - At the moment physicists as a whole contribute little for the development of Turkey, but I strongly believe that they can contribute more if they deal with the local problems more closely. I shall give a specific example on this remark from my own department. In fact my department is very young - about five years old. Initially when we set up the department we all had different specializations in various branches of physics. To start to do research in our own specialization was almost impossible because we had very limited funds. So we thought we could do research on some joint research projects which were relevant to the region. Since there is plenty of sunshine in the region we soon realized that it would be a good idea to initiate joint research projects on solar energy. So we did.

I am personally very glad with the outcome of these projects. Since more and more people in the region are interested in solar energy usage a small business was even set up in the region to build hot water solar collectors. The people are even interested in building passive solar houses for themselves.

3. CONCLUSIONS

I have mentioned some of the problems regarding the role of physics in the development of Turkey and I strongly believe that physicists can increase their share in the development by:

a) Reorganizing themselves in well-oriented research groups;
b) Teaching broader optional subjects to the students that are related to the industry;
c) Dealing more closely with the local problems;
d) Trying to get the industry's involvement in the research activities of the physics departments;
e) Organizing collective lobbies to persuade the related government departments to increase the research funds;
f) Publicizing physics among high school pupils to attract the more able students to study physics.

Recently an organizational change took place among the physicists' community of Turkey, namely they formed some research units such as high energy physics unit, solid state physics unit and so on, supported by the Turkish Scientific and Technical Research Council. I believe that these groups became a good example to the other pure scientists in Turkey. Hence they also started to form planned research groups. This is an excellent beginning because with these groups of scientists we can attack the problems related to the country's development.

GHANA

PHYSICS AND DEVELOPMENT WITH SPECIAL REFERENCE TO GHANA

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"If to do were as easy as to know what were good to do, chapels had been churches and poor men's cottages princes' palaces."

Portia to Nerisa in Merchant of Venice,
by William Shakespeare

Learned professors, distinguished scientists, fellow colleagues, ladies and gentlemen!

I feel deeply honoured by the organizers of this series of lectures on Physics and Development, Professors G.C. Ghirardi and H.R. Dalafi, for requesting me to talk on this topic with special reference to my country - Ghana.

May I begin by briefly giving a history of Ghana. Ghana lies on the West Coast of Africa, boarded to the South by the Atlantic Ocean (Gulf of Guinea). It extends from longitude 3°07'W, from its western neighbour Ivory Coast, to 1°14'E, to its eastern neighbour Togo, a distance of about 536 Km. From South to North, the land extends from 4°45'N to 11°11'N, about 672 Km, boarded by Upper Volta (see Fig.1). Ghana covers an area of about 339.460 sq. Km., approximately 3.6% being covered by the largest man-made lake on the globe the Volta Lake. The present population is estimated at about 11.3 million people. Tema, Africa's largest artificial harbour, lies on the Greenwich Meridian (0^{o}). Ghana was the first African country, south of the Sahara, to be granted formal political independence by Great Britain on 6th March 1957, with Dr. Kwame Nkrumah as Prime Minister, and later as first President of the Republic, proclaimed on 1st July 1960.

I. PAST GLORIES AND PRESENT REALITIES

Past Glories

The present Ghana takes its name from a medieval empire of Ghana in the northern Savannah area of West Africa, extending to the Western Sudanese grassland. Thus, the frontiers of ancient and new Ghana are not geographically identical. The empire flourished between AD 600 to about 1600 - contemporary with the Franks empire in Europe. Writing on the African past, the British historian, Basil Davidson, described the time of the Ghana empire as one of the grand periods of African history [1]. Some quotations from chronicles of Muslim writers say: " The King of Ghana is a great king. In his territory are mines of gold and under him a number of kingdoms. In all this country there is gold (Al Yakubi, Ref.1). When he gives audience, he sits on a pavilion around which stand ten pages holding shields and gold mounted swords and on his right hand are sons of the princes of his empire, splendidly clad and with gold plaited into their hair. The beginning of royal audience is announced by the beating of a kind of drum made of a long piece of hollowed wood (Al Bukri, Ref.1).

So was the ancient imperial system of Ghana, which flourished by controlling the trans-Saharian trade in gold (from West Africa northwards) and copper products from Europe and Egypt and salt from the desert fringes.

Connection to present day Ghana is through migration of the people, after the collapse of the empire, to present areas of Ghana, parts of which were named the Gold Coast Colony during the British colonial rule. Ceremonies inherent in kingdoms and chieftancies and some traditions in present day Ghana are strongly reminiscent of those described above for ancient Ghana: durbars and talking drums which among others rhyme praises of traditional leaders; the old tradition of gold refining, the craft and art of traditional gold smithing etc. do strongly suggest connections with ancient Ghana.

So it came that the baptizing of the British Gold Coast Colony Ashanti and the Northern Territories united with former British mandated Territory of Togo and as Ghana at Independence was an understandable African desire to assert that the splendour of the African past was reappearing in the community of free men, women, and children after centuries of slave trade, colonial conquest and foreign rule.

Freedom and Present Realities

The desire to freedom from foreign rule also implied freedom from social insecurity and a yearning for economic progress and social justice. The riches of the land were to be used to promote the development of the country in order to produce for the people adequate supplies of the basic essentials of human society: food, clothing, shelter and indispensable social services like health care, transportation, communication. education and work. This, for us, implied development. Then, Ghana like most other similar countries, which gained political independence from foreign rule, has been characterized by conditions which used to be called in the early 1960s "underdeveloped" - this terminology having given way to "developing". This then is the present reality of Ghana.

II. CONCEPTS OF DEVELOPMENT

In the hope of fulfilling the dream of bringing better living conditions to her people after independence, Ghana, like many other so-called third-world countries, has tried to launch development programmes and projects in agriculture, industralization and infrastructure, education and health etc.

She has sought and taken loans form International Bodies such as the International Monetary Fund, IMF, the World Bank, and from Governments in both West and East. She is heavily indebted to her principal trading partners - mainly Organization for Economic Cooperation and Development, OECD and European Economic Community, EEC, countries - debts standing at about $ 340 million by the end of 1980 (Ref.2, see also Refs.3 and 4).

Like others she has sent delegations to economic conferences between the haves and have-nots - from the United Nations Conferences on Trade and Development - UNCTAD through European Economic Communitiy - African, Caribbean and Pacific countries conferences to north-south dialogues.

How can the results of all these efforts be measured in terms of Development? Are we fumbling in the dark?

Most of us may be aware that there is no uniquely accepted concept of development; the increased awareness of the ecological problems inherent in industrialization and continuous industrial growth and increased demand for energy, especially in the rich northern part of our globe, have contributed to intensifying the debate on what development should be since the late 1960s [5]. Although there is no universally accepted definition of development, the majority of us may probably agree that development also involves economic development (industralization included) with ecological balance and an acceptable degree of social harmony.

With regard to social justice and harmony, the new independent Ghana abounded in mottos and slogans:

"Freedom and Justice"
"Work and Happiness"
"The condition for the development of one, must be the condition for the development of all". (Kwame Nkumah)
....

Accepting then that development also implies economic development with industrialization , it would be important to note that the scientific world outlook has come, more or less, to accept the following four ingredients as constituting the economic potential of a country:

Raw materials,
power resources,
labour,
productive capacity.

The actual transformation of this economic potential into active development in a particular country, depends to a large extend on the relative development of the four ingredients and the sorts of internal and external relations influencing the country.

In the present Atomic, or Nuclear, or Space, or Computer Age or whatever we may prefer to call it, the tremendous impact of physics on human society as a whole cannot be done away with, or overlooked in any sphere of human activity. However, the degree of impact which the rapid development of physics and its technolgical applications in the past few decades may have on various countries in the direction of progress differs tremendously; the impact on progress is possibly related to the contribution of the scientific communities in various parts of the globe towards this rapid development of physics and its technological consequencies.

As pointed out by Abdus Salam in 1970 [6] the problems of the weakness of physics in most developing countries - "lack of graduate schools for research, lack of industrial openings, lack of conscious science policy - cannot be considered in isolation, neither internationally nor nationally". This implies that what physics is made to do in the undustrialized world "as result of national science policy, affect us in the developing countries strongly".

Hence, in a stricter sense, the role of physics or science as such as far as economic development is concerned may be relevantly analyzed with respect to its role in the transformation of raw materials into products, development of power resources, labour, productive capacity and the maintenance of ecological balance.

III. VISIONS AND CAPABILITIES

3.A Raw Materials and Power Resources

Ghana is very rich in natural resources. Although mines have been operating in the last few years at about 25% capacity only, Ghana still ranks about eighth in the world gold production; manganese production at Nsuta ranks among the world's highest; Ghana has very large bauxite deposits. For decades, the country had been the main supplier of cocoa to the world's cocoa and chocolate industries, having dropped to second position behind Ivory Coast in the past few years. Ghana exports industrial diamond and a large variety of hard tropical wood [2-4].

Visions of creating a large modern aluminium industry and other ancillary industries involving ferro-manganese steel and fertilizer plants, the promotion of agricultural growth, boat and fishing industries, lake transportation and obtaining cheap water supplies for towns and villages led to the damming of the Volta River to generate hydro electric power. With the building of the Akosombo dam with a power output of about 768 MW, the new Ghana hoped to have developed a potential power resource for industrialization. The project had been a gigantic one involving financing from the following sources (see Ref.[7], p.16).

1. <u>Dam Project</u>

Ghana Government	35 million (pound sterling)
Loan from USA and United Kingdom Govts.	35 million (" ")

2. <u>For Aluminium Smelter</u>

Volta Aluminium Company (VALCO) owned by Kaiser Aluminium and Chemical Co and Reynolds Metals Co.	11.4 million (pound sterling)
Export-Import Bank of Washington	32.1 million (pound sterling)
Other sources	10.5 million (pound sterling)

The project also necessitated the resettlement of about 80,000 people from over 700 towns and villages to specially build model villages.

Today, seventeen years after the formal switch on by Dr. Kwama Nkrumah in September 1965 to mark the first Akosombo electric power generation commercial basis, the unfavourable sides of the agreement between Ghana and VALCO are becoming more and more unpleasant.

In effect the Akosombo dam project presently benefits first and foremost the Volta Aluminium Company Ltd. - owned by Kaiser Aluminium and Chemical Corporation and Reynolds Metals Co. - which consumes over 65% of the electricity generated, at a fixed cheap rate less than half of that in force in any other country [8]. Of late, VALCO. is to take even more power from the recently completed second hydro-electric Dam Project at Kpong, 24 Km downstream from Akosombo with installed capacity of 140 MW. With the contract to run for thirty years, not only did the Ghana Government promise not to nationalize the Aluminium Smelter, but special concessions were granted to VALCO, exempting the company from duties and taxes on imports and exports. VALCO also has had a free hand to ship in aluminia from Jamaica for processing into Aluminium at the Tema Smelter while Ghana's huge bauxite deposits lie in the ground a few tens of kilometers away at Kibi and Mpraeso, several hundred kilometers away at Aya-Yenahin and at Awaso where the British Aluminium Company mines about 275,000 tons of bauxite annually for export.

Since December 1972, Ghana has been selling electricity to neighbours like Togo and Benin in addition to VALCO in order to raise foreign currency partly to pay the loans which she had taken for the realization of the project! On the home front, one may mention that the flooding of agricultural land has left serious problems for peasant farming communities which cannot now take to fishing. The vision of modern villages with agriculture and village industries flourishing side by side has not materialized. And, through the creation of the Volta Lake, bilharzia (schistosomiasis), transmitted by microscopic snails living in the lake, has spread to areas where the disease was formerly absent.

But no doubt, with the Volta Lake stretching through beautiful landscapes some 400 Km inland from Akosombo dam, a potential exists, not only for internal lake transportation, but also for lake fishing and extensive lake side agriculture. But these potentials have yet to be developed and the unfavourable contract terms with VALCO yet to be negated, if the Volta River Project is to be, according to Dr. Kwame Nkrumah's words "in the truest sense, an expression of our national purpose and aspirations" (see Ref.[7], p.60).

Certainly without the Volta River Project, Ghana might today be experiencing worse power resources problems. In this regard, it is worth noting that despite the availability of hydroelectric power, the country's expenditure on importation of crude oil in the first six months of 1982 amounted to more than 110 million dollars, being payment for past and current crude oil imports. The amount represents about 75% of the value of all imports for the same period [9]. In this connection, it may be relevant to mention that a United States Company, AGRIPETCO, began drilling oil off the coast of Ghana at Saltpond in January 1979 at a rate of about 3,000 barrels a day. Local news media reported several months ago that the company planned to increase the daily output. However, whether the country's economy can benefit from the oil deal with AGRIPETCO and from gas discovered in 1980, remains questionable.

3.B The Problem of Education and Manpower Development

The dream of creating better living conditions for the people meant that Ghana had to train the essential skilled labour: ones own scientists, engineers and technicians, medical doctors and nurses, administrators and managers and the like who would turn the dream into reality.

In the colonial period, education and hospital health-care were mostly in the hand of missionaires and churches, There were a handful of elite training secondary schools like Achimoka, Mfantsiprim. Adisadel College, St. Agustines; a few teacher training colleges and the University College of the Gold Coast, founded by the colonial administration in 1948 and affiliated to the University of London.

After independence, numerous primary schools were opened. The 1961 Educational Act made provision for a free and compulsory education at primary level including the first two years of middle school. Secondary School education was also to become free by the middle of the 1960's the number of secondary schools rose to about 60 in the 1960s, and a large number of teachers training colleges were also established. A People's Educational Association (PEA) was established to teach grown up illiterates to read and write. For a population of about 6 million then things seemed to be working well.

Today these are over 6843 Primary Schools with over one million pupils, 3711 Middle Schools with over four hundred thoudsand pupils, 168 Secondary Schools with over seventy thousand students. A new educational system of elementary level was started on experimental basis in 1974/75

academic year: 6 years primary education followed by three years junior secondary. Pupils would then be prepared for the ordinary level West African School Certificate Examinations in technical and commercial subjects. Pupils completing this stage would either proceed to the Senior Secondary Upper Course, or for a Teacher Training or Polytechnique Course.

Higher Education is provided at Ghana's three Universities. The University College of the Gold Coast became autonomous -University of Ghana - in 1961. With a present students population of about 4,000 only 8-10 major in physics and about 4-5 in mathematics annually. The University of Science and Technology (UST) Kumasi, was founded in 1961. Out of a student population of about 2,870, about 15 students take to physics annually. The University College of Cape Coast was founded in 1962, primarily to train teachers for secondary schools and training colleges. It has a students population of about 1,400. Physics is usually taken together with other subjects for a general first degree.

There are a number of technical and polytechnical schools in Accra, Takoradi, Kumasi, Kofordidua, Ho and Kpandu to train intermediate technical and administrative personnel.

There is a Ghana Academy of Sciences, founded in 1959, to which various academic societies are affilitated.

Other higher institutions or establishments in Ghana which may be mentioned are:

a) The Council for Scientific and Industrial Research (CSIR) founded in 1958 to encourage scientific and industrial research relevant to national development, co-ordinate research in all its aspects in Ghana and publicize, collate and disseminate research results. Among the large number of institutes affiliated to the CSIR are:

- Animal Research Institute;
- Building and Road Research Institute;
- Forest Products Research Institute;
- Industrial Research Institute;
- Scientific Instrumentation Centre;
- Soil Research Institute;
- Water Resources Research Unit;
- Geological Survey Department;
- Ghana Meteorological Services Department; and
- Health Laboratories Services.

b) The Ghana Atomic Energy Commission established in 1963 to promote the development of nuclear energy for peaceful applications in Medicine, Agriculture, Geological Survey and Scientific Research and Training generally. Construction work on a swimming pool type research reactor was started in 1964 near Accra with aid from the Soviet Union, but was halted following a military overthrow of Dr. Nkrumah's Regime in 1966. The project is in the process of reactivation since 1974.

IV. THE REAL SITUATION IN GHANA

Under the Administration of the late Dr. Nkrumah, serious efforts were made to bring scientific and technical awareness into higher education in Ghana. This was evident through the establishment of the University of Science and Technology, the Council for Industrial and Scientific Research and the Ghana Atomic Energy Commission. In order to evaluate the success or failure of these efforts, one may make the following observations:

(i) There has been no concrete science policy in the country since 1966 after the overthrowth of the Nkrums Regime, which Regime did in fact attempt to promote scientitifc education and research in Ghana. Presently, basic education in science subjects and mathematics at secondary school level is suffering a reverse trend compared with the 1960s to mid 1970s because of lack of motivation, lack of equipment which are mostly imported and lack of teachers, a large number of whom have left the country.

(ii) Although a small section of the scientific community in the universities and research institutions is aware of the relevance of physics to our development problems, the society as a whole does not seem to be aware of the potential impact which physics or science as such can have on development; this may be said especially also of the policy making and implementation machineries after 1966.

(iii) Very few students take to physics at pre-university level and in the universities. Students seem to do some physics only where it is compulsory to get them qualified to take to engineering or medicine. Most students take

to law, economics commerce, administration, medicine and the arts. These areas offer better chances of gaining livelihood in our society after university education. THE SCIENTIST SEEMS TO BE IRRELEVANT.

(iv) With the population having grown from about 6 million at independence to the present estimated value of about 11.3 million, more than half, possibly 60%, of the population is illiterate. The positive results achieved through mass education programmes run by the Peoples' Educational Association PEA in the early days of independence have been obliterated.

(v) Although successive Governments have stressed the need for education and the necessity for the educational system to be geared more closely to the needs of the country, one can assert that the implementation of a comprehensive educational policy involving free and compulsory education at various levels must be extremely difficult indeed, if not impossible, under the present economic conditions.

(vi) Most young people flee the country side to the cities, especially after elementary school, hoping to find some job. The idea of taking to farming is no longer appealing. This is left to our aged parents, resulting partly in considerable reduction in food production. The cities seem to have a stronger attraction – there are at least light and water, even if supplies are intermittently cut. There is better chance of getting medical attention – no doubt, most of our doctors settle in the cities where there are electricity, pipe borne water supply and some good schools where they can send their children to the mission hospitals in the provincial and rural areas are still playing a vital role.

(vii) Existing higher institutions, Research Centres and Industry, Police and Army depend strongly on imported equipment, the maintenance and repair of which pose very serious problems. Tropical conditions of high temperature and humidity, coupled with accumulation of dust inside equipment, and lack of maintenance engineers and technicians put many equipment or machines out of function within short periods.

With no foreign exchange to import spare parts for equipment, or material for industries depending on raw materials of foreign origin, most industries are currently operating at about 20% capacity only.

With low productivity and a disproportionately high number of people engaged in distribution business, prices of commodities and inflation rates have been very high in the past years, especially since the mid 1970s. Cheat and let's cheat sort of economic practice flourished resulting especially in a small section of the population amassing a tremendous amount of wealth. This was called locally "Kalabule". Under these conditions, scientific activity has had very low output.

Many trained personnel, university graduates, lecturers and scientists have gone outside the country on leave without pay, on sabbatical leave, on study leave or simply resigned to take up jobs elsewhere - mostly in Nigeria, but also in such countries like Great Britain, Canada, Papua New Guinea, and with international organizations.

(viii) Some researchers in various fields do in fact obtain results but these are not made use of. They remain locked up in the research institutions or universities. However, awareness is growing in Ghana to the effect that contact between industry on one hand and the universities and research centres on the other would be of mutual benefit. Representatives of the Ghana Manufacturers Association did in fact attend the 1981 Biennal Conference of the Ghana Science Association at the University of Ghana, Legon.

(ix) An indigeneous - "home industry" - is growing on its own. Fitters, artisans, welders, mechanics, blacksmiths home-trained technicians, most of whom may have had no high level formal education even to secondary or technical school level, have been making serious efforts to make simple machines and useful utensiles for the society. Cars damaged to almost 100% are put back on the road. Broken down electrical equipment - household equipment - is repaired. Presently, there are no attempts to coordinate their efforts with those of the higher institutions. Will there be a useful convergence between efforts which are growing out of the needs and with roots in the society itself and the research activities of the universities and research establishments which have their roots, so to say, outside the society?

Two films will be shown, one on "Home Industries" showing indigeneous efforts and the second "Impact from the campus". The latter documented hopes which the establishment of the University of Science and Technology in Kumasi has awakened in the 1960s with regard to carrying out research to help meet demands for raw materials locally in industry, housing and other areas. In my opinion, the two films offer good material for discussion on the right way to development in a country like Ghana. Permission has been granted by Ghana Broadcasting Corporation (GBC) for the films to be shown as an educational exercise within the framework of the programme "Physics and Development" at the International Centre for Theoretical Physics, Trieste. I thank GBC for this kind gesture.

Ghana's experience with the collapse of industrial ventures such as TOYOTA and DATSUN Car Assembling Plants and the like built in the 1960s through foreign investment immediately justifies the question whether a developing country like ours can achieve genuine technological progress by bypassing the creation of a sound local scientific basis.

V. THE POTENTIAL IMPACT OF PHYSICS ON DEVELOPMENT

As pointed out already the development of physics has had fundamental consequences for human society as a whole. It has affected relations between states, countries and continents. The continued monopoly of the industrialized world over scientific and technological knowledge and research, and the lack of, or the relatively insignificant presence of these in the developing world, have certainly contributed to making futile, all attempts to negotiate a new economic order between the "haves and the have-nots" of our globe.

In the course of its development, physics has permeated almost all branches of science and technology. The relevance of physics, whether as a fundamental or an applied science, to the problems of development of a country like Ghana cannot be overemphasized. However, with regard to the possible impact of physics on the burning problems of development in our country today - food, shelter, clothing, indispensable social services - it is in the domain of applied physics, engineering physics and physics education that we may be looking towards more, while allowing those who have the aptitude to pursue and promote the development of fundamental physics to do so.

With the above in mind, I would mention a few areas, where physics can make its impact, especially interdisciplinary, with relevant disciplines like engineering mathematics and computation, chemistry, biology and medicine.

FOOD

A large variety of food crops, fruits and vegetables etc. grow in Ghana. The problem is not only one of insufficient quantity, but also storage beyond the seasons of growth, especially when these items cannot be processed. With no proper storage or handling facilities, a large quantity of food items get rotten quickly under our tropical conditions. Some develop the toxigenic mould Aspergillus Flavous, which if collected in the liver beyond a certain threshold can result in liver cancer. Thus these are the problems of storage, processing and preservation. Preservation here refers more to the techniques of refrigeration rather than preservation through treatment with ionizing energy (irradiation). In my opinion, the intrastructural and technical problems involved in the latter technique render its application on a large scale in a country like Ghana less attractive than the former.

HOUSING

Since decades, Ghana has exported large quantities of wood to industrial countries with little economic gains, while rapidly depleting her tropical forests. Research into the physics of local building materials such as wood, bamboo, grass, clay and the like may be rewarding. While reducing the quantity of wood exported, more trees can be planted for building purposes for future generations. The advantage of wood over other building materials such as concrete and bricks from the point of view of radiation protection has been documented by the United Nations Scientific Committee on the Effects of Atomic Radiation [10]. The physicist must make his voice heard in this area, likewise with regard to the dangers involved in the increased use of asbestos, a highly toxigenic substance as building material in Ghana!

PHYSICS IN MEDICINE

Using physical methods such as electron microscopy, X-ray scattering and spectroscopy, physicists and medical scientists can undertake research and studies on various types of parasites, bacteria and viruses in our environment. Some of these methods can also be applied to the study of natural products of pharmacological and industrial interest. Medical physicists can cooperate with radiologists and radiographers in solving problems of quality assurance and radiation protection, for example, in X-ray diagnosis. Mathematically oriented physicists can cooperate with health

authorities and medical departments of our universities in the quantitative formulation and solution of epidemological problems and in the collection and analysis of statistical data.

The problems of environmental pollution and sanitation open possible avenues for scientific research and concrete actions based on existing scientitifc knowledge. The physicist has a contribution to make in this area. While promoting the idea of the dominant role which primary health care must play in our society, awareness must be created of the spectacular advances made in modern medicine as the result of progress in physics - fibre optics, biomedical engineering and computer in medical diagnosis to mention a few.

PHYSICS IN TRANSPORT AND COMMUNICATION

The problem of infrastructure is fundamental to development. Ghana has about 953 Km rail network built during the colonial days, primarily for transporting goods from the interior to the coast. The rail network is becoming obsolete and its condition deteriorating rapidly. Road transportation is playing a vital role. With approximately 32,000 Km of road networks, only just over 1,000 Km are over-laid with bitumer. Road maintenance and construction of new ones is posing a serious problem; many of the roads cannot be used conveniently during the rainy season. Not only road building equipment but also bitumen have to be imported from outside.

With regard to the internal telephone network built earlier, there are problems of maintenance and repair, cut wires and obsolete equipment cannot be easily replaced, nor can new lines easily be added to existing ones. Thus, much of the commmunication work in administration, industry, commerce education and scientific activity, has to be done through personal contacts or letter writing, resulting often in undesirable delays and increased motor fuel consumption.

Regarding our external communication, the construction of an Earth Satellite Station at Nkutunse, 27 Km from Accra, is to enable direct telephone, telex telegraph and television links with the western countries - Italy, United Kingdom, West Germany, France and the USA. This project, the first stage of which was completed on 17th August 1981, has been financed partly with a loan of 5.8 million dollars form the Export Development

Corporation of Canada to cover certain foreign exchange aspects of the project [11]. The project has had no impact on internal communication, nor on communication with other African countries. The Pan-African communication gap is to be bridged by a Pan African Telecommunication Network (PANAFTEL) project which is to connect the capitals of all member states of the Organizations of African Unity (OAU). Ghana's portion of the project - construction of the transmission network form the border of Togo to the Ivory Coast border, is scheduled to be completed by the middle of 1983. The contractors for the project are the Nippon Electric Company. (NEC) of Japan [11]. In this project, the contractors plan to replace existing Microwave Radio Equipment with NEC low power consumption solar Power System [12]. Although these projects have very good aims, they illustrate once again how developing countries with no scientific potential of their own, must, in their well intentioned search for modernization, import one technology to replace another and in the process become more dependent on the industrial countries.

The problems of transport and communication throw a formidable challenge to the scientific and engineering communities of our continent.

PHYSICS IN INDUSTRY

If development is not to exclude industrialization, then Ghana with its abundant raw materials, and large supply of hydroelectric power has a potential need for material scientists. With frequent "black outs" and voltage fluctuations resulting in damage to scientific and household equipment, and most of the country yet to be supplied with electricity from Akosombo or Kpong, one cannot doubt the necessity for developing an electrical industry in Ghana.

The Ghana Industrial Holding Corporation (GIHOC) established in 1967, manages a large number of state enterprises including steel, paper, bricks, paint, pharmaceuticals, electronics, metals, canaries, distilleries and boat building. If development is to be real - based on self reliance- then GIHOC can open up avenues for physicists.

Another important scientific institution is the Ghana Standards Board, founded in 1967 to establish and promulgate standards promote standardization, industrial efficiency, industrial welfare, health, safety and carry out certification of products. With regard to internal standardization exercise

and importation of industrial goods and equipment from outside, the Ghana Standards Board has indeed a tremendous obligation to fulfill. The Board can do this satisfactorily only with the necessary scientific and technical personnel. The physicists must have their part to play.

A FEW REMARKS ON SOLAR ENERGY

From scientific reports and newspaper articles, one may infer that the technical application of solar energy may not be as easy as the tabulation of the advantages that are usually mentioned for solar energy over other sources of energy like nuclear reactors and fossil energy (oil, gas, coal). With regard to simple design of equipment, easy installation, no fuel requirements, high reliability, no maintenance problems, no environmental pollution etc. We are also often told that solar energy in form of solar engines, solar heaters and solar electricity can be applied in many areas ranging from telecommunication to household, agriculture and water delivery systems and many more. It is no mere chance but a result of scientific development - and of late space research - that, today, much more effort is being made in the industrial countries of Europe, Japan and America to realize the technical application of solar power than in the tropical countries which enjoy more sunshine then the temperature zones.

Ghana enjoys about 5 to 6 sun hours per day, with average radiation of about 415 $MW/cm^2/day$ (see Fig.2) [12]. However, no serious research efforts are currently being undertaken towards the technical application of solar energy. Ghana is depleting her forest reserves rapidly, not only through the export of wood, but also because of its use as fuel. Statistics indicate that between 1973 and 1978, the country consumed 62.41 million cubic metres of wood as fuel wood [13]. With electricity in household for cooking etc. accessible to only a very small section of the population, the use of wood as the main source of fuel both in the cities and in the rural areas is bound to continue well into the future. But even so, it would be worthwhile to start serious efforts in Ghana towards the technical application of solar energy. Initially, one may think of such items as solar cookers, water boilers, solar driers and the like.

Naturally with the world's largest man made lake in Ghana, the application of solar energy in water delivery systems in the country, especially for domestic use and in agriculture, is an area to bear in mind. Solar powered pumping systems could help irrigation and boost agriculture along the Volta Lake . The successful use of solar power in running cold storage rooms would indeed be a great achievement.

What should be clear is the following. From the international conferences and research symposia on semi-conductors, there is no doubt that research work being carried out on semi conductors crystals of interest to the development of solar cells - for example, silicium and gallium asenide - is very specialized indeed. The future market products for the technical conversion of the sun's radiation into electricity (photovoltaic) or into heat (photothermic) are not going to be some sort of Christmas presents to any developing country. There is a long way indeed between importing and making appropriate technology.

THE STRATEGY TO MAKE PHYSICS PLAY ITS ROLE

I have no doubts that the terminologies "Technology Transfer", "Intermdiate Technology", "Appropriate Technology" and their like are not going to perform any wonders for us. There seems to be no substitute for scientific development emanating primarily from our own societies, naturally in interaction with the existing advanced scientific communities of other countries. What we need now is a strategy to make physics play its role.

First and foremost, the awareness must be created in our own environment of the relevance of physics and science as such to our development problems. Science education may have to be introduced early at elementary levels of education. This can help impart scientific outlook rapidly to larger sections of our society. Traditional methods and attitudes in the upbringing of children in Ghana and, possibly, in many other African communities is still, to a large extent, biased against inquisitiveness and desire on the part of children to know or find out what is unknown. such attitudes must be discouraged.

Efforts must be made to motivate young pupils and students to take to physical science and mathematics as a powerful resource in studying, understanding and influencing the living and non-living world in our own environment. Introduction of science subjects at elementary levels can be

made more realistic and fascinating by using examples in our own environment instead of starting with "the meter is some fixed distance on a bar in Paris" sort of textbooks. Selection of students to upper forms of secondary schools and universities and financial assistance schemes can be devised to favour the sciences and mathematics. Students of subjects like religious studies, sociology, philosophy, economics etc. may have to follow some basic courses in the development of science including modern physics and electronics. Such concrete steps can encourage more students to take to physics and mathematics. The curricula of our schools and universities contain subjects which have no immediate nor long term relevance to the burning problems of our society. With university resources and places limited, such subjects can be reduced in importance.

We need formulate and revise from time to time concrete science policies at national level for schools, universities and other higher institutions.

Physicists should contribute actively to creating scientific awareness in our environment and fight ignorance and superstition. They should no longer accept to be placed in the corner of irrelevance but help the society realize that it is not only intellectuals like lawyers, judges, medical doctors, and their like and get-rich-quick businessmen who matter in society, especially in our society, but also scientists. The physicist has the duty to define concretely the sort of contribution which physics can make in those areas which have potential for physical research, application and development (R.A.D.). The increasing number of physicists, who successfully branch to various areas like medicine - X-ray diagnosis, radiotherapy, nuclear medicine, cancer research (oncology) biophysics, chemistry, industry and philosophy, is a pointer to the fundamental relevance of physics to diverse spheres of activity in modern society.

CONCLUDING REMARKS

In efforts to promote the development of science in our part of the world, it may pay to learn from history. Without resignating, we should be aware of the fact that our universities of today are still vey young compared with the old European universities of Bologna, Padua, Prague, Oxford, and others. Although the progress of society and the acquisition of scientific knowledge are essential parts of a unit, the development of science and its technological consequencies have not always been at a constant rate throughout the ages. Already in ancient Greece, in an environment relatively conducive to scientific enquiry, Aristostle had searched for the fundamental or the origin - Proton (physics of Aristotle). And today, Greece still has its place in scientific terminology. In the 17th century, Galileo Galilei was sent to the Roman Inquisition as a heretic and sentenced to life imprisonment for documenting a scientific observation which every school child learns today - that the sun, and not the earth is in the middle of our planetary system with the earth moving round the sun. In the 19th century, the century of the industrial revolution, Karl Marx made his controversial statement about religion being opium "fuer das Volk" (for the folk) and no one summoned him to court for that. It is not yet a century since the first aeroplanes went up successfully, so to say, without suffering gravitational disaster. But from the first Sputnik to the Apollo Moon landing was just a period of about a decade. The rapid development of modern physics and its tremendous effects on human endeavour in the past few decades both in human society and beyond the boundaries of our planet has been made possible on the foundation, or as part, of a scientific culture and world outlook.

In our part of the globe, the foundations have now to be laid. In my opinion a major problem which the physicist or scientist in our part of the developing world has to face today in this exercise, is not religious prejudice or active bias against science as such. It is probably more, the lack of awareness that the development of science in our environment is going to be decisive in giving substance to our independence, indeed for our very survival.

Thank you for coming
Thank you for listening

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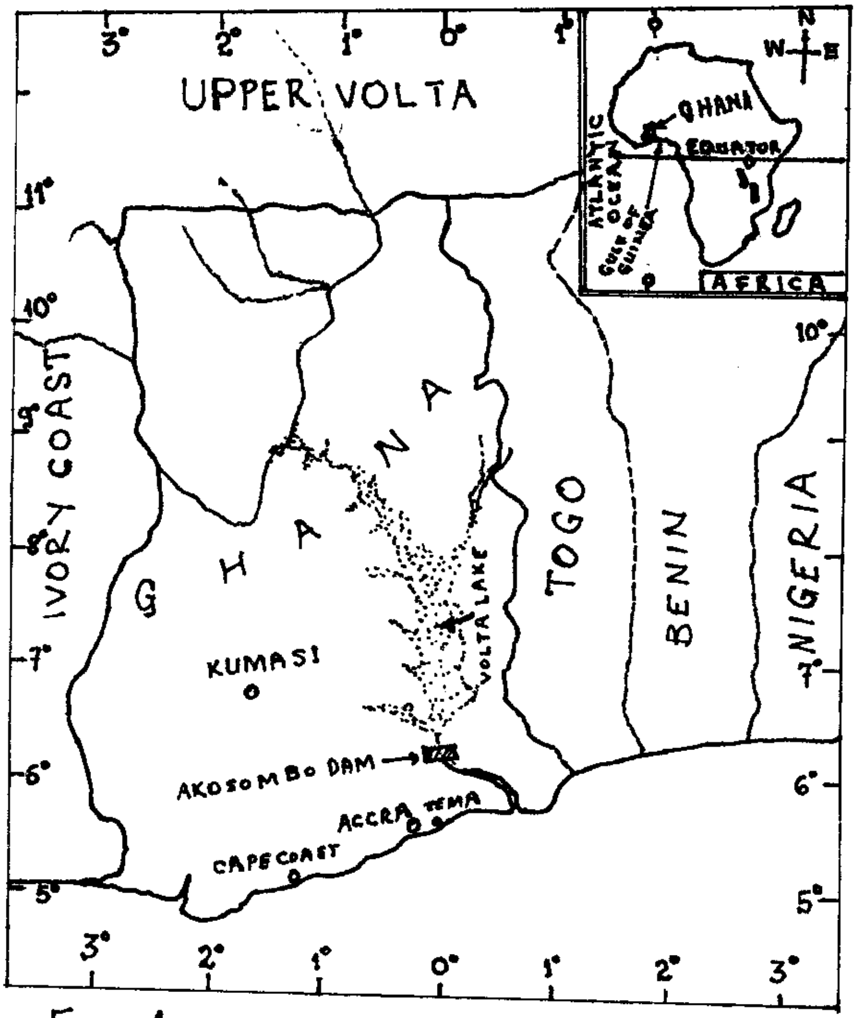
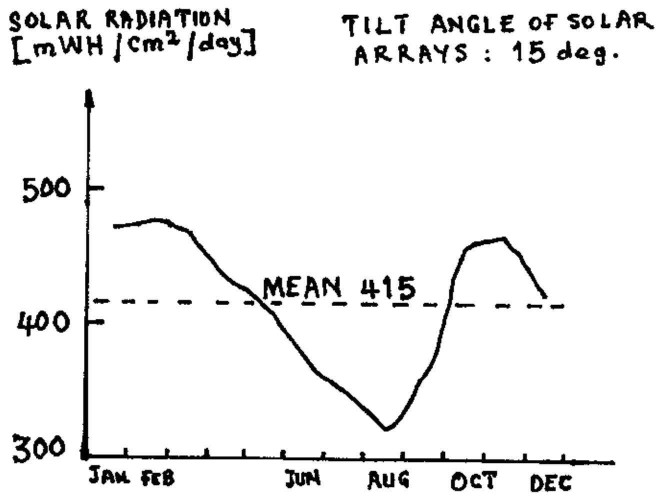


FIG. 1



ESTIMATED SOLAR RADIATION IN GHANA.

Ref. NEC, 1982

FIG. 2

PHYSICS AND DEVELOPMENT IN JORDAN: Glimpses and Snapshots

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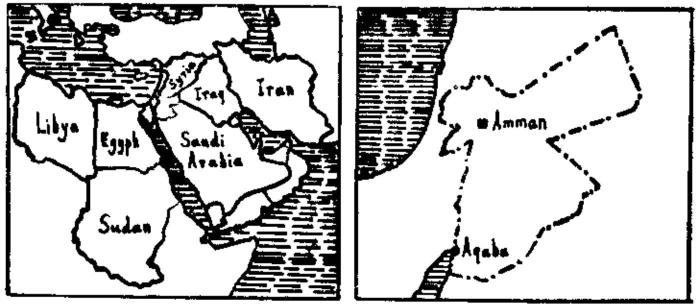
Amman - Jordan

General Scheme:

I. Introduction.
II. Socio-Economic Background.
III. Physics in Jordan.
IV. Some Ideas and Reflections.
V. Conclusion.

II. Socio-Economic Background

1. Geography:



Jordan is bounded on the north by Syria, on the north-east by Iraq, on the east and south by Saudi Arabia, and on the west by (occupied) Palestine.

Total Area: 96,500 km^2, including the (occupied) West Bank. Of this, only 13% is cultivable. Most of the cultivated land relies on rainfall; an exception is the Jordan Valley, which relies on irrigation.

Climate: Mediterranean. The rainy season is from October till April, and the summers are fairly hot and dry.

Capital: Amman (population in 1978: 732,587). Other major cities are Zarqa, Irbid, Salt and Aqaba (the only port in Jordan).

Natural Resources:

1. Phosphate rocks.
2. Potash and other salts (in the Dead Sea).
3. Other minerals with commercial value: manganese, copper, ceramic clay and glass sand.

2. Population:

≈ 3 million. East Bank ≥ 2 million, with males making up ≈ 51 % of the population.
56% are concentrated in "Greater Amman" (the Amman Governorate).
≈ 69% are under the age of 25; thus the population is relatively youthful (unlike the case in Trieste!).
≈ 60% live in urban areas.
The labour force ≈ 20%.
Many skilled Jordanian workers have left the country to work in oil-rich Gulf States. The resulting acute labour shortage has recently been alleviated, however, both by a large inflow of immigrants (mainly from Egypt, South-East Asia and the Indian subcontinent) and by an improvement in salaries and social security.
The large majority of the population are (Sunni) Moslems, but the Constitution recognizes freedom of worship: Christian churches of all denominations are allowed to hold religious services.
The State's official language is, of course, Arabic; however, most educated Jordanians speak fluent English.

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3. Economy:

- Recent History:
  - 1952-66: a rapid growth, notwithstanding the scarcity of natural resources and the large influx of Palestinian refugees in 1948.
  - 1967 war: a temporary halt in the growth momentum of the economy.
  - 1973-75: partial recovery - the Three-Year Plan.
  - 1976-80: the Five-Year Plan - further growth of the economy.
  - 1981-85: another Five-Year Plan aiming at (i) technological development, (ii) training the labour force; and (iii) industrial decentralisation.

- The most important exports are:
  phosphates, fruit and vegetables, and some manufactured goods (such as plastic goods and pharmaceuticals).
  The most important imports are:
  machinery, transport equipment, crude oil, and iron and steel products.

- GNP (at market prices in 1978): 2,270 million US $.
  Growth Rate (1970-77):
  a) Population: 3.3%;
  b) GNP per capita: 6.5%.

- In spite of a chronic trade deficit, there has been a surplus in the balance of payments recently - thanks to large foreign grants and substantial remittances of Jordanians working abroad.

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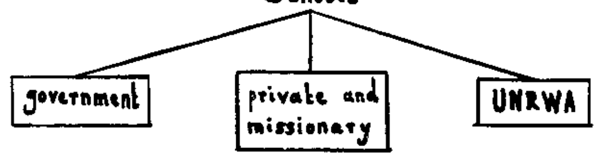
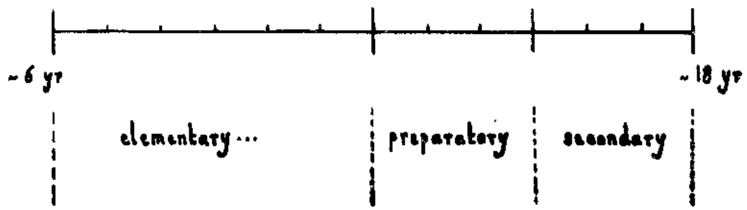
4. Education:

- Schools



- Schooling



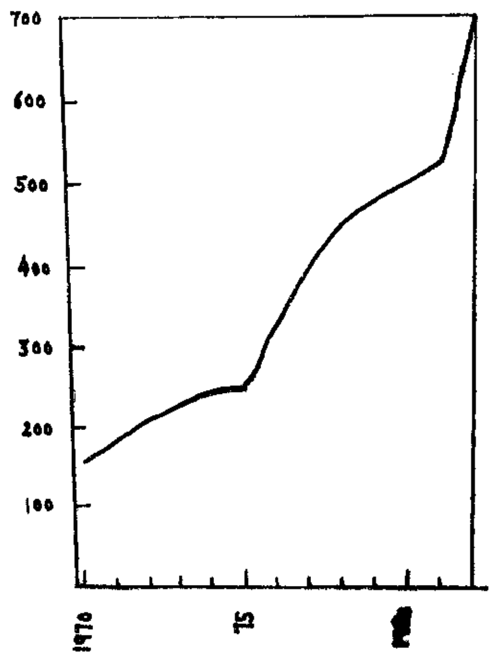
- The <u>Ministry of Education</u> supervises all schools; establishes the curricula, teachers' qualifications and state examinations; distributes free textbooks to students in government schools; and enforces compulsory education till the age of 14.
  The Minister of Education is also the president of the <u>Education Council</u>, which consists of 15 other members. This council acts as an advisory board to the Minister on educational policy, planning and procedural matters.
  Recently another <u>Council of Higher Education</u> has been established.

- There are a handful of <u>agricultural</u> secondary schools in operation, as well as a number of <u>vocational</u>, <u>labour</u> and <u>social affairs</u> institutes, a <u>Shari'ah (Qur'anic)</u> seminary, and <u>nursing</u>, <u>military</u>, <u>technical</u> and <u>teachers'</u> colleges.
  Vocational education has recently received additional emphasis, thanks to the high demand for skilled manpower in both Jordan and neighbouring countries.

- The number of students ≈ 30% of the total population of the East Bank [1975]. Besides, there are large numbers of Jordanians studying abroad, one-third of whom are doing medical sciences and engineering.
  The <u>literacy ratio</u> in the East Bank ≈ 71% [1975] (for those above 12 years old).

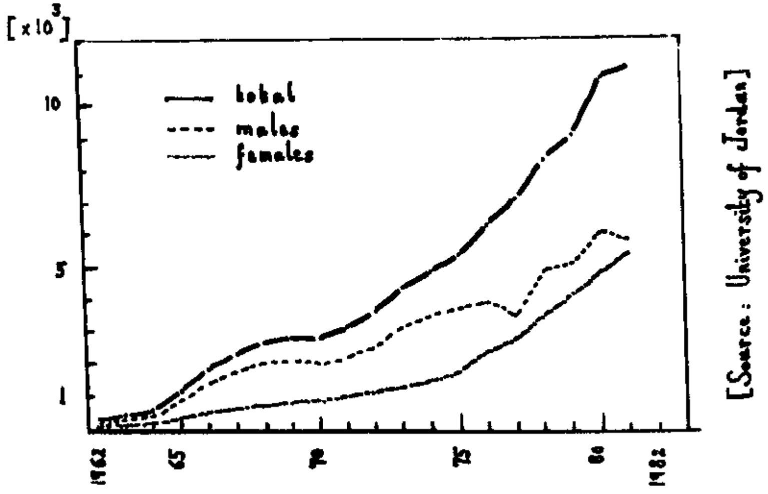
- <u>Universities</u>:

  I. <u>University of Jordan</u>:
  This was founded in 1962. At present it is made up of 12 faculties [Arts; Sciences; Economics and Commerce; Shari'ah (Islamic Studies); Medicine; Nursing; Pharmacy; Agriculture; Education; Engineering and Technology; Law; and Physical Education], comprising 54 departments, as well as 3 deanships [of Student Affairs; Scientific Research; and Graduate Studies].
  Its first objective is to disseminate knowledge through programmes leading to B.Sc./B.A. and M.Sc./M.A. degrees (plus Ph.D. in Arabic and history). Its second objective is "to perform and promote scientific research" and "to develop and promote technology in the service of society". In this connection, the Deanship of Scientific Research gives "priority to those projects which serve the development of Jordan in particular and the Arab World in general".
  Languages of instruction: Arabic and English.
  Academic year: October - June (two semesters).
  There is also a summer session (July - August).
  <u>Teaching Staff</u> (including part-time lecturers):



[Source: University of Jordan]

The Student Population:



II. Yarmouk University:

Founded 1975; teaching started October 1976. Since then it has been expanding at a phenomenal rate. According to its Charter, "The University will serve society through the promotion, organization and implementation of scientific research, as well as helping parties concerned to solve problems facing society and its development."

III. Mu'tah University:

This is barely one year old. Teaching has not yet started; but many candidates are being sent abroad to specialise in various disciplines, so that they could join the teaching staff in due course. The new university is largely to concentrate on science and technology.

[Note that in the (occupied) West Bank there are three more universities – Bethlehem, Birzeit and Najah – together with many other institutes of higher education.]

5. Cultural and Research Institutes:

I. The National Planning Council

This was founded in 1971. It is the only Jordanian institution which is empowered by law to formulate social and economic development plans on a national level. In fact, as outlined in its Charter, foremost among its objectives and functions is "to formulate long-range national plans that aim at developing the Jordanian society in the economic, social, cultural and manpower fields". The comprehensive development programmes are to be executed with established priorities over a specified period of time. In order to secure financial resources and technical assistance funds for financing various projects, the Council negotiates agreements with friendly countries and international agencies. It is indeed the link between all ministries and foreign financial sources. A development project cannot be executed without prior approval of the Council, its Board of Directors and the Cabinet.

II. The Royal Scientific Society

This is a research and development institution basically oriented towards industrial research. According to its Charter (1973), its main objectives are "to undertake research, conduct studies and offer scientific and technological consultation, especially that which relates to the economic and social development of Jordan, and to the proper utilization of the country's resources, with the ultimate purpose of increasing the national income and improving the standard of living".

III. Natural Resources Authority

Among its responsibilities are the formulation of a national water policy, as well as a policy for the utilization and development of mineral and rock resources of the country, the cooperation with the Ministry of Agriculture in cultivating the areas brought under irrigation and reclamation, and the provision of technical and consultation services in the field of mineral exploitation.

IV. <u>Scientific and Technological Public Services</u>

During the last two decades or so Jordan has developed a very impressive network of scientific and technological services. These comprise natural resources and environmental services (such as topographic and scientific mapping, geodetic and geophysical services, hydrology and water supply services, energy services, land conservation and resource analysis, and meteorological services); information and documentation services (e.g., statistical information and data processing services); and standards and industrial services (rendered, for instance, by the Directorate of Standards and the Royal Scientific Society).

V. <u>Other Institutes</u>

There are several units at various institutions dealing with research matters or involved in planning as appropriate to their institutions. Such units exist at the Ministries of Agriculture, Health, Education, Transport, and Industry and Trade, the Central Bank, the Royal Medical Services, the Jordanian Refinery Company, the Jordanian Phosphate Company, the Jordanian Potash Company, and the Arab Pharmaceutical Company.

Other cultural institutes of note are:

Jordan Academy of Arabic (which has been sponsoring an exceedingly ambitious programme of translating university-level scientific textbooks into Arabic), the Royal Academy of Research in Islamic Civilization, Department of Culture and Arts, Jordan Library Association, as well as several public libraries and museums.

6. <u>Radio, Television and Press</u>:

- Radio:

  The Hashemite Jordan Broadcasting Service:

  This was established in 1959. There are daily broadcasts in both Arabic and English to the Arab World and Europe.

- Television:

  Jordan Television Corporation:

  This was established in 1968. The broadcasting time is ≥ 60 hours weekly. The main languages employed are Arabic and English. However, there are also daily broadcasts in French and Hebrew.

- The Press:

  There are 5 dailies (4 Arabic, 1 English) and 2 weeklies. In addition, there exist a number of weekly and monthly journals. By and large, the emphasis is on political and socio-economic issues. Nonetheless, cultural and scientific matters are also given some attention.

III. Physics in Jordan

- Facts and Figures:

1. Universities:

The physics communities in the two well-established Universities [University of Jordan (Amman) and Yarmouk University (Irbid)] are more or less equal in size. Each community consists of ~ 17-20 Ph.D.-members of staff, plus a handful of M.Sc.- and B.Sc.- laboratory instructors.

In Amman there are two theoreticians (one in condensed matter and one in nuclear reactions), whereas in Irbid there are five (in condensed matter and particle physics).

The rest are experimentalists working (or trying to work) in:
solid state physics;
nuclear physics; and
atomic and molecular physics (including laser physics).

The highest degree both Universities confer is M.Sc., which consists of both course work as well as research. The M.Sc. programme in Amman started almost ten years ago; while its counterpart in Irbid is only a few months old.

Laboratories and Equipment:

In Amman we have, among others,

a laser laboratory;
an XRF (x-ray fluorescence) laboratory;
a small ($\leq$ 5-MeV) Van de Graaff accelerator which is about to start operating;
a helium liquefier; and
an HP85 minicomputer.
A PIXE laboratory is also being set up.

The accelerator will be used in both basic and applied research: PIXE analysis; Rutherford-Backscattering; (p,γ) reactions; and fast-

neutron experiments. Several joint projects with Yarmouk University, the Royal Scientific Society, the Natural Resources Authority and industry are envisaged.

In Yarmouk the emphasis will primarily be on solid state physics. The EEC and other organizations have contributed generously to the very painful process of setting up the laboratories there.

Good computing facilities are available in both Universities (as well as in the Royal Scientific Society).

Research Grants:

These are allocated to all faculties by the Deanship of Scientific Research, to which every research proposal must be submitted after approval by the Department and Faculty Councils. As expected, the most generous grants go to projects which are considered relevant to the immediate agricultural, medical and industrial needs of the country. A maximum of 450 J.D. (≈ $1220) is granted for a visit abroad, provided it is well-justified in the context of an overall specific project. Moreover, publication charges are paid by this Deanship.

Conferences:

During the summer physicists are free to go anywhere. Conversely, during the academic session it is difficult to obtain an official leave for more than a few days at a time (except, of course, for sabbaticals and leaves without pay). Partial financial support for attending conferences is occasionally available. No grants are generally available for such activities as seminars, summer schools and so forth; support must come from other institutions.

Libraries:

The University of Jordan Library is first-rate. Apart from a slight time lag, the journal service is quite good. Recommendations of members of staff for books and journals are (more often than not) handled efficiently. Further, photocopying facilities are more than satisfactory.

The Yarmouk Library is much smaller; however, it is expanding fast.

2. Schools and Colleges:
There are numerous physicists (mainly B.Sc.-holders) working in the education sector. However, most of these are disillusioned and disheartened by the present status of physics in schools and colleges, since it is not given the proper attention it deserves by the Ministry of Education. True reforms in this field should undoubtedly start here.

3. Elsewhere:
One would think that, in principle, there is some scope for physicists in such institutes as the Natural Resources Authority and the Royal Scientific Society (where there exist solar-energy research and a fully-equipped electronics department, among other "riches"). In practice, however, this is not the case. All the same, there are a few physicists scattered here and there – for example, in the Meteorological Department (Ministry of Transport). I should also mention the two physicists (1 Ph.D., 1 M.Sc.) in the Department of Education, the Royal Scientific Society, who have been doing an excellent job of disseminating scientific knowledge among teachers and the population at large.

c. Diagnosis of Problems and Some Remedies:

1. Irrelevance to Society and Development:
The limited research undertaken at present in physics is, needless to say, of no direct relevance to Jordanian society or development, although it is arguably making one or two physicists better teachers – not to mention the broader issue of self-respect and psychological well-being. Nevertheless the Jordanian establishment is becoming more and more conscious of the impact of science on society and is encouraging development-oriented research.

2. Teaching Load:
In general, teaching obligations are quite heavy for university-staff. Although they amount officially to twelve credit hours per week, in practice active members of staff (who also supervise M.Sc. students, as well as long-term B.Sc. projects, and participate in the activities of one or two committees) hardly have any time for their own research. This they must do, in fact, at the expense of their social and family life. The Jordanian active physicist is becoming a "multidimensional being" – a Greek Hydra!

3. Dearth of Scientific Contacts:
There are no comprehensive visiting schemes or exchange programmes. The classical symptoms of isolation (the "alienation syndrome") are apparent. The three-fold way which we have devised to alleviate this problem is based on

- contacts with the ICTP;
- Petra School of Physics [Professor Salam's idea]; and
- TOKTEN Programme [= Transfer Of Know-How Through Expatriate Nationals, which is sponsored by the UN, and which Dr. Hamende has kindly brought to my attention].

4. The Cultural Climate:
Broadly speaking, this is not very conducive to research and creativity of any kind. The problems involved here are profound; I will defer their discussion to a future occasion

5. Lack of Teamwork:
This may be a reflection of our subcritical size. Maturity will no doubt come with age and experience; we are still Davids amongst the Goliaths.

IV Some Ideas and Reflections

1. "... the outcome of any serious research can only be to make two questions grow where one question grew before."
[Thorstein Veblen, in The Place of Science in Modern Civilization and Other Essays (The Viking Press, New York, 1919); quoted in Ref. 1, p. 21.]
This is the origin of the ceaseless social consequences of science. ...
Can we in the Third World live with this?
In Ivan Illich's words (Ref. 6, p. 11): "... cancerous acceleration enforces social change at a rate that rules out legal, cultural, and political precedents as formal guidelines to present behaviour". ...
An all-embracing vision is clearly needed.

2. What can we learn from history? ...
"The growth of science is more a matter of many small steps than of a few giant leaps" (Ref. 1, p. 27).

3. The Third Culture (Ref. 5).

4. Appropriate Technology; Adaptive Research; Selective Education (Refs. 7,8).

5. Reflections on Development (cf. Ref. 7).

6. The Question of Values ... .

V Conclusion
(Further Food for Thought ...)

- Once a sage was asked why scholars always flock to the doors of the rich, whilst the rich are not inclined to call at the doors of scholars. 'The scholars', he answered, 'are well aware of the use of money; but the rich are ignorant of the nobility of science'.

  AL-BIRUNI (973 - 1048)

- And when statesmen or others worry him [the scientist] too much, then he should leave with his possessions . . . [for] every region is his fatherland.

  TYCHO BRAHE (1546 - 1601)

- ... physics the subject, makes old hearts fresh; ...

  WILLIAM SHAKESPEARE (1564 - 1616)
  [The Winter's Tale I, i]

- Art is I; Science is We.

  CLAUDE BERNARD (1813 - 1878)

- Whoever, in the pursuit of science, seeks after immediate practical utility, may generally rest assured that he will seek in vain.

  HERMANN VON HELMHOLTZ (1821 - 1894)

- Socialism is inconceivable without ... engineering based on the latest discoveries of modern science.

  VLADIMIR ILICH LENIN (1870 - 1924)

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PHYSICS AND DEVELOPMENT IN BLACK AFRICA

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ABSTRACT

This paper discusses the fundamental problems of countries in black Africa, with examples coming mainly from Nigeria. The paper highlights the internal forces responsible for very slow development of these countries. It is the intention of the writer that until such internal forces have been overcome, black Africa is never going to be in a position of strength to tackle the external forces. This viewpoint is a departhure from the prevailing trend within the third world that tends to put the blame for very slow development mostly on external forces, without giving the same emphasis to the internal forces that constitute the real problem. The call for a New International Economic Order or a New Trde, and similar calls or demands at the UN, will continue to remain ineffective unless a majority of third world countries can successfully compress the timetable for reaching the scientifically and technologically sophisticated stage best suited to their aspirations.

The frequent or permanent breakdown of imported machines and equipment, infrastructure problems, and the underutilization or non-development of resources are all due to the very weak local scientific and technological capacity. As a way out, all educational institutions in black Africa must need to be strengthened. Governments in Africa must pay more attention to education and create, with deliberate speed, that domestic scientific infra-structure that is necessary for the development of resources, and the proper selection and use of the technologies that have of necessity to be imported.

A more functional and creative approach to physics is proposed, in view of its importance to science and technology. The assistance of international academic bodies, like ICTP, is also sought in the area of continuous training of high level academic man power.

1. INTRODUCTION: STATEMENT OF THE PROBLEM

The intrinsic desire to be self-governing, together with the belief that development in all aspects would necessarily follow independence constituted the two dominant forces which sustained the quest for political independence in Africa in the early fifties. Many nationalists believed that as soon as citizens were allowed to manage their own affairs they would so conduct the affairs of the nation that the country would quickly attain the level of development already reached by the advanced nations. Regrettably this has not happened. Whether we consider the political, economic, technological or any other aspect of life in these countries we find the situation poor[1] and disappointing compared to what obtains in the advanced countries.

The development of the third world (the collective name, usually, for the developing nations) is now regarded as an issue of very great concern. The quest today in all third world countries is for economic and technological independence. What hope is there that this is possible? The literature on this problem is quite vast and is still growing[2-16]. Contributions come from experts in various disciplines and schools of thought, and the United Nations[4] interest in this problem is a reflection of the global interest.

From within the third world, a certain picture or awareness has gradually emerged, clarifying the problem of development and putting the blame for non-development or very slow development mostly on external forces. Despite varying recipes for this problem, this picture has led to:

(i) the demand for a new International economic order and a new Trade[5].

(ii) The call for reduction in expenditures on armaments by the advanced countries. The money saved from such reduction could be utilized for the betterment of humanity generally. The arms race is a wrong approach to the threats of Wars that may occur in the future.

(iii) The call for a review of the operational methods of the UN. The flouting of UN resolutions by the advanced nations whenever such resolutions do not favour their interests is under very serious criticism. More serious, by vesting the Right of VETO in a few powerful nations, the UN can be manouvered by those nations to protect their interests.

(iv) Condemnation of Slavery, Racism, and Apartheid - institutions that have hindered development and progress.

(v) Condemnation of the negative role of Transnationals or Multinationals and their corporations in the developing countries, and of Colonialism, Neocolonialism or Imperialism.

(vi) The demand for Transfer of Technology from the advanced nations to the less developed - not just the transfer of already-processed technological products, but the KNOW HOW and the KNOW WHY.

(vii) The call for development of Appropriate or Alternative Technologies[7,8] in the third world.

(viii) The call for SELF-RELIANCE[9] amongst developing nations. Self reliance, as used here, does not mean "No more contact with the advanced nations", or "No more purchases from the advanced nations", but rather, the maximum utilization of local factors or resources.

2. THE RELEVANCE OF SCIENCE AND TECHNOLOGY, PARTICULARLY PHYSICS

There is no doubt whatsoever that the attainment of National economic stability and the full exploitation of the resources of a country is via science and technology. Since the Industrial Revolution in Europe, and in the light of the numerous major technological innovations and breakthroughs coming from the developed parts of the world in the decades immediately following World War II, it has been generally accepted that science and technology would offer the most realistic possibilities for human progress and development. The role of science and technology in transforming a nation is very evident when one travels through the developed nations of the world.

Despite the fact that all nations and previous civilizations have contributed to the present state of science and technology, today technology has been commercialized - that is, it has become part of a system of property - and its transfer is no longer free; the knowledge is monopolized and bought and sold. The third world, particularly Africa, gets almost all its technology from the advanced countries where most of the search for new technology takes place. The benefits of basic science and technology are still to be felt in many parts of Africa.

The technological dependence of the third world on the advanced industrialized countries, while beneficial to her in some ways, has a very serious disadvantage. Apart from the economic disadvantage and the loss of control over decisions, it has contributed to the lack of an effective local scientific and technical capacity. It does so by inhibiting the process of learning-by-doing in technical development, which is essential for the development of scientific capacity; and by leading to a structure of productive activity, which tends to make the activities of the local scientific and technical institutions either totally irrelevant, or poor images of advanced-countries' institutions. However, the experience of Japan suggests that a controlled policy towards technology imports can succeed in securing many of the advantages of technology imports while avoiding the worst consequences[10].

Graham Jones describes science as KNOW WHY[11]. It is the means by which we understand our natural environment, including ourselves, and it produces knowledge. Technology on the other hand is described as KNOW HOW. Technology provides the means by which we manage and control our environment. True science constitutes the building blocks of technology.

Certain underlying physical concepts and laws constitute the foundation of many of the scientific and engineering disciplines that have played a significant role in bringing about the sophistication and efficiency in modern technology. The role played by these laws is to systematize and to correlate the vast body of empirical knowledge that man has acquired over the

years. The science that is concerned with the discovery, and the development, of these laws is known as physics. The physicist is dedicated to investigating the laws that govern the Universe in order to gain an understanding of his physical surroundings. By its nature, physics is a very fundamental science and it interfaces with a variety of other disciplines, its study providing a unique interplay of logical and experimental disciplines. The study of physics and the physicist's methods of acquiring and evaluating knowledge should therefore be regarded as a necessary part of the education of all children.

We may end this section by noting that technology, having science as its inner structure and foundation, is the WAY or ROAD to the development of a nation. The builders of this road are the scientists of the nation. The construction of this road means hard work and sacrifice for everyone. However, the WILL to build and walk on this road rests with the people, more particularly, those that control political power, those in charge of the various institutions and establishments in the country, and the scientists of the nation. It must be emphasized that the WILL together with the WAY are crucial to any successful development. It has often been the practice in most third world countries to dwell at length on the way to national development via science and technology and to highlight the external forces responsible for very slow development, without giving the same emphasis to the negative role of the absence of a strong will and discipline (internal forces) to successfully pursue certain policies that lead to rapid development.

3. FUNDAMENTAL PROBLEMS OF BLACK AFRICA: SOME EXAMPLES FROM NIGERIA

In this section we have grouped the fundamental problems of black Africa into three types. Problems of type A affect the WILL and constitute the internal forces responsible for very slow development, while problems of type B and type C are amenable to science and technology. Very good sources of abbreviated information on History, Geography, Government, Economy, etc., of countries in black Africa are easily available in the literature[12]. The problems discussed below are in the main common to all the countries of black Africa.

PROBLEMS OF TYPE A: PROBLEMS AFFECTING THE WILL

(i) ATTITUDE: There exists a very poor attitude to work at all levels in the society. Much labour is idle for much of the time, while when in use labour productivity is very low. The high potential human resource is thus underutilized and wasted. As a result of divided interest, people are not very faithful to their professions. This may be due to the African culture of many children and extended family system. In order to cope with the heavy financial demands, people seek various channels, some corrupt, that may bring in money quickly. Poverty has led people to see education mainly as a means of securing a livelihood, and hence encourage their children to pursue those educational disciplines that are more marketable. Much more serious is the selfish attitude displayed by people to the detriment of the nation. What needs to be done about rapid development is known to some extent, but the will is weak. For instance, the inability of certain African countries to successfully control importation, despite the obvious usefulness of such controls to their economy, due to high smuggling and corruption is a problem of attitude. To the extent that governments consist of individuals who benefit from, and represent those who benefit from, the political economy in existence, they may not wish or be able to change it. The effective implementation of a development strategy or policy for many African countries would threaten interests in the advanced countries as well as those in Africa who are currently benefitting from the present political economy. A strong development strategy may involve an alternative political economy - a different distribution of the benefits of the economic system. This imposes limits on their willingness and ability to pursue different policies on a sufficient scale to secure a significant change. This is a very serious problem.

(ii) ORGANIZATION: Countries in black Africa are still far from being very organized at all levels. This is due partly to poor attitude, already mentioned above; partly to inexperienced leadership; and finally, a non-scientific approach to planning.

(iii) ECONOMIC AND POLITICAL INSTABILITY: Political instability in black Africa is a very serious problem, leading to weak or constantly changing national policies on development. Economic and political instability can affect very seriously long-term planning, and such instabilities affect tremendously the strength and unity of the affected country, and also that of Regional or Continental bodies like ECOWAS, OAU, etc.

PROBLEMS OF TYPE B: INFRA-STRUCTURE PROBLEMS

(i) COMMUNICATION PROBLEMS: The road and rail networks are very poor and the telephones do not function most of the time.

(ii) NO ADEQUATE AMENITIES AND INFRASTRUCTURE IN THE RURAL AREAS: This problem is responsible for the high drift of young people to the urban centres in search of white collar jobs. This leads to unemployment problems in the urban centres and the neglect of forms in the rural areas.

(iii) SHORTAGE OF WORKING TOOLS: Workers in many professions experience shortage of working tools. For instance, medical doctors in government hospitals experience shortage of drugs and essential equipments in the hospitals. Academicians in the Universities also experience non-availability of important books and research equipment. The lack of science equipment in many educational institutions is a serious handicap.

(iv) TEACHING MANPOWER: There is the shortage of well qualified teaching manpower in many educational institutions.

(v) FREQUENT BREAKDOWN OR PERMANENT BREAKDOWN OF IMPORTED MACHINES AND EQUIPMENTS: In many government establishments and higher educational institutions the absence of scientific and technological expertise leads to improper operation and maintenance of imported machines and this leads to breakdown. Normal breakdown may become permanent or indefinite due to the problem of obtaining spare parts, or the inability to effect a repair.

PROBLEMS OF TYPE C: UNDERUTILIZATION OR NON DEVELOPMENT OF RESOURCES

Many resources are untapped in Africa and areas that will need to be looked into seriously are:

(i) HUMAN RESOURCES: The right people should be given the right jobs and productivity should be highly weighted in issues like salaries, promotions, the award of contracts, etc. This will help bring out the best in people. Continuous training facilities and opportunities will also help the efficiency and performance of the available manpower.

(ii) RESEARCH RESULTS: The few research results available and unutilized and the reports and recommendations of various commissions set up by governments are often set aside and not implemented. A body should be set up to compile available research results and channel them into production and service to the nation.

(iii) Land, forests and Agricultural resources: Under Agriculture, for instance, the problems of food preservation, pest control, and increased crop yield are still to be satisfactorily tackled.

(iv) The integration of the rich African traditional herbal medicination with modern medicine.

(v) Mineral resources - their extraction and effective usage.

(vi) Rivers and oceans, and their effective utilization.

(vii) Desert, Winds, Rainfalls, and their effective utilization.

(viii) Solar Energy and other non-conventional energy sources.

(ix) Development of adequate local materials for building.

(x) Using modern scientific approach to develop African traditional industries - soap manufacture, brewing industry, etc.

(xi) Scientific and technological public services - information and documentation services, meteorological services, hydrological and geological surveys, bureaus of standards, museums, etc.

The experience of Nigeria illustrates very well the three types of problems already discussed, and this will be briefly narrated here.

The Federal Republic of Nigeria is situated on the West Coast of Africa and lies between latitudes 4°N and 14°N, and between longitudes 2°E and 15°E. It is bounded on the South by the Gulf of Guinea, an arm of the Atlantic Ocean, on the North by the Republic of Niger, on the West by the Republic of Benin and on the East by the Cameroon. Nigeria has an area of about 923,000 square kilometers. The provisional results of the 1973 census give a total population of about 80 million. There is considerable uncertainty over the total population and this is one of the problems facing the country - to obtain reliable statistics, which is very vital to effective planning.

A belt of mangrove swamp forest lies along the entire coastline in the South. In the extreme North of the country there is semi-desert. From the South to the North of Nigeria there is a rich variety in vegetation and landscapes. There are a few mountains except along the Eastern boundary and on the Northern plateau, where peaks of about 1.5 Km. occur. The Niger, Benue, and Cross are the three main rivers. The climate is tropical in the South of Nigeria, with an average temperature of 90°F and high humidity. It is drier and semi-tropical in the North, where temperatures of aver 100°F are common. Most of the rain falls between April and September in the North and between March and November in the South. Rainfall varies from under 64 cm. a year in the extreme North to about 440 cm. on the coastline. During the dry season (non-rainy season) the harmattan wind blows from the desert. The land is very fertile and very much available for farming. If this natural resource is fully utilized, there would be no justification for importing food.

There are many tribes and languages in Nigeria, of which the three major languages are Hawa, Ibo and Yoruba. The foreign and official language is English, a unification due to colonization.

On 1 October 1960 Nigeria, formerly under British rule, became sovereign and independent and a member of the Commonwealth. 1 October 1960 to 15 January 1966, Nigeria operated a parliamentary government patterned after Britain. 16 January 1966 to the end of September 1979 was a period of military rule. During this time also there was a Civil war which lasted for about three years. 1 October 1979 to date Nigeria operates a presidential style of government patterned after the United States of America. At present the entire country is divided into 19 States. It is likely that more States will be created in the future. Serious inter- and intra-party feuds between political parties which often have strong tribal bases tend to threaten the political stability of the country.

Agriculture used to be the mainstay of the Nigerian economy and in the 1960's provided 66 per cent of the GDP. The huge rise in the price of petroleum after 1973 gave an extra impetus to the Nigerian economy to such an extend that oil became the principal export. By 1980, because of the vast growth in the volume and value of petroleum the output agriculture was not much emphasized by government to such an extent that its share of the GDP dropped to 17 per cent though it still employs about two-thirds of the working population, almost entirely on small holdings. Despite the introduction since 1976 of controls on wages and imports and stringent foreign exchange measures, there was some deterioration in the economy during 1977 and 1978, and also very recently - 1982. The industries in the country are still at a very low level of operation - mainly assemblers of imported parts. The industrial structure is generally characterized by high-cost of finished products, low-scale production of products in quantity and quality, and high import content.

The deteriorating economic situation in Nigeria is derived from three main causes:

(i) the significant fall in the earnings from export of crude oil and the equally rising outflow of funds due to rising import;

(ii) the mismanagement of the public sector of the economy as a result of corruption and poor planning, and

(iii) the structural imbalance that persists in the economy.

Currently there are efforts to revamp the ailing economy. The efforts are aimed at diversifying the revenue base away from just petroleum in order to reduce the over dependence on oil as the main foreign exchange earner. The Government is making efforts to establish agro-based industries, petro-chemical industries, iron and steel industries, etc.

Inability to fully harness the wealth or resources at its disposal, is a serious handicap of all African countries and Nigeria richly illustrates this point.

4. THE WAY OUT

The most important capital of any industrialized country is not its physical capital but its human capital[13,14] its scientific and technical knowledge which are the products of improved education and training. Education is the only way out, and everyone in Africa needs education to learn new skills and develop talents; to keep up with the pace of modern science and technology; to improve efficiency and performance; and to acquire the right attitude to work. People must realize that their negligence, misdeeds, and poor attitude to work adversely affects the nation. With the right attitute the problems of corruption and idling may by minimized. The graduate in agriculture, for instance, must realize that he contributes more to the nation in a productive farm than idling away in an air-conditioned office. Again, the parliamentarian or senator must know that his vote on issues or bills being debated in the Howe can affect the entire nation. He needs education to participate meaningfully in the debates, to vote properly, and to always have in mind the interest and progress of the nation.

Bearing in mind the fundamental problems of type B and type C discussed in Section 3, it may be necessary to review the educational curriculum often taken over without modification from the colonial powers. The present educational curriculum does not seem to provide pupils with enough skills needed for survival and community development. It would be more desirable to have an education system that would be more practically oriented, more closely geared to real development needs of the nation, encouraging creativity, adaptability, and development of inner talents, rather than mechanical rate-learning. In addition, each level of education should be self-sufficient rather than, as present, merely a preparation for the next higher stage, ignoring the needs of the majority who would leave school before ever getting that far.

Educational objectives at both under- and post-graduate levels are concerned with a student's acquisition of new skills, knowledge and modes of thinking, while fostering his personal development. As the technology and management of an industrial economy becomes increasingly complex, labour is required which is highly skilled, flexible and innovative. This highly skilled manpower is provided by the higher institutions, supplemented by the training schools or research laboratories of the big industries. Since the industries in Africa are at a very low level of operation, countries in Africa must therefore strengthen their educational institutions far beyond what they now are, to enhance technological development. This will definitely involve increasing the financial allocation for education in order to provide adequate educational infrastructure for the institutions, and also to adequately fund research in the higher institutions. In Nigeria, the funding of universities is far from satisfactory. At a time when the old universities are crying for more funds, more and more new universities are being opened to cope with the increasing demand for higher education. So today, there are about 21 universities in Nigeria.

Governments in Africa should create more and more opportunities and responsibilities for scientific and technological development in their own countries in order to check the serious problem of brain drain to the advanced countries. Governments should also induce more students to pursue educational disciplines in Science and Engineering by offering more scholarships in those areas. This will help check the high drift of students into the more marketable disciplines of Business Administration, Accountancy, Law, etc.

Institutions of higher learning, their traditional role notwithstanding, must find solutions to problems which have become increasingly urgent, in order to justify their relevance to society and also to justify the heavy financial budget. The universities, particularly, have a great role to play in an educational system which is tailored to the needs and problems of the developing nations. A few suggestions on this role are offered below.

(a) GENERAL:

(i) Encourage interaction between universities and other educational institutions, and deal more closely with the problems of the latter.

(ii) Encourage interaction between universities and industries and identify areas of cooperation. Industries may agree to fund certain researches in the universities when importance of research is realized.

(iii) Encourage more interaction (inter- and intra-) of universities. Such interaction will help to overcome the problem of non-interaction of scientists; it will help new Departments and new universities benefit from the experience of the older ones; and finally, mutual problems can be jointly tackled more effectively.

(iv) Reorganize research in the universities into well-oriented research groups. The present structure of people doing research in self-created isolation and not interacting - model of non-interacting particles - has not been successful, and it has led to wastage of research funds.

(v) Universities are to organize more frequently educational seminars, symposia, research workshops, etc.

(vi) Work towards the realization of a strong and respectable national research council. Such a council is to commission a study into the present state of the universities and give good advice to government. In the area of post-graduate training and further training of academic staff, such a council should undertake to organize advanced colleges and special research workshops during the long vacations. It may seek the assistance of International academic bodies, like ICTP. Such a council should also work towards improving the status of the local Journals.

(b) INFRASTRUCTURE FOR EDUCATIONAL INSTITUTIONS:

(i) Science text-books for secondary schools and other institutions; the writing of science text-books by local scientists should be encouraged. Will such books be cheaper than imported ones? Cheap or not, such books will draw upon familiar symbols from the local culture for illustrations and examples. This makes teaching more effective. This suggestion is more important in the Biological sciences.

(ii) Low-cost science equipment[15] for schools: the department of physics, particularly, in the universities should be actively involved in the construction or fabrication of low-cost equipment for schools. Designing is to be done by academic staff and the technicians, who are idle most of the time, can be actively involved in the actual construction. The quality of the finished products improves with more and more practice.

(iii) Man power for schools: universities are to organize re-fresher courses for teachers in secondary schools. This will help to keep teachers well informed on effective teaching methods and developments in various disciplines, thus improving the quality of manpower in the schools.

c) MORE FUNCTIONAL APPROACH TO PHYSICS:

(i) The teaching of physics, in this age, should reflect the current technological awareness. Efforts should be made, possibly at the second and third year levels, to include actual electrical installations and the typical electrical circuitry in houses and common electrical equipments in the Physics Electricity Course. Also part of the time spent in measuring the resistance and resistivity of a copper wire in the physics laboratory class, can be spent measuring, in addition, the resistivity of earth samples, which has applications in Geology and minerals exploration. Again, a Course on Electronics should include fabrication or repair of various solid state devices which are now becoming available almost in every home. Similar suggestions can be given for some of the other courses in physics. The basic idea is to teach the physics courses in a manner that will make the graduating young physicist more functional in a technological age, and well-equipped to cope with the development needs of their nations.

Every Physics Department should endeavour to support an active science club where the scientific attitude to life could be developed. Such a club should not be left entirely in the hands of students. Science projects should be outlined that can be undertaken during free periods by students working in teams. Many educational projects can be undertaken without costly equipment or a complete laboratory.

(ii) The Physics Degree Course should include an Industrial Attachment Programme. Also physics majors should take some courses in Technology or Engineering Faculties. To implement this suggestion successfully, the minimum 3-years Physics Degree may be increased to 4 years.

(iii) If it is not possible to incorporate the ideas in (i) and (ii) in a Physics Degree Course, then efforts should be made to implement these suggestions in a Department of Applied Physics and Instrumentation. Efforts should also be made to teach broader optional industry related subjects, and the proper maintenance of machines and various solid state devices.

(d) ICTP AND THE TRAINING OF HIGH-LEVEL ACADEMIC MANPOWER FOR THE UNIVERSITIES

Scientists in black Africa experience isolation from the main stream of research in the fields of Science and Technology. High level academic man-

power requires specialized and continuous training through active participation in research, research workshops, advanced colleges, etc. In view of the low level of research activity in Africa at present, and more seriously, bearing in mind the political, economic and organization problems facing many countries in Africa and which problems do hamper, for now, the formation of a strong national or regional research center, the assistance of the International Centre for Theoretical Physics (ICTP) is definitely required in:

(i) helping the Interim Committee for Science and Technology in Africa to realize its objectives as contained in the Ghana Communique[16];

(ii) funding more and more physicists or scientists from Africa to participate in the advanced colleges and research workshops organized by the ICTP, and if possible organizing a short stay for such participants in some research laboratories abroad;

(iii) educating physicists on how physics can be fully employed to exploit the resources of a nation. Working papers in this area seem to be very general without being very detailed on how physics actually comes in.

Other International academic bodies can also assist in the realization of the above, just like the ICTP.

The literature on the problem of very slow development of third world countries is currently dominated by contributions from Economists, political scientists, etc. Now that mathematicians and physicists are wading into the problem, a computer approach has rich and interesting possibilities. To motivate and invite discussion in this direction, I shall end this write-up by proposing the following research problem which can be solved on a computer - one of the most important predictive tools in this technological age.

Consider a typical third world country X with possibly an ideology D_X. Let $(I_1, I_2, I_3, \ldots, I_N)$ be an array of vital informations on X, to be fed into the computer as input. From a variety of development plans, each one characterized by $(P_1, P_2, P_3, \ldots, P_M)$, select the development plan which gives the least number of years for reaching the scientifically and technologically sophisticated stage best suited to the aspirations of X. What is the minimum number of years, assuming the current state of scientific and technological awareness remains constant in the more advanced countries of the world (static case). Re-do the problem for the more realistic situation (the dynamic case). The job of the research is to first determine the elements I_1, I_2, ... P_1, P_2, ..., P_M; to select the aspirations of X from some estimated Universal set of aspirations for humanity; and finally, to specify enough realistic boundary conditions that will help define the problem more clearly and thus guarantee a unique solution. Reasonable approximations are to be invoked when necessary. The United Nations and all other bodies or agencies that are interested in the issue of development should fund this research.

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SUMMER WORKSHOP ON FIBRE BUNDLES AND GEOMETRY

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S U D A N

MATHEMATICS AND DEVELOPMENT
REMARKS ABOUT THE SITUATION IN SUDAN

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I have been asked at rather short notice to talk on a variety of admittedly related subjects: Mathematics in Sudan; its role in development and the problems facing it. The following analysis, which should be looked upon as representing a personal view, is neither deep nor exhaustive.

I begin by giving a brief description of the most important of the institutions entrusted with the propagation of mathematics in Sudan. This is the University of Khartoum. It is fair to say that the state of mathematics in Sudan is overwhelmingly dictated by the activity in this institution.

Prior to 1977, the University had three departments in the Faculties of Science, Engineering and Education together with a sub-department in the Faculty of Economics. This department in the Faculty of Science offered two types of degrees: a B.Sc. Honours degree in mathematics and joint B.Sc. general degrees in physics or chemistry. The departments in the Faculties of Engineering and Economics were service departments offering a level of training dictated by the needs of these faculties. The Faculty of Education - which was originally a teachers training institute - provided a joint Maths-Education degree, the emphasis being on offering the would be teachers sufficient "head room" for competent high school teaching.

As early as 1969 which heralded the arrival of the first qualified Sudanese mathematician - and in anticipation of the return of more qualified scholars from graduate studies abroad, a proposal was made for the establishment of a School of Mathematical Sciences to replace the Faculty departments (education was not a part of the university then). The new body was to be entrusted with offering - to degree level - comprehensive and coherent training in the Mathematical Sciences, meeting the service requirements of all the other faculties of the University and with providing a leadership for the propagation and development

of mathematics in Sudan through better relations with the curricula and training sections of the Ministry of Education, the research of its members, its involvement with the problems of development and through its efforts to popularize mathematics and science in general. After a number of years of promises and dashed hopes, the School came into existence in 1977. It started its life as a more "efficient" sum of its component departments while a degree structure was under creation by the joint efforts of its staff. The vigorous and fundamental debate about this structure is very much tied up in the theme of development.

MATHEMATICS AND DEVELOPMENT

I begin here by an attempt to dismiss a popular interpretation of the role role of mathematics in development. Often we hear political leaders and educationists speak of the impact that mathematics can have and ought to have in development. Almost invariably it is implicit that (i) by development is meant the current program rather than any long term process and (ii) by mathematics is meant sophisticated research level mathematics. Such statements are usually made under a cloud of vagueness that leaves one with the impression that the problems of poverty will simply disappears as soon as they are tackled by the arm of mathematics. This I believe is wrong. It is safe to say that the speed with which sophisticated research in mathematics can be transformed into tangible improvement of standards of living depends on the level of technological sophistication, degree of robustness of the economy and the general degree of cultural awareness of the community.

It is sad to note that mathematicians in the third world countries have seldom corrected this often made interpretation of their role and have at times fostered it. This is done perhaps in pursuit of justification for their activity in surrounding conditions of near raw survival or perhaps in aim of securing for their discipline a share of the material resources in a climate of hand to mouth economy. It is dangerous to let this happen because it would result in disillusionment with science on the part of the masses and governments alike. It is important to stress the strategic and futuristic gains of all educational activities and in particular the mathematical and scientific ones, and to insist that these gains are so great as to warrant a share of our efforts and resources today.

So what possible role can mathematics play in development? The answer is not clear and there is no real consensus on any particular formula. Two bodies of opinions can be isolated.

(a) View One

This realizes that no claim to development can be made if we cannot stay in the race for mathematical achievement - a race which we have only recently joined. It would be - it is argued - a great loss if we let go now only to try to catch up later. In a sense this view sees progress in mathematics as an aim of wide sense development rather than only a means for it. All the same, it is claimed that a strong and successful mathematical activity would of itself entail a favourable effect on the other facets of development - be it though in no guided or pre-determined form. On the practical side it is argued that a minimum level of activity is necessary before any claims to its impact can be seriously entertained. The attainment of such a threshold requires the attraction of talented students to the field. As fact bears it, this is not a mean task; there can be no denying that success and international recognition are potent stimulants.

That success is possible in the face of chronic poverty has been proven by the Indian experience. So the recipe is one for emphasizing our position as a part of the international community of mathematics, producing mathematicians to its standards and carrying research in the areas it sees as valuable and interesting.

It is feared by protagonists of this view that attempts to channel the activity by way of policy would only lead to weakening it and to relinquishing its claims to high standards.

(b) View Two

This maintains that should a choice be meaningful and necessary, our committment should be to the community we function within, rather than mathematics itself. The interests of this community are better upheld if its resources are not stretched but rather manipulated for optimal use. It is not surprising then that a call is made for a policy that requires an early input from the mathematical activity into the other facets of the development process. It is asserted that the growth of mathematics (and science) in absence of simultaneous growth in other areas of the socio-cultural front would only result in the formation of a scientific elite and certainly not the creation of a basis of a scientific culture. Indeed such an elite would always be captive of its own successes thus limiting its sphere of influence. On the practical side any platform resting on such an elite would be sensitive to the number, strength and quality of its members and would thus be extremely unstable given the problem of emigration that we have to face for a long time to come.

This is not a cry for tying mathematics to concrete isolated problems with quick returns. It is claimed that good, exciting mathematics can be

generated from and around themes relevant to development in the third world. We are reminded that the seemingly self-motivating mathematics of today has started its evolution by calling on themes of physics, astronomy and engineering. The advantages of such an activity are that it would ripple through to other parts of the socio-cultural sphere and that it lends itself more readily to concretization to specific problems when needed.

It is yet to be seen whether this claim is true or not. There is always the danger of the argument being pushed further to result in constructing simple models amenable to practical handling but of doubtful mathematical significance. The feasibility of this claim, however, poses in my view a real objection to View One.

I hasten to add that the community in the School of Mathematical Sciences is not rigidly divided into supporters of one or the other view. The working reality has always been somewhere between the positions stipulated by these views; the differences are ones of emphasis. I outline here the reflections of these views on some of the practicalities of policy laying and actual running of the School.

1) The Degree Structure (specialization vs. board training)

This has been a platform of a heated debate since the creation of the School. A section of the staff advanced a proposal for three honours degrees in Mathematics, Statistics and Computer Science together with joint honours degrees Math-Stat, Math-Computer Science and Math-Education. While this has been justified by the practical considerations of needing to attract good students by adding a semi-professional aura to the school's program, it is easy to see that this proposal tallies in spirit with View One of which it seems a logical conclusion to push for early specialization.

A counter proposal calling for a single broad degree (apart from the Education joint degree) was also made. This, of course, puts the emphasis on the vision of View Two; the argument is that products of such a degree will be better equipped to touch on a variety of the facets of the cultural development, furthermore such a degree would release a good deal of the School's efforts to uphold a high standard of service courses in the other faculties.

The option of the several degrees has been adopted but they have been so constructed that the first two years of the four-year program are the same for all the students - specialization beginning only in the third year. This goes somewhere towards offering a broad training and to reducing the effort employed on these degrees through the expediency of pooling students.

2) Weight and Content of Service Courses

This has been touched upon in (1). It is to be expected that a supporter of View Two would push for emphasizing the role of service courses in the process of propagating the mathematical activity. Demand for a greater share of teaching time for these courses is made; the need for drawing separate coherent plans for these courses with a view to giving as much headroom above the requirement of the faculties concerned as possible is stressed; the strategy of pooling service-course students and degree students for seemingly similar courses is criticized (the experience of the Faculty of Science department indicates that things would be driven to favour the aims of the degrees). In attempting to accomodate such pressure while insisting on maintaining high standard degree training, the School applied for an increase in its establishment.

3) Research, Graduate Education and Extra-Teaching Activity

An academic leadership in the School is still in the making. Research is not yet given any direction by way of policy. Members of the School pursue their fragmented interests with varying degress of vigour and success.

Ph.D and M.Sc. programs have been successfully held in "Applied Maths". A link has been established with Liverpool University (England) whereby each year they provide us with one or two of their staff in disciplines of our choice while they act as hosts to one or two of ours who carry on with their research at the more scientifically motivating atmosphere of Liverpool University. All these are activities very much in line with View One. On the other side of the fence, a graduate diploma/M.Sc. in Statistics open to non-mathematicians (generally government employees) has been held several times. In 1978 the Khartoum Conference on Developing Mathematics in the Third World was organized by El Tom. As a follow up last year the School held a one-year symposium at Khartoum on Mathematical modelling for problems relevant to the Third World (epidemiology, urbanization etc.). The success or otherwise of this symposium will prove vital in selling View Point (2) to a wider section of the section of the mathematical community.

Our post-graduate training abroad is now relatively more controlled with some of the prospective members of staff channelled to the fields of "New Applied Maths".

THE PROBLEMS

A host of problems beset the process of developing mathematics. The most important of these are not particular to Sudan or to mathematics. I outline some of them.

(a) The General Poverty Problem

There is no denying that an atmosphere of general poverty can hardly be stimulating to good academic work especially in a field like mathematics requiring a no mean measure of single-mindedness and positive application. The waste time and effort in pursuit of basic necessities at times of general shortages is taking toll in a direct way on the performance of the staff and more seriously is gradually laying roots for a mood of apathy and lack of faith. The poverty problem has other indirect implications on our question. The burden of creating and sustaining a scientific culture is being placed on the shoulders of non-motivated and badly equipped students. The talented and capable ones are almost all lost to the professional faculties because their degrees go a long way to alleviating the burdens of poverty. Another consequence of the poverty problem deserves a separate discussion.

(b) The Brain Drain

Surrounded by rich, undeveloped countris eager and capable to employ every expert in every field, the losses of Sudan in terms of qualified staff are beginning to mount. The situation for developing mathematics is aggravated by the fact that the losses are not confined to university level teachers; a vast number of our Maths-Education graduates end up working outside Sudan.

A sober assessment of the situation indicates that - notwithstanding the official efforts at stopping it by making it technically harder to leave the country - the trend for emigration is likely to rise.

I hope our rich neighbours may be persuaded that they would get better value for their money if the question of building educationally capable institutions is approached regionally and that they stand to lose if we are depleted to inability.

(c) Unrest in the University

Where literacy is the exception, it is nor surprising to find the body of university students possessive of huge political weight. Throughout its history, governments have found it expedient if not necessary to close the university whenever politics within it took a turbulent turn or looked likely to spark unrest outside it. The effects of this state of frequent disruption and closure on the technical execution of the mathematical education program need little elaboration - it simply kills drive and inevitably leads to a general lowering of standards.

(d) Democracy in Higher Education Institutions

The policy making and top academic bodies in and outside the university are not accountable to the generality of university staff on whose shoulders lie the burden of executing these policies. Selection to such bodies and leading posts of the university does not even involve an opinion input from the totality of staff and is a matter wholly in the hands of the political machinery. Against a background of erratic changes in the political fortunes of of groups and individuals alike, continuity and drive in the running of the university cannot be satisfactorily and simultaneously maintained. The aims of education are futuristic and cannot be reached via chaos or without drive. The call for greater democracy in the policy making and running of our universities should not be ignored.

Finally I draw the attention of those interested to a significant document where the questions of mathematics and development are studied: this is the Proceeding of the Khartoum Conference on Developing Mathematics in the Thirld World Countries edited by El Tom and published by the North-Holland Company.

I N D I A

DEVELOPMENT OF PHYSICS IN INDIA

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Friends! I was given very short notice to deliver this talk, So regarding the presentation of the matter, I myself do not feel satisfied. Anyway, in this talk, I shall present a brief sketch of the development of physics in India.

Of course, India has a long and distinguished tradition in science. Universities of Takkshila (now in Pakistan) and Nalanda were two great centres of learning in ancient India. Indians made remarkable contributions in Mathematics (i.e. decimal place value system of numerical notation, the concept of zero which revolutionized mathematical thoughts originated from India and the foundation of indeterminate analysis), Astronomy, Medicine and Metallurgy. Despite the existence of advanced scientific knowledge in certain fields in ancient time, there seemed to be a break in scientific traditions in the medieval period and India suffered a great set-back in scientific and technological development after the twelfth century. According to P.C. Ray - a famous Indian scientist - the Indian soil was rendered unfit for the birth of a Boyle, a Descartes or a Newton because of continuous chain of aggressions, total disorder and political instability in the country. However, India had continued to maintain a fairly high level as far as Astronomy is concerned which is obvious from the astronomical observatories of Delhi, Jaipur, Banaras and Ujjain built by Maha-raja Sawai Jai Singh II of Amer and his well-known contribution to this field in the early part of the eighteenth century. But, nevertheless, the traditional period of the eighteenth and nineteenth centuries, however, is the darkest period for Indian science. Even during the period of over six hundred years from the twelfth to the nineteenth centuries over 10,000 books were written in India on science and technology. Indian manuscripts were translated into Persian and Arabic, and knowledge travelled to Furope through Persia and Arab, outwards from India.

In fact, the first effort to organize the scientific activities and disseminating scientific efforts of individual scholars came about with the establishment of the Royal Asiatic Society of Bengal by Sir William Jones in 1784 at Calcutta. The society provided a commodious house for scholars and some necessary facilities. Anyhow, at the end of the nineteenth century, the sign of scientific talents as well as activites started emanating and orginal research along modern lines began to spring up in various parts of the country. But it was again Mathematics which occupied the place of pride in which Indian contribution started flourishing. Even in the early period, however, Indians showed a fairly high level of interest and competence in Mathematics. It was within this relatively short period that India produced a mathematical prodigy Srinivasa Ramanujan who did most outstanding contributions in the field of analytic number theory, theory of partitions and elliptic modular functions. Moreover, there were many others such as Sir Ashutosh Mukherji, Dutta, V.P. Aiyar, R.P. Paranjpe, M.T.N. Aiyangar, Ganesh Prasad etc. at that time, clearly in world class in their fields whose work laid down the foundation of modern mathematical discipline in India.

Thus by the end of the nineteenth century, Indian intellectuals exposed to the western modes of thought and scientific metodology had begun to make unique contributions in science. The earliest of the great pioneers was Sir J.C. Bose in whose work we see the beginінng of the history and remarkably early development of modern physics in India during the last decade of the nineteenth century. Bose first worked on the experimental demonstration and detection of 5-25 mm electromagnetic waves, and later on accurate measurements of biophysical parameters relating to plant growth and behaviour, designing very sensitive instruments himself. However, probably the earliest attempt by Indians to organize the scientific research on their own was made with the establishment of the 'Indian Association for the cultivation of sciences' at Calcutta in 1876. The Association was inspired by Sir Ashutosh Mukherji and generously financed by Dr. Mahendra Lal Sircar. Up to the beginning of the twentieth century, the association concerned itself mainly in organizing lectures and demonstration

popularizing science. But at the end of the 2nd decade, with the induction of Sir C.V. Raman in 1917, it became a major centre for research in physical sciences. A high point in the research activities in physics at this centre was the work of C.V. Raman which resulted in the famous discovery of the Raman effect in 1928 and that ultimately brought the Nobel prize to him in 1930. One can imagine the great utility of this work by the fact that this led to the publication of about 1,800 research papers within the next two years after this discovery. Raman continued to do outstanding scientific work on the optics, theory of vision, crystallography, diamonds, throughout his life in Calcutta and later in Banglore. Next, there was the pioneering work of S.N. Bose which led to the Bose-Einstein statistics; the work of M.N. Saha on the Saha theory of thermal ionization on which is based our understanding of spectra observed in astrophysics and theory of monopoles (1936, 1949); the work of S.K. Mitra on ionosphere, crystals; and the work of K.S. Krishnan on spectroscopy, dia- and para-magnetic properties of crystals. Here I would like to remark that today what goes by the name of the Ziman formula for resistivity was orginally formulated by K.S. Krishnan in the forties. The outstanding work of these first generation physicists of India brought the country on the international map of physics.

Now, roughly, the gradual development of physics in India may be classified under the periods as follows:

(1) First period (before 1938)

In the early period, fundamental science was being done primarily by individual scholars either in the university or on their own without any resources and support either from the government or private agencies. In spite of this, Indians were able to maintain an international standard of achievements as reflected in the works of such scientific geniuses as J.C. Bose, C.V. Raman, S.N. Bose, M.N. Saha, S.K. Mitra and K.S. Krishnan. The early twentieth century saw the growth of physics teaching in the universities. Before this period, physics had been taught only in the technical institutions such as engineering and medical colleges. The three premier Universities of India, Calcutta, Madras and Bombay (all established in 1857) were originally affiliating universities. Most of the colleges affiliated with them had only a few science departments. Research was almost non-existent within the ambit of university education. At the intial stage, the researches in Physics were being conducted at the 'Indian Association for the Cultivation of Sciences' and at the Presidency College of Calcutta. But, with the growth of post-graduate teaching within the universites from the second decade of this century, a number of science departments came into existence. Post-graudate studies began at

Calcutta University in 1917 and a number of professional chairs were introduced. Thereby an impetus to research in Physics started to gain momentum and as a consequence of this, there developed a centre of General Relativity at Calcutta, University under Prof. N.R. Sen. Moreover, as a natural felt need, the University of Allahabad was set up in 1887 first as affiliating type and then a full fledged residential type in 1922. Physics department started in 1923 with the appointment of Prof. M.N. Saha. Since then this university became a major centre of researches in Astrophysics, X-ray, Spectroscopy, Electronics, Acoustics, Quantum Statistics, Wireless, Scattering of light, Crystal Physics (measurements of optical constants, electrical resistivity and dielectric constants of crystals) and physics of upper atmosphere and a well-equipped X-ray crystallographic laboratory which was established there, became one of the leading laboratories of the world. At the same time, Banaras Hindu University came into being in 1918 and after its functioning research work started on the spectroscopy, crystal physics and a school in Relativity was established there by V.V. Narlikar.

In the early decade of this century with a solo objective of providing advanced instructions and research facilities in science and technology to promote the material and industrial welfare of India the 'Indian Institute of Science Banglore' came into existence through generous funding from J.N. Tata in 1909. But physics department could be started only when Sir C.V. Raman became the director of the institute in 1933. Since then this institute has developed to a premier research centre in various branches of physics such as molecular spectroscopy, theoretical, mathematical, nuclear, solid state, bio, astrophysics, magnetic resonance and high voltage techniques etc. Moreover, for intensifying research activities, J.C. Bose himself founded the Bose Institute in Calcutta in 1917 where researches on biophysics, interaction of ultra-sonic energy with i liquids having different physical properties, solid state detectors, incoherent scattering of x-rays, diffusion problem in liquids and liquid metals have been done. In the meantime, sufficient awakening arose in the Indian scientific community to gather at a platform so as to interact, collaborate, organize and shape the future of scientific activities on various disciplines in the country. So as a result of this, 'Indian Science Congress'Association' was formed by McMohan and Simon in 1914. While an apex body of scientists called the 'Indian Academy of Sciences' was established in 1934. Another academy called the 'National Academy of Sciences' had come into existence in 1930. Further, the 'National Institute of Sciences of India' which later became 'Indian National Science Academy' was set up in 1935.

By the fourth decade of the present century, the scientific community in the universities has grown up considerably. Second generation of physicists of high ability and great potential like D.S. Kothar , S. Bhagwantam, K.R. Ramanathan, R.K. Asundi, G.N. Ramchandran, P. Venkateshwarloo trained in India and steps in Indian traditions has already come up to shoulder the rising responsibilities and lead the development of physics in the country. Many new universities such as Aligarh, Agra, Nagpur, Lahore, Lucknow, Ducca, Waltair, Patna, Mysore, Annamalainagar, Trivendrum mostly of affiliating type and a few of unitary nature had come all before 1940 and teaching at post-graduate level and reasearches on many branches of physics had already been commenced in almost all these universities.

(2) <u>Second period</u> (1939-1949)

In this period a great deal of thinking and preparatory work was done, and also a period when the visions of an emergent India and the role of science and technology in it got better crystalized. This was the period when it was keenly felt that there must be a body to look into close collaboration between basic and applied research and promote the industrial research in the country, and which could bring together scientists, industrialists and administrators at the highest national level. So an autonomous organization 'The Council of Scientific and Industrial Research' was formed in 1942. After independence, the council did a fine job, on the one hand, collaborating with the universities, and, on the other hand, setting up a chain of national laboratories (25 national, 4 regional laboratories and two centres for scientific documentation, publication and information) throughout the country to promote the applied and industrial research through the enterprising efforts of Prof. S.S. Bhatnagar.

During the fifth decade of this century, also some Indians scientists such such as H.J. Bhabha, V. Sarabhai, P.S. Gill of high enthusiasm and great vision, educated abroad and trained on Western traditions came to India. Bhabha felt a strong need of an advanced institute in the country for research in basic sciences and nuclear energy. His vision was turned to reality through the creation of 'Tata Institute of Fundamental Research', a national institute for researches in basic sciences, software development and computing techniques' in 1945 with funds (initially) from Tata trust (now fully financed by the Indian Government) which over the years has become one of the finest institutes in the world for researches in theoretical, experimental nuclear physics, particle, solid state, Astrophysics, biophysics, electronics, cosmic rays, atmospheric physics, computer techniques, chemical physics and pure mathematics. Moreover, realizing the potentialities of nuclear fission, M.N. Saha founded the 'Saha Institute of

Nuclear Physics" at Calcutta in 1945. Further, Raman established "Raman Research Institute" in Bangalore in 1947. Another landmark in this direction was the establishment of the "Physical Research Laboratory" (PRL) at Ahmedabad by Dr. V. Sarabhai in 1947. These three became prominent centres for researches in physics. By this time, several new universities such as Utkal, Karnataka, Kashmir, Baroda, Saugar, Punjab, Poona, Rajsthan, were created and teaching at post-graduate level and research activities in Physics was introduced.

(3) Third period (1950-1959)

This is the period when agency organizations became better formalized and the foundations of system of science and technology in India were laid down by linking up the growth of the scientific institutions with the five-year plan. Visualizing that physics is a force for rapid economic and social change in this period the first installation to enhance the researches in applied physics was the "National Physical Laboratory" at New Delhi in 1950. Next, viewing to the rising role of science and technology in the all out development of the country, the Indian Government opened three institutes of technology at Kharagpur (1950), Bombay (1958), Madras (1959) on the pattern of the Massachussetts Institute of Technology which right after inception became active on the basic and applied research on many branches in physics. Further, a body the "Defence science organizations" was constituted in 1948 to advise the government on the defence matter which, later on, became "Defence Research and development Organization" (DRDO) in 1958. This has a chain of 23 laboratories in the country, several of which are actively engaged on the applied physics such as electronics, radar, sonic waves, etc. relating to Defence.

Atomic energy programme - The Atomic Energy Commission (AEC) was established in 1948 as an advisory body to the Government of India with H.J. Bhabha as chairman. The Department of Atomic Energy (DAE) came into being in 1953 which could, however, begin vigorous work only from 1954 onwards. Earlier scientist and technicians were trained at TIFR and the institution engaged them in the translation of the knowledge into applied research in nuclear physics. The Atomic Energy Establishment (now called Bhabha Atomic Research Centre) at Bombay was set up in 1957 as the national centre for research and development in the field of atomic energy.

Under the leadership of Bhabha, remarkable efficiency, produced in the cohesion of the programmes, was achieved as reflected by the rate of progress with which its goals were attained within the schedule time. For example, in 1956 it was decided to put up a plant for the production of reactor grade

Uranium metal. Within the period of less than two years, i.e., Dec. 1958, the first power grade ingot of Uranium metal was produced. Simultaneously, preliminary work was begun on a plant to produce thorium from Monazite and Ilmenite sands. In 1959, the construction for this was started and within a short span of three years, it was produced. The history of the construction of a number of reactors is more startling. In march 1955, the AEE decided to build a nuclear reactor and work on it commenced in July 1955, and by July 1956 the reactors "Apsara" was commissioned. Simultaneously, in April 1953 a collaboration agreement was signed between India and Canada for the production of a slightly bigger reactor under the name of CIR (Canada-India Reactor). The agreement was concluded in April 1956 and by July 1960 the reactor reached criticality.

At present India has four research reactors in operation and a fifth one under construction as follows:

(i) APSARA - A 1MW swimming pool type indigeneous reactor using enriched Uranium as fuel and demineralized water as moderator; became critical in 1956; and continuous in operation for isotope production and physics experiments.

(ii) CIRUS - A 40 MW natural Uranium, heavy water reactor; built with Canadian cooperation; became critical in mid 1960 and continuous to operate for isotope production, experimentation and training in various disciplines.

(iii) ZERLINA - A zero-energy reactor, designed and built indigenously in early 1961, using natural Uranium and heavy water. This is being used for studying new reactors concepts and components.

(iv) PURNIMA - A zero-energy fast reactor, built indigenously and commissioned in mid 1972 for experimentation in fast reactor physics.

(v) R-5 - A 100 MW high flux natural Uranium type, completely indigenous reactor, in advanced stages of construction. This will be used for the production of isotopes and development of power-reactor technology.

Moreover, the country has four power reactor in operation, two each at (i) Tarapur Atomic Power station of 220 MWe capacity, each using slightly enriched Uranium and are of boiling water type, (ii) Rajsthan Atomic Power Project Kota (RAPP) of 220 MWe capacity each, while much of major component for unit was imported from Canada and unit II was more or less built indigenously. RAPP and two further nuclear power stations consisting of 235 MWe capacity each are under construction at various stages of completion at Kalpakkam (near Madras) and Narora (in Uttar Badesh). These are of natural Uranium-heavy water type.

The further programme includes 500 MWe capacity heavy water reactors for which design work has already been initiated. Also, in preparation for the second phase of India's nuclear fuel cycle strategy, a 40 MW Plutonium fuelled fast breeder test reactor is under development at the Reactor Research Centre at Kalpakkam. In addition to this AEC has established complexes for the survey, exploration, processing of atomic minerals, fuel, heavy water plants etc. and for the use of atomic energy to various peaceful purposes.

During the period 1949-1959, more than 12 new universities, viz. Gorakhpur, Ahmedabad, Jadavpur at Calcutta, Kashmir, Kerala, Kurukshetra, Aurangabad, Tirupati, Shantiniketan, etc. a chain of laboratories were opened which also started contribution towards research in pure and applied physics.

(4) Fourth period (1960-)

In this period still larger number of universities and scientific laboratories under various agency organizations such as CSIR, ICAR, ICMR, DRDO, DAE, DOS, DOE, and DST came into existence, while to foster the harmonious growth of science and technology throughout the country two new Indian Institutes of Technology were established at Kanpar (1960) and Delhi (1961) which took up reaching and research programmes in both pure and applied physics at highest level.

If during (1948-1961) India saw the progress of atomic energy programmes, then this fourth period is knwon for the development of space research programmes in the country. In fact, in 1962 the Indian Government set up a "National Committee for Space Research" in the Department of Atomic Energy under the chairmanship of V. Sarabhai for promotion in, and exploration of space science and in 1963, this started functioning and established Thumba Equatorial Rocket Launching Station(TERLS). In 1969, on August 5, Indian Space Research Organization (ISRO) at Banglore was set up under DAE. In 1972, Indian Government created the Department of Science and Technology (DST) and Space Commission under the chairmanship of Prof. Satish Dhawan. The main research and development centres to carry out the Indian Space Programmes are as below:

(i) The Vikram Sarabhai Space Centre, Trivendrum - Main centre for space technology relating to sounding rockets and launch vehicles, and to develop Rohini series of sounding rockets, a satellite vehicle (SLV-3) and other advanced launch vehicles like ASLV and PSLV; and maintaining the UN-sponsored Thumba Equatorial Rocket Launching Station.

(ii) ISRO Satellite Centre, Banglore - The centre to plan, build and test the satellites for scientific experiments and to conduct research and development in satellite technology.

(iii) Space Application Centre, Ahmedabad - Apart from designing and

fabricating payloads for Indian satellites, this is the main centre for activities relating to the application of space science and technology for all practical uses such as telecommunications, TV broadcasting and reception via satellites, survey of natural and renewal earth resources from space using remote sensing techniques and studies in space meteorology and satellite geodesy.

(iv) National Remote Sensing Agency, Secunderabad - The agency for utilizing the potential of remote sensing technology in the survey of natural resources through aircraft flight facility, Indian Photointerpretation Institute and Landsat Earth Station, Hyderabad.

(v) Physical Research Laboratory, Ahmedabad - This laboratory is devoted to the basic and applied research in many branches of physics and especially space physics.

(vi) Sriharikota Satellite Launching Station - India's principal rocket and satellite launching station having facilities for launching large multi-stage rockets for static tests on launch vehicle motors; and for large scale production of propellants along with rocket fuel research centre.

Besides these, Department of Space has set up a chain of centres in the country and in the friendly countries relating to a nationwide telemetry, command and tracking work for operational support to national satellites. Within a short period of 18 years, under the able leadership of V. Sarabhai and S. Dhawan, Department of Space, has attained marvellous achievements and ISRO has designed and fabricated 6 satellites indigenously, two of them Rohini-1 and -2 have been launched using India's own satellite launch vehicle SLV-3, and and other four Aryabhatt, Bhaskar-1 and -2 and APPLE have been launched abroad among them the last APPLE is India's first experimental three-axis stabilized communication satellite which was launched by European Space Agency Ariane Vehicle but was put into geosynchronous orbit with an Indian apogee boost motor. In addition to this, for the eighties new work is going on to develop Polar Satellite Launch Vehicle so as to put 800 kg pay-load satellites in sun synchronous polar orbit and 1000 kg sateliites in near earth orbit.

In the field of astronomy and astrophysics, to cope with the modern advancement, the country has the following observatories:

(1) The Kodaikanal and Kavalur Observatory run by the Indian Institute of Astrophysics;

(2) the Jappal-Rangpur Observatory near Hyderabad run by Osmania University, Hyderabad;

(3) U.P. State Observatory at Nainital.

All these observatories have optical telescopes of one metre class or small. The Indian Institute of Astrophysics is currently in process of

The Indian Institute of Astrophysics is currently in process of setting up a 2 m class telescope. Moreover, there are three major radio telescopes in the country:

(1) The cylindrical large Ooty radio telescope (LORT) 530 m long and 30 m wide, indigenously designed, fabricated, installed and being operated by TIFR-Bombay. It operates at 326.5 MHz and is being used to carry out high resolution lunar occultation observations. Currently work is in progress to set up a 9 km synthesis radio telescope with 7 small antennas and the LORT as the element.

(2) A large T-shaped decameter wave radio telescope array (34 MHz) at Gauribidanur near Banglore jointly commissioned by Raman Research Institute (RRI) and Indian Institute of Astrophysics. It is being used by the technique of interplanetary scintillation (IPS) to study the state of interplanetary medium and of extended galactic regions.

(3) A three station IPS network of high sensitivity at 103 MHz of Physical Research Laboratory at Ahmedabad to study the interplanetary medium and also as a long base line interferometer system to study galactic and extragalactic objects. Presently RRI is setting up a millimeter radio telescope with 10 m reflector. With all these four installations, the Indian astronomers seem to be well poised to to make major contributions in the years to come.

In the direction of meteorology and oceanography India has established a vast complex of observatories and institutes in the country. The earliest meteorological observatory was set up at Madras in 1973. To intensify research in tropical meteorology the Indian Institute of Tropical Meteorology was established in 1972 while the National Institute of Oceanography was set up at Goa in 1966. Since India's economy through agriculture and hydropower generation heavily depends upon good monsoon so to boost its economy, the country is making significant achievements through the work being conducted on various aspects of meteorology at these observatories, institutes and at Andhra University Waltair, PRL Ahmedabad, IITs at Delhi and Kanpur and I.I. Sc. Banglore etc.

Now, I should like to mention that recently the Indian government has set up S.N. Bose Institute and installed an indigenously designed and fabricated Variable Energy Cyclotron Facility at Calcutta to gear up the research on heavy-ion physics. Further, among many other prominent research activities in the country, it is worth mentioning that as well-known, a crucial experiment to verify the proton decay is being conducted by TIFR-scientists at Kolar Gold Mines in Karnataka.

Thus apart from Indian Association for Cultivation of Sciences, Bose Institute, Saha Institute of Nuclear Physics-Calcutta, Raman Research Institute,,

I.I. Sc. Banglore, TIFR-BARC Bombay and Birla Institutes of Science and Technology at Mesra (Ranchi) and Pilani, so far 120 universities, affiliating 1650 colleges, five Indian institutes of technology, 150 engineering, colleges and 350 polytechnics have been established during the last thirty years or so And almost in all universities, post graduate colleges in science, engineering colleges, teaching instructions and research facilities at higher level are available and these all are engaged in the research on many, many branches of physics. Simultaneosuly, 130 specialized national laboratories and institutes under various agencies have been established out of which several laboratories and institutions are making excellent contributions towards the researches in basic as well as applied physics. This indicates that India has succeeded to some extent in setting up a sound base to foster, promote and sustain the cultivation of physics and research in every branch of physics by all means and in all its aspects - pure, applied and educational - in the country.

Thrust areas for research in physics under sixth five-year-plan

A. BASIC PHYSICS

1. Condensed Matter Physics
   - (a) Amorphous/Random physics
   - (b) Liquid crystals
   - (c) Defect dynamics
   - (d) Mechanical behaviour of solids
2. Polymers
   - (a) Rheology
   - (b) Biopolymers
   - (c) Magnetic and conducting properties
3. Surface Phenomena
4. Shocks
5. Computer Simulation
6. Non-linear Optics/Systems
7. Intensity Fluctuation Spectroscopy
8. Chemical Physics
   - (a) Non-equilibrium phenomena
   - (b) Tunneling spectroscopy
   - (c) Atomic and molecular beams
9. Production and Detection of Monopoles
10. Heavy-Ion Physics
11. Plasma Physics

B. APPLIED PHYSICS

1. Materials Research (Inclusive of crystal growth, materials preparation, characterization and tailoring properties), e.g., metallic glass and glass mixture
2. Superconducting Materials and Devices
3. Quantum Electronics
4. Transducer Development
5. Studies at High Temperature and High Pressure

C. INTERDISCIPLINARY AREAS

1. Solar Physics and Energy Research
2. Climatology and Meteorology
3. Oceanography
4. Biophysics
5. Astronomy and Astrophysics

... main centres in India for research in:

1. General Relativity and Astrophysics - Gujrat University Ahmedabad, PRL-Ahmedabad, Aligarh Muslim University, Banaras Hindu University, RRI-Banglore (Radio Astronomy), Inst. of Astrophysics Banglore, Bhavnagar University, TIFR-Bombay, Calcutta University, Delhi University, Gorakhpur University, Shivaji University Kolhapur, Lucknow University, Inst. of Math. Sciences, Madras, IIT-Madras, Punjabi University, Patiyala, Poona University, Udaipar University.

2. Nuclear Physics - Aligarh Muslim University, Banaras Hindu University, Banglore University, TIFR, Bombay, BARC, Bombay, IIT, Bombay, Bombay University, Burdwan University, Utkal University, Bhuwneshwar, Calicut University, Bose Institute, Calcutta, Saha Institute for Nuclear Physics, Calcutta, Calcutta University, VEC, Calcutta, Punjab University, Chandigarh, NPL, Delhi, Delhi University, Rajsthan University, Jaipur, IIT, Kanpur, Kurukshetra University, IIT, Kharagpur, Lucknow University, Madras University, Institute of Mathematical Sciences, Madras, Punjab University, Patiyala, Poona University, Roorkee University, NEHU-Shillong, Udaipur University, Andhra University, Waltair, Nuclear Research Laboratory IARI E.M. Station, New Delhi.

3. Particle-, High Energy Physics - University of Allahabad, Aligarh Muslim University, Banaras Hindu University, RRI Banglore, TIFR Bombay, ITT Bombay, Utkal University Bhuwneswar, Inst. of Physics Bhuwneshwar, Indian Association for Cultivation of Sciences, Calcutta, Saha Inst. for Nuclear Physics, Calcutta, VEC, Calcutta, Jadavpur University Calcutta, Cochin University, Punjab University Chandigarh, Delhi University, Gauhati University, Usmania University, Hyderabad, Rajsthan University, Jaipur, Jammu University (High Altitude Research Lab.), IIT Kanpur, Kurukshetra University, Inst. of Mat. Sciences Madras, Roorkee University, NEHU Shillong, Kashmir University, Srinagar, Vishwa Bharli University Shantiniketan (WB), Nuclear Research Lab. IARI EM Station New Delhi.

4. Spectroscopy - PRL-Ahmedabad, University of Allahabad, Aligarh Muslim University University (laser), ISRO-Banglore, RRI Banglore (laser Raman, infrared spectroscopy), I.I.Sc. Banglore (light scattering), TIFR Bombay, BARC Bombay, IIT Bombay, Bose Inst. Calcutta, Indian Association for Cultivation of Sciences Calcutta, Saha Inst. for Nuclear Physics, Calcutta (LPR of N2R spectroscopy), IIT Delhi, NPL New Delhi, IITs at Kanpur, Kharagpur and Madras, Vikram Sarabhai Satellite Centre Trivendrum, CSIR Labs, Defence Research Labs.

5. Condensed Matter Physics - Aligarh Muslim University, Banaras Hindu University (metallic glass and glass mixture), ISRO Banglore, Banglore University (metallic glass), RRI Banglore (composites of piezo-electric and piezo-magnetic crystals and thin films), TIFR Bombay, IIT Bombay, Bombay University,

Indian Association for Cultivation of Sciences Calcutta, Saha Inst. for Nuclear Physics Calcutta, IIT Delhi, NPL New Delhi, Usmania University Hyderabad, IITs at Kanpur, Kharagpur and Madras, Madras University, BITS Pilani, Roorkee University, NEHU Shillong.

6. Crystallography - University of Allahabad (X-ray crystallography), Banaras Hindu University, RRI Banglore (liquid crystals), I.I.Sc. Banglore (crystal physics-condensation of ionized glass, metallic glass, magnetism and magnetic resonance), Indian Association for Cultivation of Sciences Calcutta, Saha Inst. for Nuclear Physics, Calcutta, Delhi University, Madras University.

7. Biophysics - I.I.Sc. Banglore, TIFR Bombay, Bose Inst. Calcutta, Madras University. IIT, Madras.

8. Electronics - University of Allahabad (Microwave Lab.), Banaras Hindu University, Aligarh Muslim University (computer and automation), TIFR Bombay, BARC Bombay, IITs at Delhi, Kharagpur and Madras, BITS, Pilani, PRL Ahmedabad, I.I.Sc. Banglore, Jadavpur University, Calcutta, Inst. of Radio Physics and Electronics Lab. Calcutta, Saha Inst. for Nuclear Physics, Calcutta, Roorkee University, Defence Electronic Research Lab., Hyderabad, NPL, New Delhi, Andhra University, Waltair, Delhi University, SSPL, Delhi, Space Application Centre, Ahmedabad, ISRO, Banglore, Central Scientific Instruments Organization, Chandigarh Defence Naval Physical and Oceanographic Lab., Cochin, Defence Electronics Application Lab., Dehradun.

9. Theoretical Physics - TIFR Bombay, I.I.Sc. Banglore, Utkal University Bhuwneshwar, Madras University, Meerut University (atomic physics), Roorkee University (atomic physics).

10. (a) Quantum Optics - University of Allahabad IIT Delhi,
(b) Electron Optics - Banaras Hindu University, RRI, Banglore, TIFR Bombay, BARC, Bombay, Saha Inst. for Nuclear Physics, Calcutta, ITT Delhi, NPL New Delhi, BITS Pilani, CSIR Lab.

11. Atmospheric Sciences - PRL Ahmedabad, Banaras Hindu University, TIFR, Bombay, Calcutta University, NPL, New Delhi, Jammu University, Roorkee University, Andhra University, Waltair, Vikram Sarabhai Satellite Centre. Trivendrum.

12. Space Physics - (cosmic rays, neutron and solar physics) Gujrat University, Ahmedabad, Aligarh Muslim University, Banaras Hindu University, ISRO, Banglore, RRI. Banglore (characteristics of pulsurs, supernova traces), TIFR, Bombay, NPL, New Delhi, Delhi University, Kurukshetra University, Punjabi University, Patiyala, IIT. Bombay, IIT Delhi, Udaipur University (Solar Lab.)

13. Public sector units engaged in Research Electronics:

Electronic and Radar Development Establishment, Banglore, Bharat Electronics, Limited, Electronics Corporation of India Limited, Indian Telephone Industries, Bharat Heavy Electricals Limited, Central Electronics Limited, KELTRON, All India Radio-Deordarshan (television), P and T Department, Department of Civil Aviation and Tourism.

ACKNOWLDEGMENTS

Finally, I would like to express my heart-felt gratitude to Prof. Abdus Salam, the International Atomic Energy Agency and UNESCO for hospitality at the International Centre for Theoretical Physics, Trieste. I would also like to thank Profs. G.C. Ghirardi and H.R. Dalafi for inviting me to give this talk, and Prof. M.S. Narasimhan and my other Indian friends here for many useful discussions in the preparation of this talk.

AUTUMN COURSE ON GEOMAGNETISM, THE IONOSPHERE AND MAGNETOSPHERE

(21 SEPTEMBER - 12 NOVEMBER 1982)

P H I L I P P I N E S

PHYSICS AND DEVELOPMENT

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I am honored to deliver this short talk on Physics and Development, a topic which implies a very broad coverage. But let me put some constraints on this by adding its relevance to my country in general and further on to be more specific, on the nature of works of my institution or agency. In this case the coverage of my talk will be limited on how Meteorology as a branch of Physics serves the purpose for national development.

In the previous discussion with the organizers of this programme, it was suggested that an introduction on the general information of one's country be touched first by the speaker and then, the link of Physics to the development of the country. This hint was enough for me to develop the issue on Physics and Development in my country with respect to my office.

Philippines, one of the developing countries represented here in "The Autumn Course in Geomagnetism, the Ionosphere and Magnetosphere" is located in Southeast Asia. The capital region is centered at about 14° N latitude and 121°E longitude. This country comprises nearly seven thousand one hundred islands and the three largest of them are Luzon, Visayas and Mindanao. The latest report on population shows that the total number of inhabitants is about 50 millions. It is mainly an agricultural country; however numerous industries are sprouting everywhere particularly in the vicinity of urban areas. At least, these remarks served as introductory pointers on my country for my co-participants and interested listeners.

From the consequence of its geographical location, Philippines is proned to a number of different weather systems or weather disturbances the whole year round. The most severe ones in terms of damages to lives, properties and economy are the occurrences of tropical cyclones of depression, storm or typhoon intensities. Statistically speaking, 19 tropical cyclones are experienced by the country annually and occurring mostly during the months of July, August and September but at times even in October, November or December. As shown in figure one, the archipelago is bounded on the east by the Pacific Ocean where these depressions, storms or typhoons originate and on the west by the South China Sea. The map depicts also the so-called Philippine Area of forecast Responsibility.*

At this point, let me continue and now say something about the organizational development of my office.

In 1972, the President of the Philippines, well informed and much aware of the tremendous impact of meteorological and allied services on national development created an agency to be known as the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) elevating the former Philippine Weather Bureau to a large and more responsive office. Associated with the Bureau's expansion both in personnel and in in field areas of services are the corresponding increases in the scopes of responsibilities. In this connection, PAGASA's general objective is redefined and thus, is entrusted with "providing environmental protection and utilizing scientific knowledge as an effective means or instruments to ensure safety, well being, economic security of all the people as well as for the promotion of national progress. Shown in figure two is the organizational chart of PAGASA. A Director-General is the head of the office and under him are six Directors of the allied offices. Apart from these six offices are the support units consisting of the Administrative, Finance and Management Service and the Technical Service, each headed by a Service Chief.

And further on, let me give you a resume of the functions of the six technical units of PAGASA. The first one is the National Weather Office (NWO) which is responsible for the preparation and issuance of weather forecasts and warnings apart from maintaining radio communications with all the 56 weather stations in the country and national meteorological centers elsewhere. The second is the National Atmospheric, Geophysical, Astronomical Data Office (NAGADO) which undertakes and supervises some 56 weather stations, half a dozen upper-air stations (radiosonde, pilot balloons and radar wind), an equal number of radar stations, port meteorological stations, agrometeorological stations, more than 300 climatological stations and about a thousand rain gauge stations. The third one is the National Geophysical and Astronomical Office (NGAO), the one that undertakes the observations and studies of seismological and astronomical phenomena. This office provides the official time for the country as well as operates a planetarium and a 12-inch reflecting telescope. The fourth one is the National Flood Forecasting Office (NFFO) which is responsible for manning and maintaining the flood forecasting systems for the different basins of the country as well as for the timely issuance of bulletins for flood forecasts and warnings. The fifth office is the Typhoon Moderation Research and Development Office(TMRDO). This office has the primary responsibilities of conducting researches and formulating methods to moderate the destructive effects of typhoons and minimize the destructions brought about by floods, rains and drought. Lastly, the sixth office of PAGASA is the National Institute for Atmospheric, Geophysical and Astronomical Sciences (NIAGAS), the office where I belong. This office is the one engaged mainly in research works as well as training of scientists and technical personnel with respect to atmospheric, geophysical and astronomical sciences. Apart from extensive research undertakings in Meteorology, Geophysics including Oceanography and scientific instrumentations, this office also coordinates, monitors, and undertakes researches on these areas in cooperation with other governmental and non-governmental institutions in the country or outside the country. On the training responsibilities, my office conducts continuing courses both on professional and subprofessional levels in the fields of Meteorology and allied areas. It also conducts and facilitates technical seminars and conferences. Likewise, fellowships, training grants, seminars and conferences for personnel both locally and abroad are handled and arranged by this office together with the publications of technical and scientific papers. In addition to these, a library facility is also made available to personnel and researchers.

Let us consider now the efforts of PAGASA, on natural disaster predictions such as of tropical cyclones in particular. Here, the science of Meteorology as a branch of Physics plays a major role in attaining the general objective of our office "providing environmental protection and utilizing

scientific knowledge as an effective means or instrument to ensure safety, well being, economic security of all the people as well as for the promotion of national progress."

It was mentioned earlier that the Philippines experienced 19 tropical cyclones (of depression, storm or typhoon intensities)** annually. These disturbances caused much damages to properties, livelihood of my countrymen and at times their lives lost and seriously peril the economy of the nation. For further information, it is worth mentioning too that an average size typhoon for one day has an energy equivalent to about 40,000 hydrogen bombs. From this energy measures, one can fully visualize the amount of energy released in one day as wind force by an average size typhoon and thus, the resulting consequences that this enormous and strong wind force,not considering the floodings caused by the associated rainfall, can create over a given area or areas. Clearly, millions of pesos were gone to these natural calamities as destructive wind force, floodings, etc. But it is also a fact that more damages in millions and millions of pesos and more lives perished, if timely and accurate forecasts or predictions and warnings were not issued to the population.

In this connection, our office upon issuing the forecasts and warnings for any coming depressions, storms or typhoons, has also a prepared scheme for storm warning signals to the public. In figure three, the explanations of the signal are fully enumerated. These public storm signals are communicated to the people in many ways, by means of radiobroadcasts, through television networks, newspapers and some local means of communications such as blasting of sirens, etc.

Here, I'd like to point out that communications at the right moment are important factors in order that the people can take the necessary precautions. These precautions observed by everybody serve to minimize if not avert the disasters to properties, economic losses and more to save irreparable lives of the people. The scheme of storm warning signal presented proves to be effective in many ways. Thus, a timely forcast and warning, communication and necessary precautions save millions of pesos, properties and the most important,lives.

CONCLUSION

Well, I think I would like to conclude that from the point of view of Physics and Development, the works of PAGASA with respect to natural disaster predictions as well as on allied field of services not accounted for here are the very typical examples of the applications where SCIENCE in general tries to fit (ensure safety, well being, economic security . . .) the world we live in. And finally, it was shown vividly that the coverage of the effects on man of Meteorology being a branch of Physics has made a noteworthy relevance of Physics to the national development and progress of my country. THANK YOU.

* PAR.. Warnings and domestic bulletins are issued by PAGASA to the public, mariners, etc , if weather disturbances of wind force from 60 kph or more were within this area or expected to be within this area in the next 6 hours.

** Weather disturbances	Intensities
Depression . . .	less than 63 kph
Storm	63 to 118 kph
Typhoon	118 kph or more

ACKNOWLEDGEMENT

I want to express my warmest thanks to the organizers of this programme "Physics and Development" for inviting me to give this talk. Likewise, I wish to extend my thanks to all my co-participants and other listeners who had expressed their eagerness to know more my country. Also, I am thankful and grateful to Professor Abdus Salam for all the hospitality offered to me here at the International Center for Theoretical Physics.

I am also grateful to the Director-General of PAGASA for permitting me to attend the "Autumn Course on Geomagnetism, the Ionosphere and Magnetosphere" and likewise to the Director of NIACAS who made the necessary arrangements and recommendation.

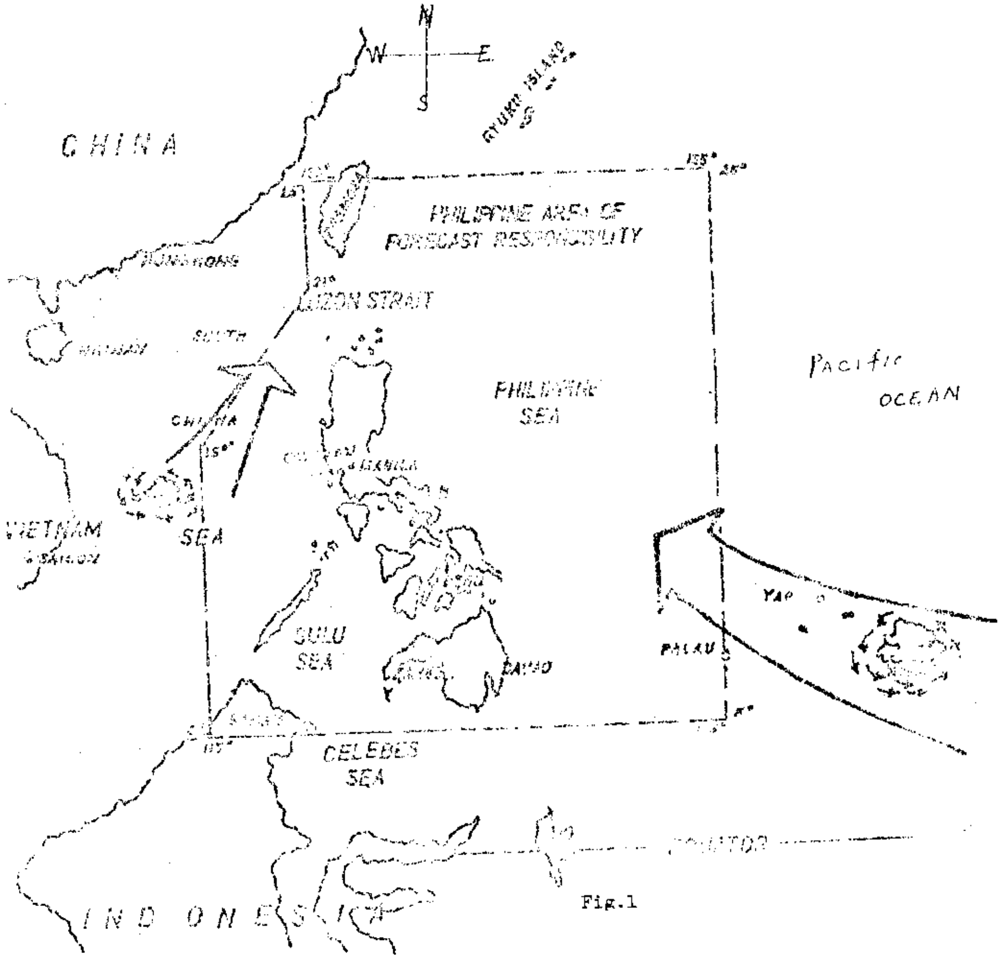

Fig.1

REFERENCE

PIS P-1 2nd Revisinn PUBLIC INFORMATION SERIES, PAGASA, 1424 Quezon Avenue, Quezon City, Philippines

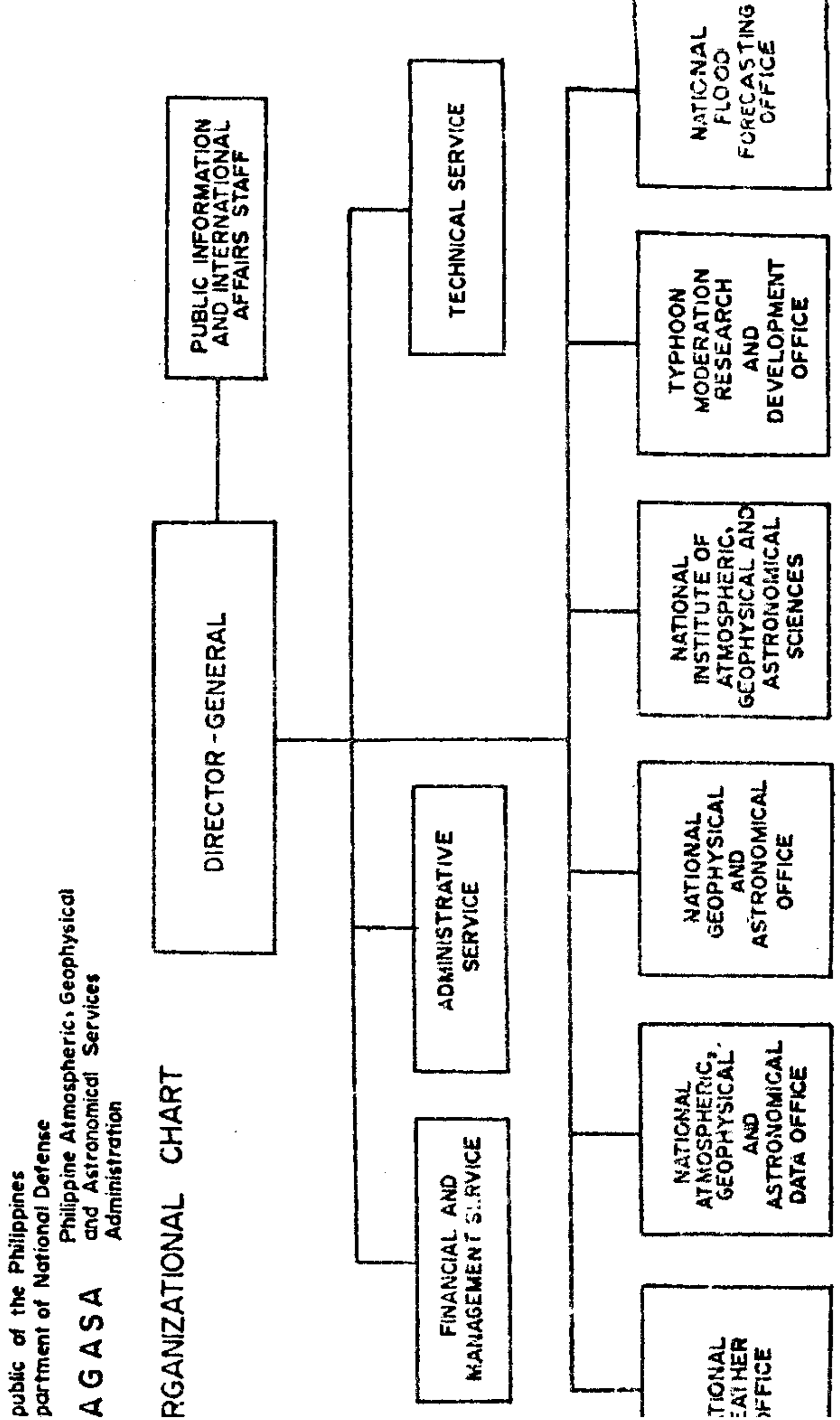

Fig.2

STORM WARNING SIGNALS

1 Signal No.1

One Blast

MEANING: Disturbance existing. Winds of up to 60 kilometers per hour may be expected in the locality within the next 24 to 36 hours. Be on the alert for further developments. Tune in to any of the radio stations for further information.

2 Signal No 2

Two Blasts

MEANING: Disturbance approaching or affecting the locality. Winds of 60-100 kilometers per hour may be expected within the locality within the next 24 hours. Strengthen houses of light materials. Children are advised to stay indoors. Suspension of classes is optional and upon the advice of higher authorities.

3 Signal No 3

Three Blasts

MEANING: Disturbance is dangerous to the locality. Winds in excess of 100 kilometers per hour would be expected in the locality within the next 12 to 24 hours. Everybody is advised to stay indoors. Classes are automatically suspended.

Fig.3

N I G E R I A

PHYSICS AND DEVELOPMENT IN NIGERIA

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I. INTRODUCTION

Physics is the descriptive formulation of the universe as a system of concepts expressable mathematically. The universe is physics. The conquest of the universe is development. Development is a measure of advancement in science, engineering and technology arising solely from practical implementation of resolved physics concepts. Therefore development is the progressive resolution of physics concepts.

Effective research and development require university level teaching and research in physics to promote advances in engineering and technology which form the basis for developing any country or culture. In the developed countries, research and development are carried out almost exclusively by private organizations and some government establishments. The universities conduct mostly basic research and very little research and development. In a developing country, the burden of both basic research and research for development, where it exists, is conducted by the universities. This is in spite of the drawbacks described later in Sec.IV. Nigeria is extremely conscious of this need for universities and their role in development. This discussion of Physics and Development in Nigeria therefore begins with a short exposition on the development of Nigerian universities to the progress of physics in Nigeria, and problems of physics in Nigeria, and plans for physics and international cooperation.

Attention is drawn to existing proposals for research and training programmes and collaboration among the developing countries of Africa, Asia, Middle East and Latin America. These projects - the Giant Equatorial Radio Telescope (GERT) and the International Institute for Space Science and Electronics (INISSE) have been formulated with the financial assistance of UNESCO at the workshop held in 1979 in India. Execution of these projects, still in the proposal form, will definitely contribute to the achievement of the objectives of the International Centre for Theoretical Physics (ICTP) by providing facilities for practical and experimental training. ICTP is called upon to take over the implementation of GERT and INISSE.

II. DEVELOPMENT OF UNIVERSITIES IN NIGERIA

This impromptu discussion is written up without access to exact data and records in Nigeria. As a result there could be insignificant errors in dates or inexactness in stated statistics, without detriment to the factual substance discussed.

Until October 1960, Nigeria was a British colony. Prior to 1960, Nigeria had only one non-degree granting university college, at Ibadan, established in 1948 and affiliated to the University of London. It is the premier cradle of most Nigerian physicists and other physical and biological sciences. Initially, it had little emphasis on geophysics, while the classics and a few of the arts disciplines were unduly emphasized. There were no programmes in engineering or technology. This, of course, suited British interests and objectives. The British also established the Yaba Higher College which became the cradle of medical personnel and degree level type training in the physical and biological sciences to produce teachers but not researchers.

Local political awareness and Nigerian nationalism started in the early 1940s. Pressure for political reforms and programmes for development started to mount. In the 1950s the British helped to establish the non-degree granting Nigerian College of Arts, Science and Technology, whose programmes were distributed to three branches, located in each of the three capitals of the three political administrative regions of Nigeria. Each of the branches later became the nucleus of an autonomous university - the University of Nigeria, the University of Ife and the Ahmadu Bello University - run by the government of each of the three regions. The University of Nigeria, founded in October 1960 as the first Nigerian indigeneous autonomous degree granting university, was so named to commemorate Nigeria becoming an independent sovereign state on October 1, 1960. It was not until about 1962 that the University College at Ibadan became a full-fledged and independent degree granting institution now called the University of Ibadan.

The University of Lagos became the fifth Nigerian University. A very high proportion of current high level Nigerian personnel in the physical and biological sciences, engineering, medicine, agriculture crucial to national development is linked to these first five universities. Before these developments in higher education between 1950 and 1965, most Nigerians acquired university education in Sierra Leone, Europe and America, mostly in the arts, social sciences and law disciplines.

Physics and development in the 20th century should under such circumstances still be in its infancy in Nigeria which is still a developing country. But physics and high level physics personnel in Nigeria have developed far beyond infancy and could easily have reached adulthood but for the fact that the political, social and economic progress towards maturity lags very seriously behind the progress of Nigerian physicists. The adverse influences of geopolitics and the interests of the multinational companies fuel the retardation of Nigeria's political and socio-economic growth. These problems are discussed later.

After the beginning of Military rule in 1966 in Nigeria, the Federal Military Government took over full responsibility for and control of all the then existing Nigerian universities. The National Universities Commission (NUC) was set up to coordinate and control the functioning of the universities on behalf of the government. In 1976, the Military Government suddenly increased the number of independent universities from six to thirteen. By

1981, Nigeria had established twenty-one autonomous universities. Five of these are owned and run by State Governments. The Nigerian constitution that came into effect after the military rule in 1979 re-established the right for both the Federal and State Governments to run universities.

As to be expected, each of these universities has a strong physics department. Nigeria has an even much higher number of polytechnics and advanced teachers colleges teaching Physics at first degree level and conducting research. This unprecedented rapid expansion of institutions of higher education is still far short of the needs of Nigeria's population of about 80 million people. Only about 10% of qualified Nigerians get admission into the existing universities. Ironically, this rapid expansion is one of the major retarding factors for the growth of physics and physicists in Nigeria. This expansion which is beyond the capacity of the Nigerian economy is causing very acute shortage of research facilities and supporting funds.

III. PROGRESS OF PHYSICS IN NIGERIA

3.1 Activities in the Universities

As outlined, the existence of over twenty universities (five of which are purely universities of science and technology) and more than twice that number of polytechnics and advanced colleges, each of which has a department of physics is an indicator of the prominence of the teaching of physics. All classical and modern branches of physics are taught. In addition, to the traditional physics courses a conscious effort is being made to teach courses that stimulate more interest in physics as an applied science and not just an abstract concept. Such subjects include engineering physics, material science, soil science and fluid dynamics. This makes the physics departments more competitive in attracting and retaining students in the face of stiff competition with faculties of engineering, medicine, pharmacy, agriculture, environmental design, who offer students more attractive post-qualification economic returns.

The Federal and State Governments have a policy to assist in emphasizing physics. They have set ceilings on the expansion of other faculties and student intake to protect and ensure the growth of physical science faculties. These is an inducement of financial payment to attract foreign lecturers/researchers in the physical sciences. Unfortunately, for physics this inducement is also extended to engineering, medicine, agriculture and environmental sciences which the government had to recognize as necessary elements for developing the country.

3.2 Areas of Research

In spite of the shortage of facilities and other drawbacks discussed later, Nigerian physicists are activily engaged in research in virtually all branches of physics. Areas in which encouraging research is going on include planetary geophysics geodesy, geology and exploration geophysics; atmospheric physics - the ionosphere, radio propagation. solar energy, meteorology; nuclear physics with emphasis on nuclear energy and the applications to medicine and agriculture; solid state physics; material science; radio astronomy; satellite remote sensing and satellite techniques in solid earth geophysics including the earths gravity modelling and oceanography; X-ray crystallography; laser technology and its applications in medicine and geodesy.

3.3 Applied Research in Local Problems

Several universities are engaged in applied physics research for solving local problems. The University of Lagos in collaboration with the Nigerian Broadcasting Corporation, is conducting sustained research into radio broadcast and reception problems in Nigeria. There are joint research ventures with some oil companies on exploration geophysics. Pollution hazard research is on going in at least four universitites. In particular, the

University of Lagos has established a radiation protection centre while the Rues State University of Science and Technology (RSUST), Port Harcourt, has an Institute for Pollution Studies which is conducting joint research with the Nigerian National Petroleum Corporation and an American Consulting firm. One aspect of this pollution study is hydrodynamic modelling and ocean/river circulation patterns as they affect pollutant dispersion. This is being carried out by the RSUST Institute of Flood, Erosion, Reclamation and Transportation (IFERT). IFERT's main function is the control of flood and erosion which must be accomplished before the government can achieve any meaningful physical, economic, agricultural and infractural development of the Niger Delta. This requires the on going intensive research in soil physics and mechanics, geotechnology and fluid mechanics.

At the University of Ife intensive government-backed research programme on nuclear energy and non-conventional energy is in progress. Another government sponsored energy research programme is at the University of Nigeria, Nsukka. The University of Nigeria has recently established a Space Research Centre to conduct research in radio astronomy, electronics, remote sensing and application of satellite technology to earth and ocean physics. In spite of a lot of teaching problems the radio astronomy is off the ground due to collaboration with a University in California which has provided a thirty-foot dish.

The geodesy group at the University of Lagos is conducting joint research with the Survey Division of the Ministry of Works and their counterpart in the Republic of Benin in the use of Doppler satellite technology for surveying and mapping, international boundary determination and definition of the African geodetic datum. There is also a joint research programme sponsored by the Government of Finland in atmospheric refraction as it affects surface to surface microwave radio propagation used in electromagnetic distance measuring instruments for geodesy.

The University of Ife geophysics group is engaged in an uranium prospecting contract research. At the Ahmadu Bello University, the geophysics group aided by the Nigerian Survey Department is executing a gravity research programme. Prior to its dissolution, the Halian Geodetic

Commission had planned to aid gravity research in Nigeria and in the establishment of absolute gravity stations. "Developing country disease" hindered the Nigerian input into this joint venture and prevented the realization of the project. At the University of Port Harcourt, the material science physicists are conducting research in local insulation materials for the Nigerian Building and Road Research Institute. These are just a few examples of applied physics research by Nigerian University physicists for development.

3.4 Scientific Organizations for Physics

(a) The Science Association of Nigeria (SAN) caters for all physical and biological sciences, engineering, medicine and agriculture. It promotes development of these disciplines through various programmes to popularize science. These include symposia, seminars and workshops; publication of a scientific journal - the Journal of the Science Association of Nigeria; publishing of textbooks adaptable to the local environment; award of national prizes in the relevant science subjects to secondary school leavers. SAN is designed to encourage outstanding scholastic achievement in science by the honorary award of Fellow of SAN. The mechanism for this as in the case of election to fellowship of the Nigerian Academy of Science has deficiencies characteristic of developing countries.

(b) Another key scientific organization is the Nigerian Institute of Physics. It fosters the development of physics and physicists through organizing forum for symposia and seminars, and publication of its journal called the Bulletin of Nigerian Institute of Physics. To strengthen physics at the secondary school level, it established the "Operation Teach Physics" programme. This is a summer programme run at several centres in different states of the country to teach physics to students in the uppermost two classes of our secondary schools.

(c) The Nigerian Union of Radio and Planetary Sciences (NURPS) is

another scientific organization for promoting physics. It has two main sections - the Radio Science and the Nigeria Association of Geodesy (NAG). The NAG works in close collaboration with the Geodetic Commission for Africa and the International Association of Geodesy which are organs of the International Union of Geodesy and Geophysics (IUGG). The NAG publishes the African Geodetic Journal NURPS and its sections organize local and international symposia and workshops and encourge regional cooperation in research.

(d) Other organizations performing supportive roles for physics and development include the Nigerian Education Research Council, the Comparative Education Study and Adaptation Committee, the Centre for Science and Technology Association of Nigeria, and the Science Teachers Association of Nigeria. Their supporting roles are of particular importance to proper laying of foundation in physics and the sciences at the primary and secondary school levels. The importance of this foundation cannot be overemphasized because the potential physicists are hatched and either nutrified or killed by the secondary school stage.

Some of the universities and these scientific organizations devote much effort towards this foundation laying in the secondary schools. To overcome some of the problems discussed later, some university physics departments promote physics by allowing secondary school students to use their laboratories during the week-ends for practical lessons in physics.

(e) Nigerian physicists and other scientists are prominent in promoting regional cooperation to enhance the advancement of science. One such effort is the West African Science Association (WASA) which also publishes its journal. For West Africa this association plays roles similar to those that the Science Association of Nigeria plays for Nigeria. It publishes the Journal Science Association and represents of West African roles similar to those that the Science Association of Nigeria plays for Nigeria.

IV. PROBLEMS OF PHYSICS IN NIGERIA

Developing countries suffer many drawbacks to their efforts for scientific and technological development. Some of the drawback factors include political perturbations, socio-economic influences, rapid exponential expansion in expenses for providing basic social amenities and infrastructure. These expenses, grossly exceed the national income and growth in gross national productivity.

The economy of developing countries is controlled by multinational companies and corporations. It is not in their best interest for developing countries to achieve scientific and technological advancement. These multinationals do their best to hinder such advancements.

Successful, progressive and dedicated scientists seldom get into political policy planning roles and hence make little impact in providing proper orientation and sense of relevant effective direction in research and development policy making. On the other hand, most scientists have to learn to bridge the communication gap between politicians/administrators/management and scientists/engineers. The politicians, administrators or managements control the funds. What management does not understand, it will not approve; what it does not approve cannot be funded; research that is not funded in this era cannot be conducted. Without research, there can be no meaningful scientific and technological advancement. Scientists and engineers must learn to explain, without technical jargons, the relevance of their programmes not only for advancement of knowledge but also the relevance to economic development and national security no matter how remotely linked.

4.1 Political and socio-economic impacts

Prior to 1960 when Nigeria became an independent sovereign nation, she was run by the British to cater for British interests first and foremost.

Nigeria was, up till 1960, essentially an agricultural economy dependent on the export of cocoa, palm oil and kernels, groundnuts, cotton and similar raw materials. In 1957, oil was found in commercial quantities and by the mid 1960s, oil had become the main source of foreign exchange earning for Nigeria. From 1966 to 1979, Nigeria was under military rule. During this period she pressed through a devastating civil war from 1967 to 1970. The civil war and the apparent quick "huge" returns from sale of crude oil combined to virtually kill agricultural production and the export of the traditional raw materials. Since about 1972, Nigeria has been depending on oil sales for about 90% of her foreign exchange earning. Current oil sale is about half of the projection used in making Nigeria's 5-year development plan. This is a very serious set-back for physics and development.

To the average mind, the immediately obvious indicator that separates the "developed" from the "developing" nations in the status of social and infrastructural development and functional facilities that establish the standard of living. Specifically, the elements of this indicator include education, health care and welfare facilities, housing, transportation, environmental sanitation, industrial production and consumer goods, food and agricultural production, communication, energy and water supply, information facilities, internal security and civil defence.

Instinctively, the reaction of all political systems in the developing nations is to draw up development programmes, involving short-term solutions to accomplish in a few decades the status of social and infrastructural development which took the developed countries centuries to achieve. This leads to rapid exponential expansion in financial spending which usually the countries economic power cannot accomodate. For this reason, in spite of apparent high income from oil sales, Nigeria is not a wealthy country as the government of developed countries ad international agencies try to classify her. Nigeria's financial spending needs astronomically exceed her oil income. This has caused and will, for a long time to come, continue to cause shortages including acute shortage of teaching and research facilities that adversely affect physics and development in Nigeria. The current worldwide recession has worsened matters.

In tracing the development of Nigerian universities, we showed that Nigeria went from one in 1960, to five by about 1965 then thirteen by 1976 and twenty-one by 1981, sketched in the graph in Fig.1.The growth curves for the primary, secondary, teachers training institutions and the polytechnics are even steeper exponential curves. The Nigerian Federal and State Governments spend about 30% of their budgets on education. Yet due to the astronomical growth of and demand for educational facilities in the face of financial constraints, the shortages in teaching and research facilities - books, journals, equipment, power and water, severely hinder the advancement of research in physics and other disciplines.

In their anxiety to achieve rapid development and impress the electorate politicians get trapped into seeking short-term solutions. This has led to heavy dependence on imported technology instead of emphasizing local research and development. Of course, the foreign multinational companies encourage this trend. These companies get contracts for construction of "turn-key" projects which often fail to function shortly after completion because of the absence of a Nigerian technological base.

The oil-economy mentality, the imbalanced emphasis on the construction sector of the economy, and the economic and social reward system and its basis are progressively and severely dwarfing the growth of physics. This has further aggravated the adverse impact of shortage of teaching and research equipment. Consequently, in some universities, whereas for a discipline like civil engineering the number of qualified applicants can exceed 10 times the allocated admission quota, physics and mathematics often do not get half the number of their quota. There is the case of a university that received 4,000 (four thousand) applications for the 50 (fifty) places allocated to the law faculty but got only six (six) qualified applications for the 40 (forty) places allocated to physics

There is a physics department which runs three different first degree programmes. All its undergraduate students are enrolled either in the combined programme for physics and material science or physics and electronics. Currently no student is enrolled for the pure physics programme.

V. PLANS FOR PHYSICS AND INTERNATIONAL COOPERATION

There is no substitute for international cooperation as a catalyst for scientific advancement. Virtually all the functioning physicists in Nigeria have either had their post-graduate training in some developed countries or been exposed to research and working experience in these developed countries through some foreign collaboration or exchange programme. The issue of "brain-drain" or the scientists who fail to return to their developing countries should not diminish but encourage more cooperation and collaboration with the developed countries.

The tremendous impact of the various programmes of the International Centre for Theoretical Physics (ICTP) in fostering the development of physics in and physicists from the developing countries cannot be adequately discussed in this short exposition. There is no other better organized or more effective "physics fertilizer" for the developing countries like the ICTP. The latest ICTP plan for awarding fellowships to physicists from developing countries to enable them gain research experience at some Italian research organizations should be wholeheartedly supported by the ICTP financial sponsors.

Collaboration of physicists from the developing nations in joint research and development programmes is a key factor for physics to make its desired impact on development of the developing countries. In this regard, several physicists have drawn up valuable proposals for intra-developing-country joint research projects. So far, little progress has been made in this area due to the political and socio-economic disposition of governments of the developing countries.

Through the aid of the International Astronomic Union (IAU) and the financial support of UNESCO, scientists from several developing countries have drawn up laudable proposals which are yet to be implemented. The leading numbers of this group include Professors Swarup and Yashpal of India and Okaye and Fubara of Nigeria. IN 1979, physicists from several African, Arab, Asian and South American countries and some from Europe and U.S.A. held a workshop in India and produced a blue print for two projects described below.

5.1 The GERT and INISSE projects

"GERT" stands for Giant Equatorial Radio Telescope. It is primarily the brainchild of Prof. Swarup of India. Swarup did postgraduate work and gained considerable working experience in radio astronomy in California, U.S.A.. On his return to India he was able to construct an efficiently functioning radio telescope at Ootacamond (Ooty) in India. The entire design, parts and fabrications, and construction were completely based on Indian technology. The telescope was set parallel to the rotation axis of the earth. The principle of such a construction is that elements of the antenna array are set in a north south direction inclined to the horizon at an angle equal to the latitude of its location. The higher the latitude, the steeper the inclination and the more difficult it is to achieve this type of construction and alignment correctly at the necessary angle of inclination to the horizon. At the equator, the horizon is parallel to the rotation axis of the earth. Therefore, at the equator the elements of the antenna of a radio telescope need only be constructed as a horizontal array. This makes it possible to construct as long a north-south array as one likes. Furthermore, on the equator, the coverage or view angle of a radio telescope is more extensive than at any other latitude for the same size of radio telescope array.

The GERT proposal is therefore to construct a giant radio telescope at some suitable location on the equator for research and training in radio astronomy. It is meant to be a joint venture of several collaborating developing countries for use by their scientists. The science and technology, especially electronics and computers required to execute the construction and running would provide a very fertile training ground for local development of technology by the developing countries. Initially, GERT, was supposed to be sited in Kenya. The latest information from Dr.

(Mrs.) M. Vannucci, (Director a.i. UNESCO Regional Office for Science and Technology in South and Central Asia, resident in New Delhi, India) is that due to lack of cooperation a new site is being searched for in Indonesia. The necessary supporting fund is still lacking.

"INISSE" stands for International Institute for Space Science and Electronics. The activities and programmes proposed for such an institute located in one of the developing countries, constructed and run by scientists and technologists of the collaborating developing countries are designed to give a tremendous boost to development of physical science and technology in developing countries.

This dream cooperation amongst the developing countries is yet to materialize. Since UNESCO is already involved in these proposed projects it is hereby suggested that the International Centre for Theoretical Physics (ICTP) can now create experimental physics facilities by taking over and executing the concepts of GERT and INISSE. This will be very complementary to current ICTP programmes and greately assist ICTP achieve its main objectives, viz.

(a) to help in fostering the growth of advanced studies and research in physical and mathematical sciences, especially in the developing countries;
(b) to provide an international forum for scientific contacts between scientists from all countries;
(c) to provide facilities to conduct original research to its visitors, associates and fellows, principally from developing countries.

The late René Maheu, former Director-General of UNESCO, emphasized that "Unless it has its own scientists and technicians, no country can call itself free". ICTP should urge UNESCO to assist it implement the GERT and INISSE proposals to provide the scientific and technical training to help the developing countries become free. The organizing Indian and Nigerian scientists are adequate and eager to see this joint venture in the developing countries achieve the objectives of physics and development for the developing countries.

K E N Y A

PHYSICS AND DEVELOPMENT IN KENYA

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ABSTRACT

The aim of this discourse is to reflect on the role that Physics plays in the development of a country and in this case, Kenya. Since independence, 20 years ago, Science and Technology have been recognized as elements critical to development in all aspects of life. It becomes imperative hence to focus mainly on the scientific, technological and cultural implifications of the subject over the two decades and possibly its influence in the future of Kenyan society.

1.0 INTRODUCTORY REMARKS:

At present, it is becoming a basic fact that physicists and mathematicians and others who are labelled as scientists, should reflect on the fundamentalities that the subject of their pursuit has in relation to development be it nationally or internationally. The education of scientists is an expensive enterprise, but however, no society at present can neglect it because there is a speedier prosperity under scientific and technological circumstances.

With the world divided as it is into zones of developed and developing (third world), it becomes imperative for scientists and the knowledge of sciences to be of immediate use in the cogwheels of development. This is urgently needed in the developing countries, particularly the applied dimensions. In the African continent, where Kenya is located, the situation is critical, and few centuries will have to pass by before she becomes a force to reckon within the arena of science and technology.

1.1 BACKGROUND:

It is an acceptable fact that virtually all major scientific and technological developments or discoveries appear to have commenced from the presently developed countries of the world, particularly those in Western Europe. This has now degenerated into Western science as is often referred to by some third world countries. It has therefore meant that there was nothing that was comparable to it in the developing countries of Africa, South America and Asia. However, it should be recalled that the advantages of printing as opposed to mere writing, effective communication system, ample climate for research and motivation, to mention a few, were realized and used earlier in the developed countries.

In their prime of historical, scientific and technological advancement, some of these Western countries became adventurous. These factors too affected their civilization. Anyhow they explored further across the seas and land to unknown lands beyond the horizon. Some of these journeys resulted with the discovery of the African continent. The significant phenomenon is the successful application of the results and discoveries of science. Theories were formulated about the nature of the universe, particularly the planet Earth and there came the insatiable need to test them and satisfy mans' curiosity. Alongside it, was the improvement of technology to facilitate the realities of the time.

In those early days, the question of spreading science was not an issue. It was mans' curiosity for more knowledge and the confirmation of hypotheses. As more successes and advancements were made, science and technology became an economic asset to the founders. These earlier revelations show that there was nothing of major scientific or technological concern taking place in Africa. If there was, it was not definitely advancing at the same rate as the above and neither was it sophisticated. Whatever theories were formulated, there was no attempt to confirm them by travels or otherwise. The coming of the Western science eclipsed whatever was there and that was the demise of indigenous science and technology. However, the dependence on Western science generates the question whether indeed there was no indigenous science and technology in Africa of value. There are no written records and there has never been a Galileo or Newton for that matter unless one looks at Egyptian civilization as they were notable particularly in the area of mathematics. It must be asked here that:
Given that, if Western Science did not eventually spread to Africa, say, what could be the level of scientific technological and cultural development at present?

One of the factors brought about by the improvement of technology is the colonising motive by the Western people. The new lands discovered were claimed and settled upon. There was unequality in the development of different levels of cultures, one inferior and the other superior. Africa is rich in minerals but less developed culturally, was exploited to the full. The resulting blow: "the total dependence on Western Civilization in science, technology and now culture". This is lamentable but unavoidable. No country in Africa today claims to be an isolated case.

Whereas the Western societies have been influenced by science and its discoveries for over 300 years, many of the African countries have just started in a real sense and only after being independent politically.

For Kenya, it is only about 20 years. To start with, the educational system has had to be modelled to suit the aspirations of the Kenyan people in order to serve them in the improvement of their living styles. Inevitably science and technology has to be given a place in regard to this for it has positive contribution and effective in meaningful development. In addition, the cultural aspect is influenced and therefore modified by it accordingly so as to respond to changing international accurences elsewhere.

1.3 EAST AFRICAN REGION

In reference to this region, one is considering the states of Kenya, Uganda and Tanzania. These three generally were colonised virtually by the same foreign country, that is, Britain and so moreless saw the same developments. All became independent between 1961-1963. Prior to independence, a central body existed which provided common services to the three countries and this was East African Common Services Organisation (E.A.C.S.O). In about 1965, the name changed to East African Community (E.A.C.). By then and onwards till 1977, the common services provided in partnership were: Railways, Airways, Ports and Harbours, Posts and Telecommunications, Meteorology, Fisheries, Commerce, Examinations, University education, etc. The latter was so until 1970, when the former East African University desintegrated into national universities by act of Parliament.

The other area where collaboration was undertaken was in basic research in medicine, technology and science, industrial development, economics and commerce and in education. In many cases, this yielded fundamental oriented research which was subsequently directed to the respective government for action. It appeared that little or no research was done on the applied aspects.

In 1977, the E.A.C. broke down completely as there was no more political will. It is a matter of fact that sponsoring research, in basic and applied in science and technology is and will be an expensive project that a single government cannot afford. This means that the fast and significant progress in these areas that could have otherwise been achieved on regional basis, now degenerates into slow and unsure business. Hence, the scientific, technological and cultural elements will take more years to be achieved. It must be observed here that though the regions problems are similar in every aspect, political speculation and suspicion, alters the nature of things significantly, forcing each country to go it alone. In this regard, Kenya as it is in the other states too, has therefore to carry its burden of population explosion, economic recovery, unemployment, education, energy and development and important of all is political stability in the consolidation and realization of national policies, It has to develop and adapt any kind of technology to herself that may solve its problems.

2.0 KENYA'S PERSPECTIVE:

Despite the presence of regional co-operation, the Kenya political system, particularly the government, had to be more central in shaping the economic, social or cultural, educational factors, and generally the enhancement of her populations' welfare (Kenya's location and other background data are given in the accompanying appendixes 1,2 at the back).

Three aspects critical to Kenya's development after independence in 1963 were: alleviation of *poverty, ignorance* and eradication of *diseases*. These have become fundamental in the successive 5-year development plans. However, one basic aspect that held the key to development, was education. It meant that the educational system was to be modelled so as to aid in achieving effectively the mentioned issues. Further, the government machinery had to be organised to provide effective plans and subsequently, implementing them.

It is apparent that there was some basic awareness since 1963 of what was fundamental. Some of these were:

1. That education and development are very related functions.
2. That global societies were living in an era of science, therefore there is need for scientifically literate society.
3. That there was need to develop or adopt appropriate technology suitable to the local conditions.
4. That due to lack of undigenous science, a dependence on Western science was unavoidable. At any rate it is a universal science.
5. That there was a general lack of all categories of manpower, particularly in the scientific fields.
6. That being part of the world societies, there are international obligations that have to be fulfilled.

2.1 PROGRAM OF ACTION:

The identification of the aforementioned needs, implied that concrete programs had to be systematically generated, and action to implement them ensured. Thus the following needed consideration:

1. The entire educational curriculum had to be redesigned and emphasis laid specifically on the teaching of scientifically based subjects, e.g. physics, chemistry, biology and mathematics and some industrial arts. Attempts had to be made to teach each purely.
2. The adult literacy rate was small. This implication is that an overwhelming majority did not know how to read and write. So as to have any significant appreciation of science, adult literacy campaigns had to be mounted. The original figure of about 85% has now come down to 50-60%. Currently, the campaign is more vigorous and a complete literacy must be achieved by 1985/86 period.
3. Provision of more secondary schools teaching sciences and other technical subjects, training facilities for both technicians scientists and science teachers.
4. Greater emphasis on applied research coupled with openings to facilitate research to continue on basic or applied aspects.

2.2 PRESENT STATUS

The struggle to be independent was to permit Kenyans to develop themselves according to their own plans and democracy. The government and the people had to respond positively and sacrifice their energies on issues of critical implications. Thus there was the slogan "HARAMBEE" (meaning lets pull together) which indeed revolutionalised the way of life in Kenya. On the educational side, it resulted with the building of so many secondary schools on self-help basis. Usually, after a lapse of time, the government takes over the school therefore equiping them adequately. Suffice, to say here that there has been positive and tremendous achievement. The current slogan is "NYAYO" (footsteps along "HARAMBEE") and is intended to pull Kenyans together for development in PEACE, LOVE and UNITY. As a developing country, characterised at times by political perturbations, Kenya generally has achieved comparatively much in 20 years. The discouraging factor now is economic perturbations, globally felt and will have a retarding effect on development.

However, the government machinery has constantly been undergoing some restructural organization to bring about achievements soon and efficiently. Large ministries have been split, namely, previous ministry of Education is now two ministries of Higher Education and Basic education; Ministry of Works also became Ministry of Transport and Communications and the other Ministry of Works and Housing. Some others are Water Development, Regional Development, Science and Technology, Natural resources and Environment, all being new ministries. Generally, there has been mounting concern for education, general development and conservation.

A ministry that was created and of interest to physicists is the Regional Development, Science and Technology one. In it is the National Council for Science and Technology which was actually started way back in 1977. The aims of the council as known are:

1. To be concerned with science and technology policy matters.
2. To act as data and information tank.
3. To educate the masses on environment and other issues for national development.
4. To provide the necessary link in the various sectors as industry, agriculture, natural resources, communications, housing and health.
5. To provide the required financial support or grants for projects that relate to science and technology that are of utility in national development.

Since the council was established, it has succeeded in providing co-ordination, communication links and activated research by individuals and groups throughout the republic. In addition, there are other agencies which provide for research also and it may be opportune now to discuss about research in the country particularly those that have a direct bearing on physics and the application of its principles.

3.0: RESEARCH IN GENERAL.

It is globally recognised that research is an inevitable enterprise for it serves in contributing to the expansion of science knowledge.However, so many societies are preoccupied with the application of the already accumulated knowledge in the enhancement and betterment of living standards. Though this is so, it is an expensive undertaking to fund research and development. The economies of the developing countries which are usually weak and whatever there is, is shared by so many agencies providing essential services, leaving virtually nothing for research. Kenya suffers from such a situation. However, there has been a fair attempt to finance some relevant and essential research.From this premise then, any serious attempt to relate the phletora of physics principles to real development issues has been absent. Much of it has been basic research which slowly gets used elsewhere.

Research could be said to be done by three groups for which one may say that principles of physics or knowledge is being given application and to issues that are developmental in character.These groups are to name them: the university, some government ministries and private companies.

3.1: RESEARCH BY UNIVERSITY:

The bulk of the fundamenatl research is mainly done by the university staff in all sorts of areas.Some of the research is basic and others essentially applied.The high activity in this field is attributed to presence of highly qualified staff concentrated there. Also the university is encouraging research by the lecturers and so there is a vote for it.A grant is made to anybody who submits a relevant research proposal.

In the Kenyan setting, as indeed in other developing nations the university has an important role to play, namely, the dissemination of knowledge, training of manpower and generally educating the puplic. Hence, research done must be relevant to national development at most. It should enhance it as well as being educative particularly in the applied dimension.
At times another school of thought holds the view that all kinds of research should be done by the university in service to the public and nation without any limitation. This could have been so if the nation was rich enough and it may well happen later.

The sole national university in existence is still a developing one and hence not so many departments are there that do much with physics for development of the nation. However, the disciplines that has something to do with the subject directly or indirectly are: engineering(mechanical, civil, electrical); geophysics;

electronics; computer science; appropriate technology; geology; meteorology. Hence, there is a faculty of engineering, and the departments of physics, geology, meteorology and appropriate technology as well as an institute of computer science. Geophysics and electronics is within the physics department.

Engineering science has greatly benefitted from the development of physics principles.Of course the real applied part of physics is this area. The trained engineers hence play a valuable role in national development. For a society to be technological, engineering science, mathematics and physics must be given a priority in the education of the youth. Curriculum designers have taken note of this and the syllabii produced emphasises it. It must be noted that the present state of development in the Western societies is due to the considerable weight given to teaching of sciences and industrial arts in schools and other institutions.

Considering actual research in the domain of physics in the university, there are four or five areas of concern and each has either a developmental or educational relevance. One fundamental objective is the understanding of the surrounding in a bid to control and subsequently exploit it, while the other is the application of the known to demanding situations. Another is to keep up with knowledge that is ever being generated perpetually.

The following is the kind of research going on with a brief discussion on what is actually done.

3.1.1: GEOPHYSICS.

Being a wide subject, research is going on in several of its subdivision. However, the subject is still under physics.

1. Geomagnetism- diurnal data collection of H,Z, and D transient elements. This was started way back in 1964 and annually Magnetic Yearbooks are prepared on each element for World Data Centre.

11. Ionospheric physics- research was initiated for sometime between 1964-72 when the only ionosonde installed was still functioning. It has been out of order since then. However, there are plans to restart it again.

The establishment of Nairobi Observatory was for the collection of the above data required for a better analysis of the global behaviour of the ionosphere, in this case the equatorial electrojet phenomena, since the area lies within the equatorial ionosphere. Also, it is known that the ionosphere has an effect on radio propagation within the tropics and there was need to have some data from the latitude, that is, dip latitude of Nairobi.

111. Seismology- Some few stations have been established for monitoring earthquakes. So far few isolated cases have been recorded.

1V. Palaeomagnetism- Studies mainly centre on the determination of the direction of magnetic field, polar wander path, continental drift . Of late, the main application has been in fossil dating in the field of archeology. There is therefore an active excavation on identified areas where human skulls could be found and its age determination could lead to the origin of human life.

V. Magneto-tellurics- studies concentrate on the conductivity of the Great Rift Valley. This valley passes through Kenya from Ethiopia (see map).

V1. Geothermal- the Great Rift Valley studies have shown that there is a possibility of harnessing geothermal energy for electrical generation. So far, a big project has been launched for the purpose and it is estimated that by the end of 1983, about 30Mw of electricity will have been added to the national grid line.

3.1.2: APPLIED PHYSICS.

The engineering sciences has a major contribution to make in national development as an applied subject. Of recent past, there has been a recognition on the contribution made by modern technology and perhaps supplementing the indigenous one. The question is, that it is not a matter of buying technology from the Western sphere but rather doing something about innovating and creating an appropriate kind which can be consumed cheaply in the developing nations. The trend generally then has been towards such a direction.

Some of the areas that appear to be urgent are: energy, crop drying and housing. The research done here is to emphasize the development of cheap and favourable technology taking into account surrounding conditions of the nation. Attempts are being made by the Appropriate Technology Centre for Research and Education at Kenyatta University Campus and their projects are as follows:

1. Energy- windmill application for electric generation and water pumping in the rural setting, the designing and testing of economical wood and charcoal stoves, biogas generation, solar cells, and the possibilty of small scale production of electricity using waterfalls and damming.

11. Crop-drying- Kenya being an agrucultural country, growing cash as well subsistence crops, crop drying and storage are inevitable procedures. An attempt is made to design a cheap drier as well as a cheap way of storage.

111. Housing- provision of housing to all in the urban and rural settings has become an expensive enterprise, especially, materialwise.Studies carried out centre on the possibility of using low cost building materials made from local materials.

3.1.3: ELECTRONICS

The electronic technology has had an impact on the Kenyan society. Many institutions whether educational or commercial employ electronic gadgets for efficiency. The computers and their capability has totally brought a different dimension of thinking and culture.The revolution has even become apparent due to the presence of calculators, radios, televisions, digital watches and others. All this indicate the kind of socio-technological development growing countrywide.

Attempts are being made in the university and few other places to carry out studies on:

1. Building of low cost data loggers of a cheap nature using CMOS chips.

11. Microcomputer assembling and modification. This include circuit design, construction and interfacing.The parts for these are usually imported.

111. Software programming for teaching purposes. The micro-computer is fast becoming an aid in the classroom situation.

1V. Microcomputer application for monitoring temperature, pressure in some defined areas particularly some zoological studies.

3.1.4: PHYSICS EDUCATION.

The teaching of physics in a developing country is not an easy task due to lack of equipment and laboratory space.The objective of producing graduates who are scientifically oriented or who have acquired scientific attitude and the scientific method of investigation is virtually impossible. Hence, the overall educational objective of having a scientifically literate society could take sometime. There are attempts at least to ensure that correct understanding of physics concepts by the learner occur. There is an on-going research related to this in the following:

1. By developing low cost and simple equipment for teaching as an aid particularly in the secondary schools. At present physics teacher education aims at involving the prospective teacher to doing innovative and creative work in the design and construction of simple but relevant apparatus for easy illustration of concepts.

11. In a small scale and mainly in the university, the use of microcomputer and television for the teaching of the subject is being attempted.

111.Some work is going on the so-called distant-learning method and another on identifying and correcting possible misconceptions in the teaching-learning of physics.

3.1.5: METEOROLOGY AND GEOLOGY.

Meteorological studies are required because of the agricultural activities of the country. Hence, weather information must be available throughout the year for the farmer.A well-equipped station for the purpose has been built and uses radars and computers for forecasting. For a country wide forecasting, there are substations away from the main one but supplies data to the central one thus enabling the meteorologists to give a fair prediction of the ensuring weather in the next 24 hours. In the university, a meteorological department is there for training and offers programmes up to the diploma level.

Geology department offers programmes up to undergraduate level and there is a hope that Kenya may be having untapped mineral resources as inferred from some isolated geological studies already done. Trained geologists who have done chemistry and physics are so much required to carry out the surveys countrywide.

3.1.6: MISCELLANEOUS

The actual data indicating on-going research outside the university is hard to come by and particularly where physics may be playing a role. In most cases, research may be done by private organisations who seldom reveal what they have achieved. The ones done by government sponsorship cannot also be circulated but may remain the property of the ministry concerned. The establishment of the National Research Council may eventually provide what is available.

Generally, research that has gone on whether by government alone or with private companies, go on the following areas which may be connected with the application of physics principles:

1. Geothermal energy exploration and exploitation.
11. Hydro-electric harnessing(main source of electricity)
111. International telecommunications network via satellite.
1V. Radio and television communications countrywide.
V. Computerization of payrolls, price indexing analysis, e.t.c.

Apart from private organisations that operate within and for purposes of doing mainly some kind of applied research and subsequently exploiting it for profits, there are World Organizations which also contribute. The main one being the United Nations and it's agencies, namely, UNEP, UNESCO, IAEA. The other agencies are USAID, and others that are sponsored by U.S. government. In many cases, the application of physics for development is apparent in each of these agencies.

4.0: IMPLICATIONS OF PHYSICS.

The disciplines has been given much weight in its teaching both in the secondary and the university. It has a considerable effect generally on development of a nation. Its implications may be cited as follows:

1. Physics has a significant influence on man's daily activities or life. Such concepts like force, energy, motion are of direct relevance everyday.
11. Man should understand the physicsl nature of the universe so as to control and exploit it meaningfully.
111. Life becomes more confortable and more interesting, e.g. transportation, communications, entertainments, e.t.c.
1V. Being a universal science, it has promoted international co-operation in research, technology, politics, economics and even culture.
V. A transformation of societies has been brought about by the elimination and replacement of cultural beliefs and superstitions.
V1. There has been a cultural revolution through usage of radio,

T.Vs', newspapers, cars,phones, e.t.c.

V11.A kind of technological creativity and innovation has been enhanced as well as know-how. This has meant generation of employment in some sectors.

V111.The basic principles under physics has had significant application in other areas,e.g, medicine(radiotheraphy, surgery), agriculture, hydrology, e.t.c.

5.0: PROBLEMS AND CHALLENGES.

Being a developing country, Kenya has her own problems to face and to attempt to seek solutions.Several issues come into focus, namely:

1. There is shortage of resources, e.g, finance, hence, research is hampered as well as the welfare of the people.

11. There is a consuming desire for knowledge and technological products rather than the development of our own.

111.The presence of high illiteracy generates less appreciation for technological or scientific discoveries through research work.

1V. The income per capita is generally low and therefore the living standards is poor.

V. Kenya has a high annual population increase and this would overstretch the meagre available resources.

V1. There are fewer institutions of science, education and training.

V11.There is a mentality for people to pursue knowledge for the sake of excellence rather than appropriateness.

V111.Regional co-operation which existed before should be re-established for the Eastern [illegible] region.

1X. There is need to popularise the teaching-learning of physics and mathematics and their application to development.

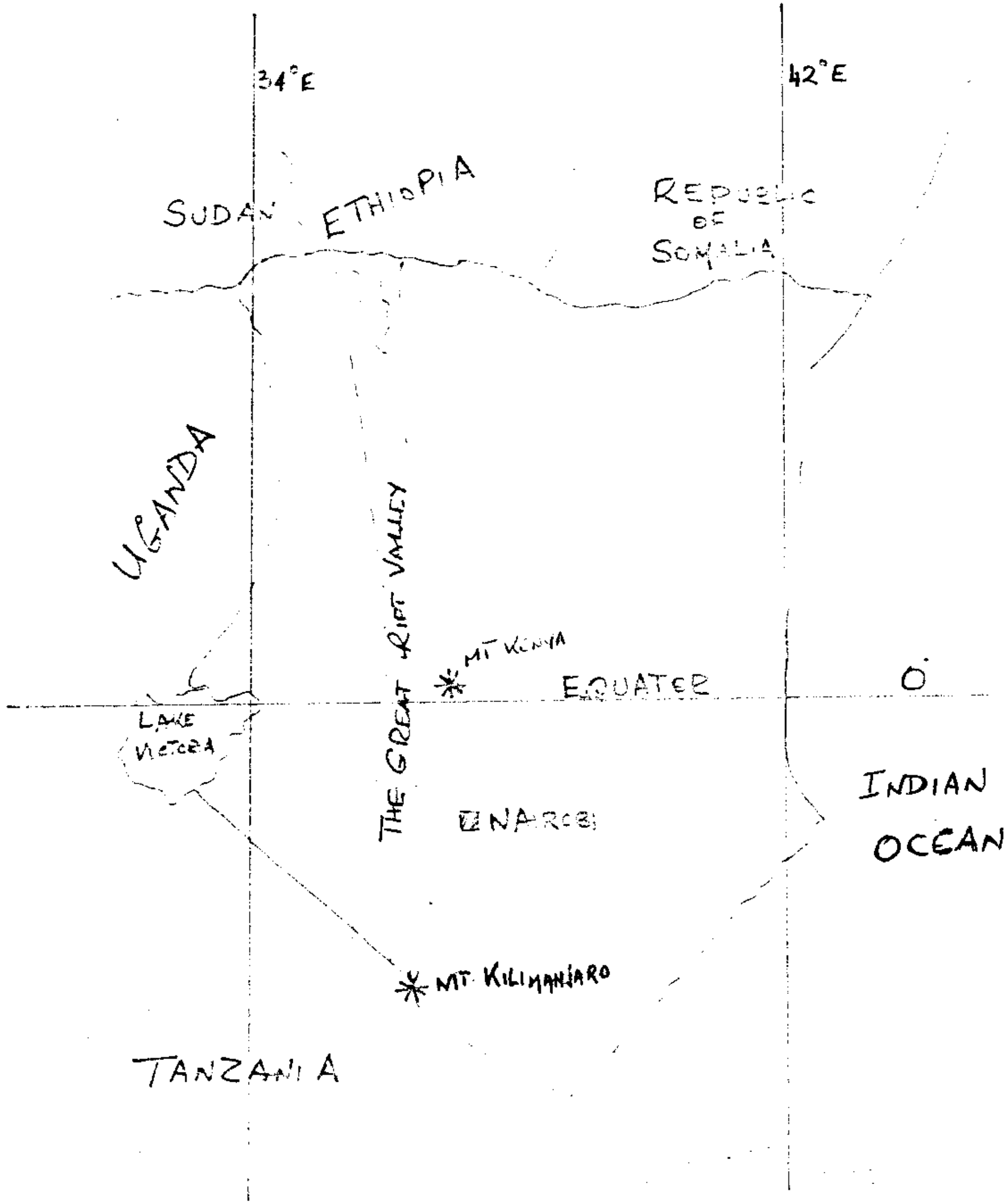
X. Provision of libraries and lack of information flow, e.g. disseminating research results and knowledge to those who may need them.

X1. Lack of forums for exchange of ideas and generation of new ones.

6.0: CONCLUDING REMARKS.

The application and the appreciation of physics principles, though is still low, but given its significance and effect on our daily lives and development, the time will come when it has priority in teaching and learning or preparation of the youth for future roles. With such problems as energy, environment, communications and others, people will gradually realise how physics actually bring about acceleration of development.The direct and indirect application of physics to relevant situations of life is a definite expectation in Kenya.

APPENDIX 1



MAP OF KENYA

APPENDIX 2

1. Location: Eastern Africa
   Longitude: 34° - 42°E
   Latitude: 4°N - 4°S
   Equator passes about the middle.

2. Population: 18 million (3.5% birth rate)

3. Capital City: Nairobi
   Located at 37.1°E, 1.5°S
   Population of 1 million.

4. Economy: Mainly agriculture, tourism.

5. Government: Civilian, 25 ministries. 5 year election cycle.
   One party state.
   5 year development plan.

6.1 Education system: Primary education (7 years and free)
   Secondary education (6 years, pay fees)
   University education (3, 4, 5 years, loan system practiced).

6.2 University: Nairobi university composed of five compuses for:
   Education, Medicine, Science, Agriculture and Veterinary, Arts and Engineering.

   (2nd University in preparation).

U G A N D A

PHYSICS AND DEVELOPMENT IN UGANDA

E.M. Twesigomwe
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I am deeply honoured and much appreciate the opportunity to give a lecture in this series on Physics and Development. This afternoon I will try to give a general outline on the role Physics has played in the development of Uganda. I will start with general information about Uganda for those of us who know little or nothing at all about Uganda.

Uganda, a republic within the Commonwealth, obtained independence in 1962. Located in the Eastern African plateau between 1°30'S, 40° N and 29°30'E, 35 E, it is at least 800 km from the Indian Ocean. The total area is 24,139 sq.km but 17 percent of this is made of fresh-water lakes, of which Lakes Victoria, Albert and Edward are shared with the neighbouring states of Kenya, Tanzania and Zaire. Lake Victoria is the source of River Nile. The Nile water leaving the lake is harnessed for hydroelectricity (Own Falls Dam). Rwenzori mountains (highest peak 5,109 m), sometimes called Mountains of the Moon, lie on the border with Zaire and are at the edge of Western Rift Valley. The country is inhabited by 13 million people who speak more than 15 different languages. This of course has created some problems since it has made direct communication difficult, thus making interaction among the people more and more difficult. Because of many different languages, English has continued to be the official language although not understood by the whole population.

Let us now examine the role of Physics in Uganda's education system since the education is the backbone of development for any nation. The education system can be summarized in the form of a chart:

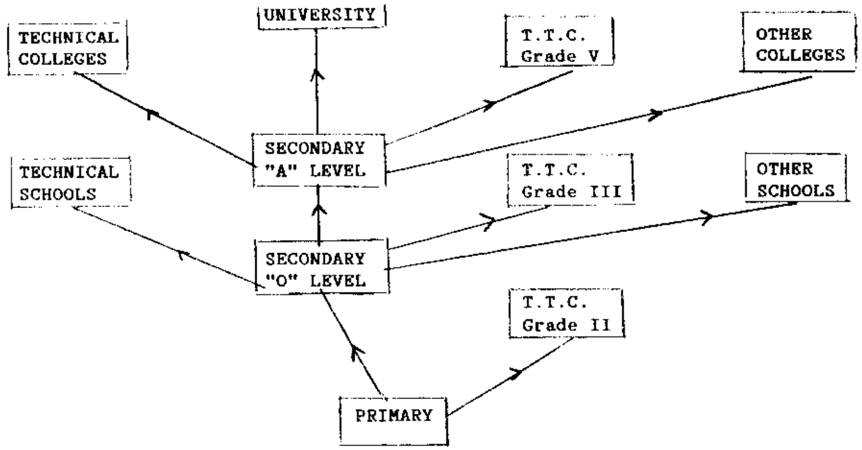

Chart showing education system in Uganda.

Keys:

T.T.C.: Teacher Training College
"O" Level: Ordinary Level
"A" Level: Advanced Level

Primary education is a seven-year course, science being one of the subjects taught but only to higher classes. At this level science consists mainly of Biology and some Physics. Secondary School education is a six-year course divided into ordinary level, four years, and advanced level, two years. Geography, History, English, Mathematics, Biology, Chemistry and Physics are compulsory subjects at "O" level. At "A" level, each student takes three subjects of his/her choice.

Pupils who do not wish to join secondary schools may join T.T.C.'s. After four years in these colleges, they qualify as grade II teachers. Students who do not join "A" level from "O" level may join other institutions to train in different fields. These institutions include T.T.C.'s at grade III level, secretarial colleges, nurse and midwife training schools, commercial schools and technical schools which offer certificates.

After two years in "A" level,students may either join University grade V T.T.C.'s, technical colleges or other colleges which offer diplomas. There are several grade V T.T.C.'s, one technical college known as Uganda Technical College (U.T.C.) and several other colleges and schools. These include Agriculture Colleges, Medical Schools and Uganda College of Commerce (U.C.C.) which offers courses in Business Education, Physics at "A" level is a requirement for students who join Medical Schools.

U.T.C. was founded in 1954. It has a population of more than 1,000 students training in different fields. The college has several departments which include

Civil Engineering and Buildings,
Electrical Engineering,
Mechanical Engineering,
Science and Mathematics,
Technical Teacher Training,
English and Liberal Studies, and
Industrial Ceramics.

Science department offers Physics which is compulsory to all students.

The National University, Makerere University in Kampala, was founded as a technical school in 1922. It became a constituent college of the University of London in 1949. In the early sixties it became a constituent college of University of East Africa. Makerere attained University status in 1970.

The University community consists of more than 4,000 students and about 500 members of academic staff. There are 7 departments, 4 schools and 3 institutes.

Faculties: Laws
Social Sciences,
Arts,
Veterinary Medicine,
Technology,
Science and
Education.

Schools : Medical School,
School of Fine Arts,
Centre for Continuing Education, and
East African School of Librarianship.

Institutes: Institute of Statistics and Applied Economics,
Institute of Social Research and
National Institute of Education.

Physics is compulsory at "A" level for the students who wish to enter faculties of Veterinary Medicine, Technology, Science, Education and Medical School.

Physics Departments are under the Faculty of Science. The department has nine members of academic staff and over 200 students. Besides, general laboratories, Microwave, x-ray diffraction and Radioisotope laboratories are available. Physics graduates are employed by various departments and corporations which include

Uganda Teachers Service Commission,
Meteorological Department,
Uganda Posts and Telecommunications Corporation,
Radio Uganda and Uganda Television Departments,
Civil Aviation Department, and some of the Research Institutes.

In addition to teaching, members of academic staff do some research work in fields of cosmic rays, micropulsions and energy. In particular, the department is examining the use of renewable energy especially biomass, geothermal and solar energy. The energy research program is sponsored by the National Research Council. The Department plans to expand its research programs to cover:

1) Raw materials - The Department is interested in the local raw materials of potential use in electrical, electronic, optical and high temperature industries.

2) Applied geophysics in which we seek to locate the probable economic concentrations of minerals. It is hoped that research in this field will be carried out in co-operation with departments of Geology, Makerere University and Geological Survey and Mines, Ministry of Lands, Water and Mineral Resources.

Researchers at Makerere University face two major problems namely:

1) Shortage of academic staff - consequently members of academic staff spend most of their time teaching since they have high teaching loads; thus little time is available for their research obligations.

2) Shortage of funds - this has resulted in shortage of equipment, lack of periodicals and journals which are essential for any research work.

It is hoped that as the general economy improves some of the problems will be overcome and research at the University will play its rightful role.

In conclusion, we see that Physics has played a major role in the development of Uganda and thus its impact is felt in almost all Government Departments, all educational institutions, research organizations and, to some extent, in the industrial sector.

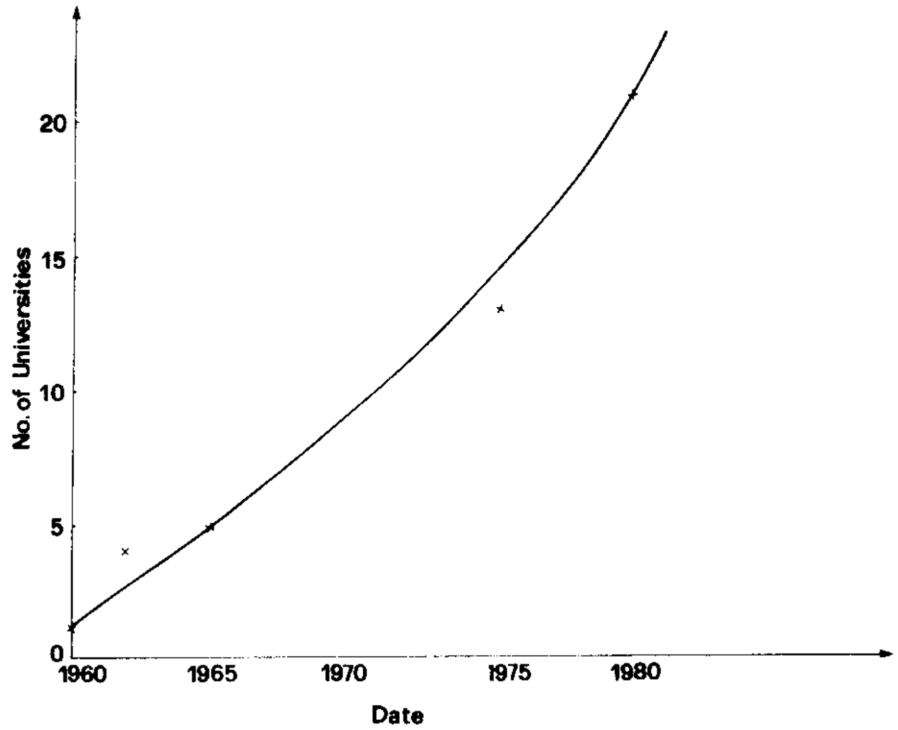

Fig.1 Growth of Nigerian universities

B A N G L A D E S H

SUMMARY OF THE SYMPOSIUM ON THE ROLE OF PHYSICS AND DEVELOPMENT

Held at Dacca, Bangladesh in 1982

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ABSTRACT

This summary shows the present status of physics in the context of research and development in Bangladesh. It is shown that cultivation of physics as knowledge is merely not an intellectual exercise, but also has a great role to play in the socio-economic development in an underdeveloped country like Bangladesh. However, it is regrettable to observe that this role of physics in the overall national development activities is not properly appreciated and implemented.

Background

This symposium was organized by the Bangladesh Physical Society, Bangladesh Atomic Energy Commission and University of Dacca. The idea for this symposium was mooted by the Asian Physical Society and this was very relevant to Bangladesh context in view of the severe difficulties faced in the physics teaching and research in Bangladesh, where activities around agriculture are given topmost priority in development plannings.

The Universities of Dacca, Rajshahi, Chittagong and Jahangir Nagar are entrusted with the physics teaching at graduate and postgraduate levels in the country. Physics in the University of Engineering and Technology and the University of Agriculture are offered as service subjects. The Universities carry out research works as a training programme associated with M.Sc. and M.Phil. degrees and sometime at Ph.D levels. Bangladesh Atomic Energy Commission (BAEC), Bangladesh Council for Scientific and Industrial Research (BCSIR), Jute Research Institute, Central Testing Laboratory, and Forest Research Institute (in addition to the Universities above mentioned) are the important research organizations where research in physics is carried out. The total number of physicists at Universities and Research Organizations would be about 200 in the country; of them about 100 physicists have Ph.D degrees or some foreign training. There was considerable response to the symposium both from home and abroad. About 25 physicists from the nearby countries and from Europe, USA and Japan presented invited talks and contributed papers.

More than 100 physicists from different Universities and Research Organizations participated in the 5-day long symposium held in January 1982. There were 12 sessions in which 24 invited talks and 43 contributed papers were presented on the following topics:

A. Non-conventional energy
B. Physics of materials
C. Physics in agriculture, medicine and industry
D. Recent development in physics.

One may ask about the possible role that physics can play towards socio-economic development in Bangladesh. This is a complicated question to answer. However, in brief this may be put as follows:

1. Keeping abreast of research developments, both basic and applied,
2. Technical manpower development,
3. Transfer and generation of technologies,
4. Creating an environment conducive to the development of science.

It is hoped from the Dacca symposium that it may be possible to assess the successes and failures in realizing the roles that physics could play in Bangladesh.

In this summary we will concentrate on invited papers about Bangladesh perspective hoping that a general picture about research in physics in Bangladesh would emerge.

A. NON-CONVENTIONAL ENERGY

Invited Talks

1. Development of alternative energy in Bangladesh by M. Hossain, Dacca University.

The author stresses the correlation between gross national product (GNP) and per capita energy (commercial) consumption, given in Table I.

TABLE I

Correlation between GNP and per capita energy (commercial) consumption

Country	Per capita GNP in US $ (1978)	Per capita energy (commercial) consumption (78)
Bangladesh	90	43
Burma	150	64
India	180	176
Pakistan	230	172
Sri Lanka	190	109
Thailand	490	327
Malaysia	1090	716

The conclusions from Table I are obvious; increased energy consumption reflects the GNP growth arising from the increase in productive activities. Bangladesh, except the few gas fields and one hydroelectric power supply, has a dismal picture in the availability and possibility for development of conventional energy. The author gives a picture of the activities of physicists engaged in the development of alternative energy in the country (Table II).

TABLE II

A picture of the research activities in the development of alternative energy in Bangladesh

Type of energy	Institution/University
Solar cells	Rajshahi and Dacca Universities
Collector plate	Dacca University and University of Engineering and Technology
Solar cooker	Council for Scientific and Industrial Research
Wind mills	Dacca University and University of Engineering and Technology
Measurements of solar energy	Chittagong and Dacca Universities
Solar stills	Dacca University

2. Physics of Materials for Photovoltaic Solar Energy Conversion by W.G. Townsend, U.K.

3. Solar Energy Research in India by H.P. Garg, India.

4. Photovoltaic Power Generation and Its Application by F. Pfisterer, Federal Republic of Germany.

Contributed papers - Of the 10 contributed papers on solar energy, seven papers dealt with the recent results in this field in Bangladesh.

B. PHYSICS OF MATERIALS

Invited Talks

1. Microstructure of jute fibres by Kh.M. Mannan, Dacca University.

Export of jute fibres and their various products contribute to more than 60% of the foreign exchange earnings by Bangladesh. This fibre is facing serious competition from synthetics. For better performability and diverse use of fibres, microstructural knowledge is very important. This paper reviews the early X-ray photographic studies carried out at the Universities of Dacca and Calcutta. Ths use of wide angle X-ray scattering (WAXS) has recently become prevalent. This talk also presents the author's studies of natural and grafted jute fibres using WAXS in determining crystallinity, crystallite size and lattice distortions. The importance in understanding the physics of the amorphous contents is stressed.

2. Proton Induced X-ray Emission (PIXE) Spectroscopy in Elemental Analysis of Biological Materials and Liquids by A.H. Khan and M. Khaliquzzaman, Bangladesh Atomic Energy Commission, Dacca.

This powerful method for rapid multi-element analysis has been set up recently by the authors at the Dacca Atomic Energy Commission. A variant of this method using external beam has been developed. The application of PIXE in the analysis of biological and liquid samples was illustrated.

3. The Physics of Amorphous Metals by E.H. Brandt, Max-Planck Inst., Federal Republic of Germany.

4. Growth Kinetics and Thickness Distribution of Ultra Thin Oxide Layer in Tunnel MOM, MOS and SOS Devices by G.P. Srivastava, India.

Contributed papers - A total of eighteen papers were presented on the section of materials science; of these ten papers were contributed by local physicists.

C. PHYSICS IN AGRICULTURE, MEDICINE AND INDUSTRY

Invited Talks

1. Medical Physics in Developing Countries by B.H. Brown, U.K.

According to the author medical physics may seem inappropriate to the health care needs of developing countries as it is a high technolgy subject. One major role of a medical physicist within a hospital can be to organize an effective equipment maintenance service as it is vital if services such as radiotherapy diagnostic X-ray and nuclear medicine are to operate.

2. Nuclear Engineering in Medicine and Industry by G.F. Knoll, USA.

This is an important talk in view of the possibility of having one research reactor by Bangladesh Atomic Energy Commission.

3. A recent Development on the Medical and Biological Utilization of Research Reactor by An Shigahiro, Japan.

This has similar importance as Talk No.2.

4. Biomolecular Mass Spectroscopy by Ion-desorption by Bo. Sundqvist, Uppsala, Sweden.

5. University Industry Collaboration by Chatar Singh, Malaysia.

Reasons for lack of collaboration between university and industry in developing countries were discussed. Form of such activities were presented.

6. The Variable Energy Cyclotron at Calcutta and Its Utilization by A.S. Divatia, India.

Contributed papers - There were twelve contributed papers in this group. The important papers were from the group of Prof. M.S. Islam of Dacca University on the electrical stimulation in bone fracture healing and on the piezoelectric and elastic properties of bones.

D. RECENT DEVELOPMENTS IN PHYSICS

Invited Talks

1. Topology and Physics by H.D. Doebner, Federal Republic of Germany.

2. Nuclear Collective Motion and Interaction Boson Model by Akito Arima, Japan.

3. Atomic and Molecular Processes with High Power Lasers by N.K. Rahman.

ROLE OF PHYSICS IN DEVELOPMENT:BANGLADESH PERSPECTIVE

Invited Talks

1. Role of Physics in Development; Bangladesh perspective by M.M. Islam, USA.

The author outlined the important role that physics can play in a country's development activities. Middle level technical manpower in computer technology, data processing, electronics, telecommunications are in high demand. Fields like geophysics, hydrology, require creative and skilled manpower. Both basic and applied research keeps nations aware of new breakthroughs that may trigger technolgical revolutions. It is also very important to appreciate the national vitality that is reflected by the knowledge that local talents are capable of tackling problems that challenge the best minds elsewhere. This gives confidence to the younger generations to face challenging problems on their own.

Cultivation of physics creates environment conductive to the development of science and scientific culture. These are very important in the transfer and generation of technologies.

The author in this article critically reviews the problems, failures and successes in achieving the roles that physics could play in Bangladesh. The universities are suffering from the lack of funds for laboratory and library, deterioration of academic values due to erosion of social values and outside interference, failure to establish research programmes and problems of the teaching community in the country. The total output is about 200 M.Sc. per year plus few Ph.D.'s employment opportunities in scientific fields, teaching and industries have shrunk. At present most of the physics graduates must compromise for jobs in banks and a few jobs in the Bangladesh Atomic Energy Commission.

It is important to appreciate the facilities and future project at BAEC towards realizing any role that physics could play in national development activities. Dacca AEC has an old 3MeV Van de Graaff accelerator, an outdated IBM 1620 computer, a 5000 Cu Co^{60} radiation source and a Medical Centre. There are also medical centres at Chittagong and Rajshahi for diagnosing and treating by radio isotopes and radiations. The Institute of Nuclear Agriculture at Mymensing has introduced two improved varieties of rice IRATOM 24 and 38. Pilot plant at Cox's Bazar is in operation for separating heavy minerals like zircon, rutile, ilminites from beach sands.

BAEC has drawn up an ambitious plan for Savar Complex which when complete would have Institutes of Nuclear Science and Technology (Reactor), Food and Radiation Biology, Electronics and Materials Science, Computer Science and Nuclear Medicine. Finding qualified personnel for these 5 Institutes would be difficult, but when commissioned the Savar Complex of BAEC would play an important role in National development.

The Bangladesh Council for Scientific and Industrial Research (BCSIR) was created to carry on research leading to the use of indigenous materials and consultancy to the use of local materials by industries. BCSIR has three laboratories, Dacca, Rajshahi and Chittagong, respectively. It is questionable to see how far this organization has utilized the facilities offered by physics in realizing their objectives. They have patented some laboratory results, but these did not attract local entrepeneurs. BCSIR never developed into an institution that delivered adequate industrial services. "In R and D only R was done and not D." The Fuel Research and Development Division and the Industrial Physics Division should play vital roles in the development activities if these are adequately manned.

In the concluding section of this talk the author presents the external problems such as:

(a) Inadequate support and commitment from political leaders for science and technology development;

(b) not enough awareness in government planning and implementing agencies that a reasonable degree of technological self-reliance is a prerequisite for economic development and a scientific base is needed for that purpose;

(c) bureaucracy.

2. Physics - The Raw Materials for Development by F.B. Malik, USA.

The author pointed out the strong correlation between GDP and education. Higher education is pertinent to the degree of development. He suggests establishing in Bangladesh an Asian Institute of Technology modelled after MIT.

COMMENTS AND CONCLUSIONS

Partition in 1947 caused serious shortage of trained manpower in the fields of education, science and technology in the erstwhile East Pakistan. Around the sixties a certain amount of activity in science and research could be initiated. The Dacca Symposium showed the potentialities of Physics as a basic science in the national development activities. However, the inputs in science and research since the creation of Bangladesh are negligible and have never reached the critical point. If things are allowed to continue like this, there is the possibility of entering into another dark era for intellectual and scientific activities that this country faced after partition. Research activities in Physics in Bangladesh suffer from lack of group formation, leadership and inadequate understanding with national economic activities. The present symposium aimed at creating consensus and impress upon the planners, bureaucrats and above all politicians the role of science and technology in socio-economic development.

ACKNOWLEDGMENTS

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21 June - 10 September 1982

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ON

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Jeofizik Mühendisligi
Yerbilimleri Fakültesi
Istanbul Universitesi
Bayazit
Istanbul
Turkey

4. AHOSE, M.K. — Togo
Institut National de la Recherche Scientifique
B.P. 2240
Lome
Togo

5. ALKATIRI, M.A. — Indonesia
Department of Geophysics & Meteorology
Institut Teknologi Bandung
Jl. Ganeca 10
Bandung
Indonesia

6. AL-NAJIM, F.A.L. — Iraq
Department of Physics
College of Education
Baghdad University
Baghdad
Iraq

(Severe meteorological phenomena, e.g. heat waves, dust and thunderstorms, and possible extratropospheric causes)

Name and Institute | Member State

ANDRIAMAHEFAMANANA, A. — Madagascar
Ministère de l'Industrie et du Commerce
Direction des Mines et de l'Energie
Service des Mines et de la Géologie
Tananarive
Madagascar

(Geomagnetism, gravity, seismic, resistivity for the geophysical surveys for mineral exploration)

AQUINO, E.M. — Philippines
Philippine Atmospheric, Geophysical and Astronomical Services Administration
1424 Quezon Avenue
Quezon City
Philippines

ARAFIN, S. — Malaysia/Bangladesh
School of Physics
Universiti Sains Malaysia
Minden
Pulau Penang
Malaysia

(Construction of a total field fluxgate magnetometer. Mathematical models for the representation of the geomagnetic field)

BAISA, A. — Ethiopia
Geophysical Observatory
Addis Ababa University
Box 1176
Addis Ababa
Ethiopia

BALCIOGLU, O. — Turkey
Geophysical Department
Faculty of Earth Sciences
University of Istanbul
Bayazit
Istanbul
Turkey

(Geomagnetism and Ionosphere)

BARAL, K.N. — Nepal
Department of Physics
Amrit Campus
Lainchour
Kathmandu
Nepal

(Atmospheric electricity)

Name and Institute	Member State
13. BARBARA, A.K. Department of Physics Gauhati University Guwahati - 781 014 India (Fundamental studies of magnetosphere and ionosphere and troposphere by ionosonde and satellite radio beacon)	India
14. BHATTACHARYYA, A. Indian Institute of Geomagnetism Colaba Bombay - 400 005 India (Geomagnetic variations due to equatorial electrojet. Study of equatorial ionosphere using ionospheric scintillations)	India
15. BICSKEI, T. Geomagnetski Institut 11306 Grocka Yugoslavia (S.V. of geomagnetic field. Numerical methods of prediction for the state of ionosphere)	Yugoslavia
16. BUKHARI, A.H.S. Institute of Physics and Technology University of Sind Jamshoro Pakistan	Pakistan
17. BUSTAMANTE, A.G. Department of Physics & Mathematics Universidad Nacional Tecnica del Callao Apartado 138 Colina 310 Callao 02 Peru (New mathematics models in this field to apply to new research work)	Peru
18. CASTANON-GOMEZ, W. Department of Geophysics Universidad Mayor de San Andres Plaza del Obelisco P.O. Box 5368 La Paz Bolivia	Bolivia

Name and Institute	Member State
19. CHAIMONGKOL, C. Department of Physics Srinakharinwirot University Prasarnmitr Bangkok Thailand (Physical properties of ionosphere)	Thailand
20. CHARGOY ESPINOLA, L.D. Instituto de Geofisica Circuito Exterior Ciudad Universitaria, UNAM 04510 Mexico, D.F. Mexico (Mathematical modelling of the main geomagnetic field, study of periodic components of secular variation)	Mexico
21. CHOUDHURY, A.M. (Associate) Bangladesh Space Research and Remote Sensing Organization (SPARRSO) Agargaon, Sher-e-Bangla Nagar G.P.O. Box No. 529 Dhaka Bangladesh (Atmospheric physics and solar terrestrial physics)	Bangladesh
22. DAS, I.M.L. Department of Physics Banaras Hindu University Varanasi - 221 005 India (Ionospheric and magnetospheric physics. Jovian ionosphere and magnetosphere)	India
23. DE PAULA, E.R. Instituto de Pesquisas Espaciais C.P. 515 12 200 Sao José dos Campos - S.P. Brazil (F-region response to magnetic storms. HF radio propagation in ionosphere. Ionospheric models using computers. CCIR predictions.)	Brazil

24. DUZGIT, Z. Turkey
Department of Geophysics
Faculty of Earth Sciences
University of Istanbul
Istanbul
Turkey

(Moderate deep conductivity of the earth. Electromagnetic induction. Tectonomagnetism.)

25. EL-HADJ TIDJANI, M. Benin
Faculté des Sciences et Techniques
Université Nationale du Bénin
B.P. 526
Cotonou
Rép. Pop. du Bénin

(Plasma and Geophysics)

26. EMANDE, F.T. Papua New Guinea
Applied Physics Department
University of Technology
P.O. Box 793
Lae
Papua New Guinea

('b' values of earthquakes in P.N.G. area)

27. ESHUN-DADZIE, P. Nigeria/Ghana
School of Physical Sciences
University of Port Harcourt
Port Harcourt
Rivers State
Nigeria

(Structure and properties of permanent magnets. Effects of terrestrial magnetic and electric fields on soil fertility.)

28. FERNANDEZ, W. Costa Rica
School of Physics
University of Costa Rica
San José
Costa Rica

(Severe convective storms. Physics of the upper atmosphere.)

Name and Institute Member State

29. FUBARA, D.M. (Associate) Nigeria
(Present)
Institute for Flood, Erosion, Reclamation and Transportation
University of Science and Technology
P.M.B. 5080
Port Harcourt
Nigeria

(Permanent)
Department of Surveying and Geodesy
University of Nigeria
Enugu
Nigeria

(Geodesy and satellite technology applications to earth and ocean physics, navigation and mapping)

30. GHALEB, A.F. Egypt
Department of Mathematics
Faculty of Science
Cairo University
Giza, Cairo
Egypt

31. GURUNG, S. Nepal
Department of Physics
Tribhuvan University
Kirtipur Campus
Kathmandu
Nepal

(Ionosphere and its application in radiowave propagation)

32. HADONOU-YOVO, C. (Associate) Benin
Laboratoire de Geophysique (FA.S.T.)
U.N.B.
B.P. 526
Cotonou
Rép. Pop. du Bénin

33. HANUMATH SASTRI, J. India
Indian Institute of Astrophysics
Sarjapur Road
Bangalore - 560 034
India

(Solar-terrestrial physics. Equatorial aeronomy of geomagnetism.)

34. HAQUE, M.M. (Associate) Bangladesh
Department of Physics
Rajshahi University
Rajshahi

Name and Institute	Member State

35. HASSAN, H.A.Z. (Associate) — Egypt
Department of Mathematics
Faculty of Science
Cairo University
Giza, Cairo
Egypt

36. HOSSAIN, M.M.A. (Deceased 24 October 1982) — Bangladesh
Applied Physics and Electronic Department
Rajshahi University
Rajshahi
Bangladesh

37. JACKSON, J.S.G. — Ghana
Department of Mathematics
University of Ghana
Legon
Accra
Ghana

(Geomagnetism and Astrophysics)

38. JANVE, A.V. — India
Department of Physics
Saurashtra University
Rajkot - 360 005
India

(Ionospheric irregularities. Studies with VHF satellite beacons. Interplanetary scintillations and solar wind plasma. Electrodynamic compting of high and low latitude ionosphere.)

39. KAKANE, V.C.K. — Nigeria/Ghana
(Present)
Department of Physics
College of Education
P.M.B. 1017
Uyo, Crs
Nigeria

(Permanent)
Department of Physics
University of Ghana
Legon
Accra
Ghana

(Scintillation. Total electron content measurements. Computer programming.)

40. KHALIL, F. (Associate) — Bangladesh
Department of Mathematics
Rajshahi University
Rajshahi

Name and Institute	Member State

41. KILICKAYA, M.S. (Associate) — Turkey
Devlet Mühendislik ve Mimarlik Akademisi
Eskisehir
Turkey

(Solar radiation and the atmosphere. Effect of atmospheric turbulence in radio propagation.)

42. KIPTUI, D.K. — Kenya
Department of Physics
Kenyatta University College
P.O. Box 43844
Nairobi
Kenya

(Geomagnetism and aeronomy. Determination of behaviour of electric currents in the ionosphere over East Africa.)

43. KOLAWOLE, L.B. — Nigeria
Department of Physics
University of Ife
Ile-Ife
Nigeria

(Ionosphere - radio propagation in the Tropics)

44. KUNARATNAM, K. — Sri Lanka
Department of Physics
University of Jaffna
Thirunelvely
Jaffna
Sri Lanka

45. LEE, J. — Korea
Department of Geological Sciences
Seoul National University
Seoul 151
Korea

(Geomagnetism)

46. LUMB, H.M. — Kenya/India
Department of Physics
University of Nairobi
Box 30197
Nairobi
Kenya

(F-region model studies)

47. MADHUSUDHANA RAO, A. — India
Department of Meteorology & Oceanography
College of Science and Technology
Andhra University
Waltair 530 003
India

(Atmospheric electric parameters. Inter-relations of Earth's atmospheric electric parameters. Ionosphere.)

48. MAHMUTCEHAJIC, R. — Yugoslavia
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Marsala Tita 72/1
71000 Sarajevo
Yugoslavia

49. MEDEIROS, J.R. — Brazil
Departamento de Fisica Teorica
e Experimental
CCE - UFRN
Campus Universitario
59.000 Natal - RN
Brazil

(Ionospheric scintillation. Ionospheric irregularities and bubbles. Faraday rotation. Radio studies of the ionosphere. Dynamo theory.)

50. MEDEIROS, R.T. — Brazil
D.F.T.E.
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59.000 Natal - RN
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(Ionospheric scintillations. Studies of equatorial spread by ionograms. Total electronic content response to magnetic storm.)

51. MELONI, A. — Italy
I.N.G. Osservatorio Geofisico
Monte Porzio Cantone
00040 Roma
Italy

(Magnetospheric physics. Geomagnetic influence on man-made systems. Geomagnetic depth sounding. Geomagnetic observatory data analysis.)

58. OROZCO TORRES, A.L. — Mexico
Instituto de Geofisica
Circuito Exterior
Ciudad Universitaria, UNAM
04510 Mexico, D.F.
Mexico

(Secular variation studies by means of harmonic analysis. Generation of magnetic pulsations and detection at low latitudes. Operation of magnetic observatories.)

59. OSEMEIKHIAN, J. — Nigeria
Department of Physics
University of Lagos
Yaba, Lagos
Nigeria

(Geomagnetic variations and numerical modelling of electrical conductiving anomalies)

60. OZALP, N. (Affiliate) — Turkey
Faculty of Basic Sciences
Karadeniz Technical University
Trabzon
Turkey

61. QAISAR, M. — Pakistan
PINSTECH
P.O. Nilore
Rawalpindi
Pakistan

62. RAHMAN, M. — Bangladesh
Department of Physics
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Bangladesh

63. RATNASIRI, P.A.J. — Sri Lanka
Ceylon Institute of Scientific and
Industrial Research
P.O. Box 787
Colombo
Sri Lanka

(Radiowave absorption and D-region modelling)

52. MOREIRA, A.A. — Portugal
Centro de Electrodinamica da
Universidade Tecnica de Lisboa
Instituto Superior Tecnico
1096 Lisboa - Codex
Portugal

(Wave particle interactions. Whistler mode propagation in hot plasmas. Oblique whistler wave stability in the magnetosheath region.)

53. MUNOZ, M. (Associate) — Chile
Departamento de Geologia y Geofisica
Universidad de Chile
Casilla 2777
Santiago
Chile

(Geophysical exploration for geothermal resources. Terrestrial heat flow problems.)

54. MURTAZA, G. (Associate) — Pakistan
Department of Physics
Quaid-i-Azam University
Islamabad
Pakistan

(Plasma physics [plasma transport and zero frequency modes; non-linear interaction of tearing modes, etc.])

55. NAMASIVAYAM, S. — Sri Lanka
Department of Physics
University of Colombo
Colombo 3
Sri Lanka

(Effect of conductivity anomalies and ionospheric effects on the polarization of geomagnetic micropulsations)

56. NARASIMHA SWAMY, G. (Associate) — India
Department of Geophysics
Andhra University
Waltair
Visakhapatnam - 530 003 (A.P.)
India

57. OKE, G. — Turkey
Department of Physics
Middle East Technical University
Ankara
Turkey

Name and Institute | Member State

64. SAFI, D.G. — Afghanistan
Department of Hydrometeorology
Faculty of Geoscience
University of Kabul
Kabul
Afghanistan

65. SAGBOHAN, W.O. (Associate) — Benin
Section de Physique
Faculté des Sciences et Techniques
Université Nationale du Bénin
B.P. 526
Cotonou
Rep. Pop. du Bénin

66. SAGHARY, G.A. — Afghanistan
National Science Center
Ministry of Education
Kabul
Afghanistan

67. SAMARASEKERA, U.P. — Sri Lanka
Department of Physics
University of Kelaniya
Dalugama
Sri Lanka

(Investigation of ion recombination rates in the F-region)

68. SAROSO, S. — Indonesia
Indonesian National Institute of
Aeronautics and Space
Aerospace Research Center
Jl. LL.R.E. Martadinata 166
Bandung
Indonesia

(Ionospheric research, in the field of radio wave propagation, absorption and drift measurement)

69. SARYONO — Indonesia
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Jl. Ganeca 10
Bandung
Indonesia

SENANAYAKE, W.E. — Sri Lanka
Department of Physics
University of Peradeniya
Peradeniya
Sri Lanka

(Study of geomagnetic field fluctuations near the magnetic equator, passing through the northern part of Sri Lanka)

71. SHENDY, E.H. — Egypt
Department of Geology
Suez Canal University
Ismailia
Egypt

(Geomagnetism and seismic exploration)

72. SHRESTHA, N.P. — Nepal
Dharan Campus
Tribhuvan University
Hattisar
Dharan
Nepal

(Irregularities in the ionosphere and the field strength measurement for the N-S and E-W propagated radio wave)

73. SOEGENG — Indonesia
Department of Physics
Institut Teknologi Bandung
Ganesha 10
Bandung
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(Ionospheric physics and radio wave propagation)

74. STEPHANOU, G.J. — Greece
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Department of Physics
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Solonos Street, 104/144
Athens
Greece

(Propagation of HF electromagnetic waves in the ionosphere. Ray-tracing in representative models of the equatorial ionosphere for the simulation of a long-range transequatorial circuit)

75. SULE, P.O. — U.K./Nigeria
(Present)
Department of Geophysics
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Edinburgh EH9 3JZ
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(Permanent)
School of Basic Studies
Ahmadu Bello University
Zaria
Nigeria

(Electromagnetic induction)

76. TELLERIA, J.L. — Bolivia
Instituto de Investigaciones Fisicas
Universidad Mayor de San Andres
La Paz
Bolivia

(Geomagnetism observatories and paleomagnetism studies in connection with plate tectonics)

77. TOLBA, M.F. — Egypt
Department of Physics
Faculty of Science
Ain Shams University
Abassia, Cairo
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(Cosmic rays - interaction of cosmic rays with geomagnetic field; modulation of cosmic rays in the interplanetary space)

78. TWESIGOMWE, E.M. — Uganda
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Kampala
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(Geomagnetism, especially methods of observations and interpretation of data obtained)

79. VIMOLVANICH, S. (Associate) — Thailand
Central Campus at Prasarnmit
Srinakharinwirot University
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Bangkok 11
Thailand

Name and Institute	Member State
80. WANG, SHUI Department of Earth and Space Science University of Science and Technology of China Hefei Anhui 230029 People's Republic of China (Magnetosphere, radio propagation, including whistlers and VLF emissions)	People's Republic of China
81. WANG, ZHEN-SONG Institute of Electronics Academia Sinica Peking People's Republic of China (Radio wave propagation in ionosphere and wave tunneling through a barrier)	People's Republic of China
82. ZOLESI, B. I.N.G. Osservatorio Geofisico Monte Porzio Cantone 00040 Roma Italy (Ionospheric physics and ionospheric radio communication forecasting, magnetospheric physics)	Italy