A WINDOW OPEN ON THE WORLD

The UNESCO Courier

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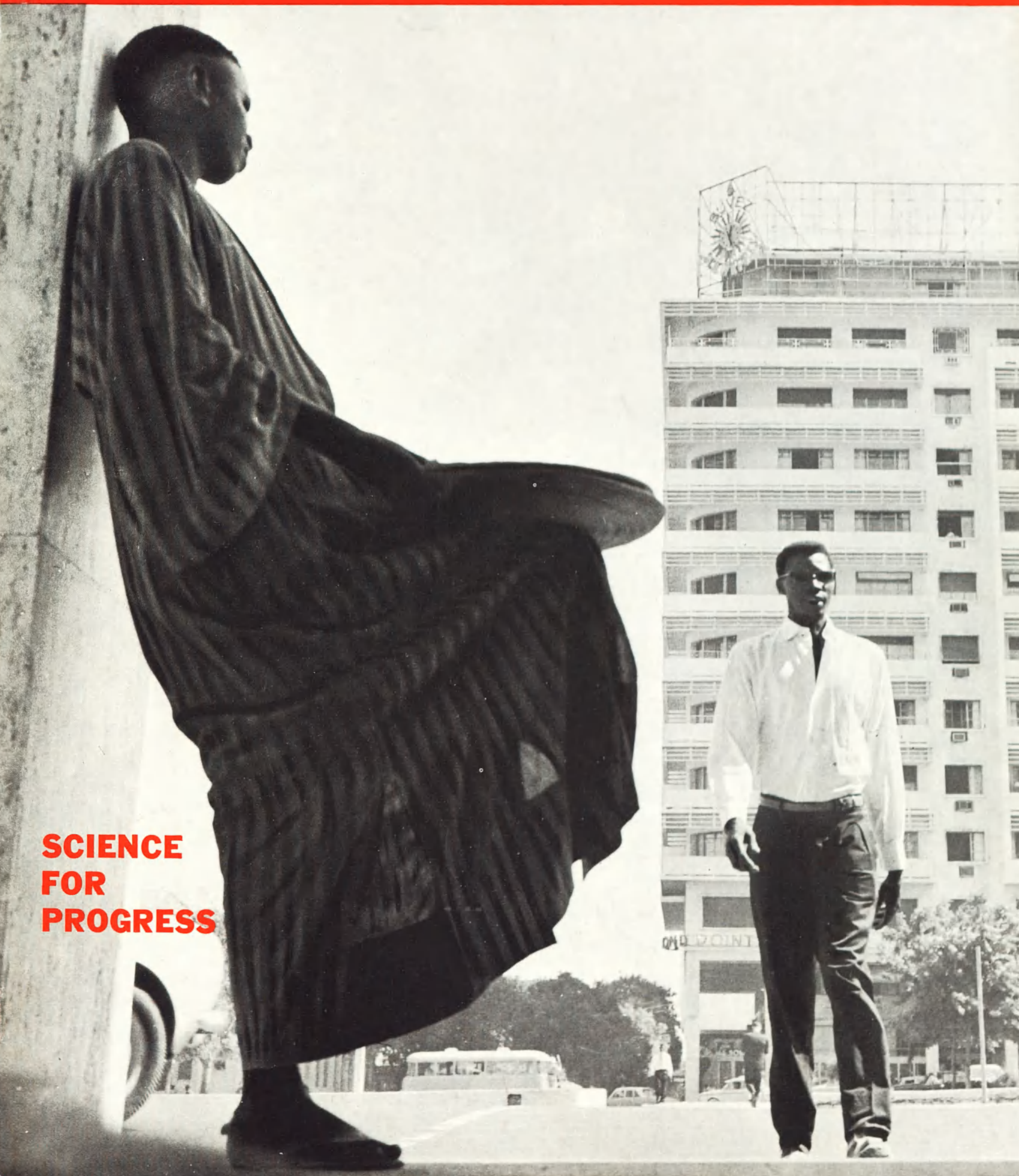

SCIENCE FOR PROGRESS

CSF - Georges Bru

ELECTRONIC INFRASTRUCTURE

Suggesting an ultra-modern artistic composition, this "tableau" is nothing more than tiny wires and metal plates which are components of that versatile electronic device, the transistor. Replacing to a large extent radio valves, transistors are smaller, use less power and have no filaments to burn out. Their use has brought a great many revolutionary changes in the control and operation of innumerable branches of modern industry and technology. (See other photos, page 62)

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COVER PHOTO

Meeting on a street in Dakar, Republic of Senegal, these young men, one a university science student, the other a peasant youth who has never been to school, symbolize two sharply-contrasting aspects of life today in developing lands.

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Science for Progress

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WORLD

by Ritchie Calder

Last February the United Nations brought together at Geneva probably the world's greatest assembly of scientists to discuss the application of science and technology for the benefit of the less developed areas. This double issue is based in major part on material from these discussions. In the special article below Ritchie Calder, winner of Unesco's Kalinga Science Prize (1961) highlights the work of the UNCSAT conference and its implications for the new nations tomorrow. He is now completing a full-length analysis of the meetings, shortly to appear under the title "World of Opportunity" as Volume I of an 8-volume condensation of the UNCSAT conference to be published later this year by the United Nations.

THERE are plenty of new flags fluttering at the mast-heads. When the United Nations was created in 1945, there were fifty-one members. Now there are one hundred and eleven and of those forty-six are countries which have won their independence in the meatime.

But flags are not enough. Political freedom is an exhilarating experience, but there is the morning after the celebrations when peoples are likely to wake up and find that freedom has been robbed of much of its meaning; they are just as hungry, just as sick, just as impoverished. They have the pride of nationhood but are deprived, by squalor and hardship, of human dignity. They have an equal vote in the assembly of the nations but they suffer the inequality of unshared abundance.

This is the contradiction of the modern world. At one and the same time, there has been the "revolution of rising expectations," of which political freedom is only part-fulfilment, and the scientific and technical revolution which has increased the prosperity of the advanced countries and has widened the gap between them and the less-developed countries.

From the peasant in the paddy-field to the astronaut

As Professor M. S. Thacker, in his presidential address to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, reminded the world: "One tenth of the peoples of the world enjoy 60% of the world's income, while 57% of them have less than 10% of that wealth at their disposal. If present trends are to continue, the gulf between the poor and the rich countries will widen still further and this at a time when great continents have awoken to freedom and their populations are clamouring for certain minimum standards of life... Prosperity, like peace, is indivisible."

The gap is as wide as the vertical 200 miles which separate the peasant, wading in the wet paddy-field transplanting rice stem by stem, from the astronaut, circling the planet Earth which 3,000,000,000 human beings have to share; between the muscle-efforts of the poor and the supreme achievements of modern science; and between those who lack science and technology and those who have them.

OF OPPORTUNITY

The closing of this gap was the "categorical imperative" of the injunction of U Thant, United Nations Secretary General, to the 1,655 participants at the science and technology conference at Geneva. Ironically, the roll-call of that conference displayed the gap; the numbers of delegates from the advanced countries were four to one of those from less-developed countries, representing two-thirds of the world's population; their governments just could not afford to send more than one or two delegates; fourteen could not send any.

A meeting of minds without precedent

Apart from its size and the 10,000,000 words which "went into the record," this conference was exceptional. It was not one more of those 1,500 scientific conferences which are held every year and at which scientific specialists discuss the details of their specializations. It was a public "stock-taking" not only of the goods which science has to offer in what Professor P. M. S. Blackett called "the supermarket of science," but of the cupboards, meagre in the essentials of human existence, of the less-developed countries. It was a venture in a new dimension of discussion—not just the laying out of facts but a consensus of human aspirations.

No one had to be reminded of what science is capable of doing—the release of atomic energy and the circling satellites (57 when the conference opened) were proof of what Thinking Man can do when he sets his mind to it. There were no bitter recriminations; political considerations, while not entirely absent, were muted. There was a certain amount of finger-wagging, of professorial cautioning about not attempting too much but also salutary reminders about the dangers of doing too little.

There was, to begin with (because it was a conference without precedent), a tendency to over-formalize the discussions but that quickly broke down under protest and perhaps more mental business was transacted outside the sessions than in them, in the lobbies, and in the bars of the Palais des Nations. And in a real sense the delegates fullfilled their function of being, in Professor Thacker's phrase, "the ambassadors of the needy and the spokesmen of the tongue-tied."

As Academian E. K. Fedorov said, the range of items was "encyclopædic." Governments had been asked to submit papers as well as to send delegations and, in advance of the conference, over 4,000 papers were sent in, from which, with political as well as scientific tact, the scientific secretariat had to reject 2,000; the number of papers eventually presented to the conference was 1,849. If all the transactions, totalling 10,000,000 words, were to be published, they would fill 80 volumes. Instead, one of the post-conference tasks was to distill from all this material eight "working" volumes (1), each self-sufficient as a

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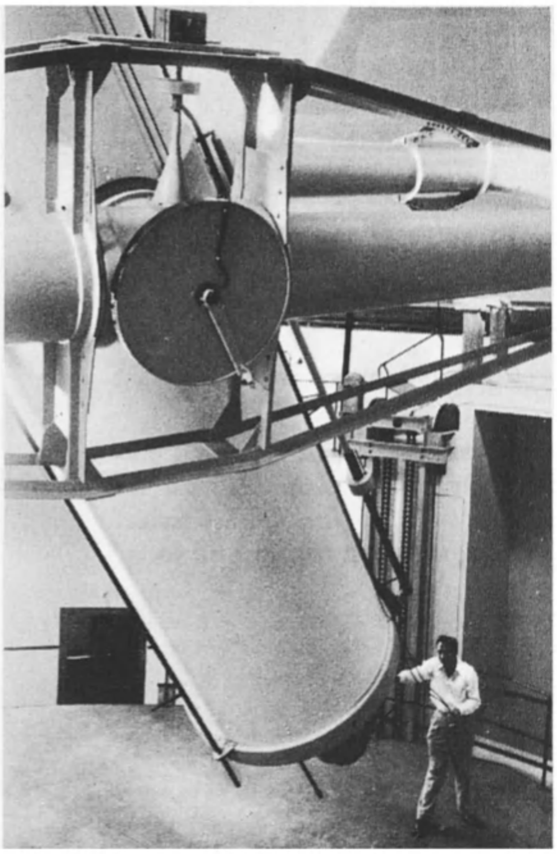
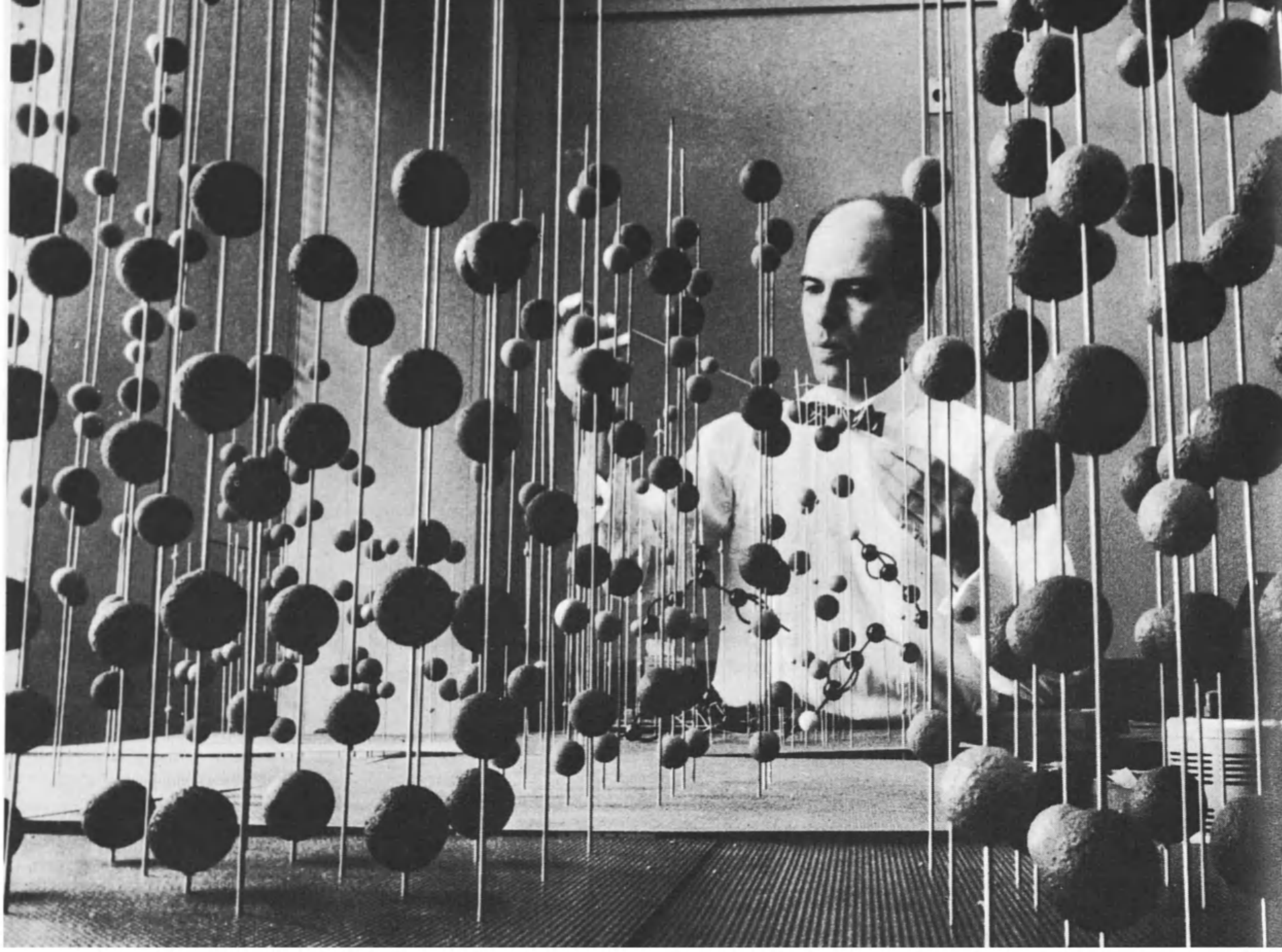


Unesco. - Pierre A. Pittet

The Bosscha Astronomical Observatory, close to Bandung in Indonesia, has been equipped, partly through a Unesco contribution, with twin telescopes, one intended for visual and the other for photographic work. Because they are situated seven degrees south of the equator, the observatory's telescopes are well-placed for studying certain constellations such as the Milky Way.

(1) 8-*volume series, "Science and Technology for Development": I. A World of Opportunity; II. Natural Resources; III. Agriculture; IV. Industry; V. People and Living; VI. Education; VII. Science and Planning; VIII. Plenary papers and Index.*



This "forest" of multi-coloured cork balls is a research laboratory scale model (100 million to 1) of an atom compound showing its crystal structure. To obtain the information they needed to build this model, research chemists first studied the direction and intensity of X-ray beams diffracted by a crystal. From research like this much has been learned about the internal structure of matter.

WORLD OF OPPORTUNITY *(Cont'd)*

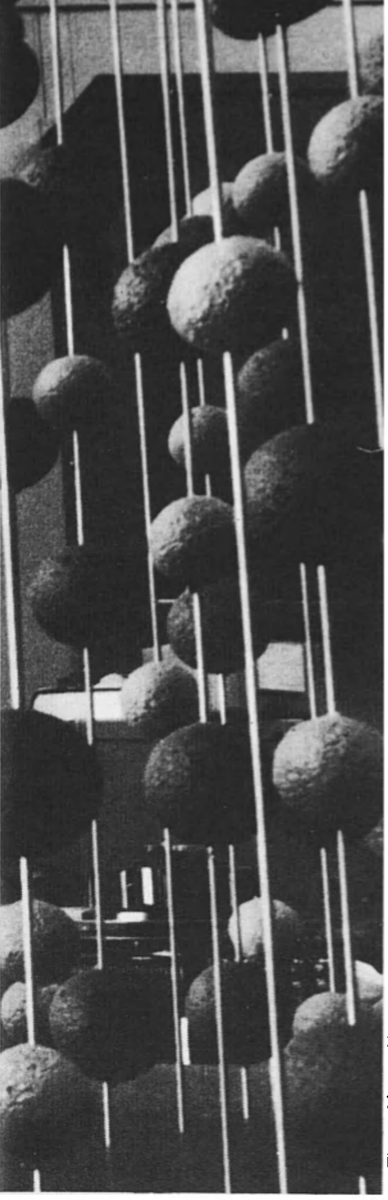
subject, so that men of affairs could comprehend and, more important, act upon the useful suggestions.

There were 96 sessions in sixteen days—three plenary sessions in which outstanding and understanding personalities could survey the problems and set up the signposts for The World Development Decade, as the U.N. General Assembly designated the 1960s; 12 general sessions, covering cognate subjects; and 81 specialized sessions.

A host of unexpected answers from the computer

At the instigation of the President, three other special sessions were arranged so that the representatives of the less-developed countries could canvass their general problems. Even that was not enough; the chairmen of the various sessions organized twenty-three extra meetings so that they could go into more detail. And—just to show how desperately in earnest the participants were—an extra-curricular service that no one had planned sprang into existence. Experienced conference-goers became the "hosts" for the hesitant and made it their job to introduce them to those who had the answers for which they were looking.

The result was a friendly "clubbing"—little groups getting together in alcoves



© Three Lions, New York

or private rooms. And it was not a one-way traffic; the "teachers" became the "taught," because they learned from the representatives of less-developed countries a great deal that is not in the text-books. In winding-up, Professor Thacker compared the conference to a computer into which a great amount of information had been fed and a lot of unexpected answers had come out.

It was, in truth, a conference without precedent but, then, the circumstances were unprecedented. Historically one might think of The Age of Reason at the end of the Eighteenth Century when there was a similar ferment of freedom, with the coming into existence of the United States, with the French Revolution, with Voltaire, Rousseau and Tom Payne and with the "encyclopædists" trying to encompass and disseminate the knowledge of their times. And all of it coinciding with the invention of the steam-engine which gave a new power to the Industrial Revolution. If, as in the case of the Geneva Conference of 1963, there had been a coming together of those two forces, of aspirations and of material change, how different would history have read today.

There was, in the Geneva Conference, this sense that it was changing human destiny. It could not be otherwise. Science and technology has become the social dynamic of our times. While reminding the leaders of the emergent nations that they were inadequately informed of the scientific advances which would give the maximum content to political freedom, U Thant, in his message, had this challenge to offer:

"Science today is on trial because of the vastly increased power it has given to the forces of war and destruction to the point that, for the first time, humanity may be threatened with instant and total annihilation but equally because, in its boldest and most far-reaching experiments science seems to have lost contact with society. Its processes have at times become so involved in mathematical abstraction and its preoccupations centred on areas so remote from daily life, that to the common man the scientists may appear today to live in a secluded world of their own. In some way, science must be made to remain aware of its human origin and human destination."

No more foundling on the doorstep of society

The scientists accepted that challenge. By their very presence in such numbers, they had accepted the fact they had social obligations and must no longer be prepared to leave their discoveries like foundlings on the doorstep of society with no responsibility for their upbringing. But speaker after speaker made this explicit in such phrases as:

"No one can deny that the scientist has become a man of power and influence in the twentieth century. Whether he likes it or not, he has obtained a high place in decision-making." (Thacker, India.)

"Science is a supra-national activity, for its truths recognize no political boundaries." (Bernardo Houssay, Argentine.)

"For far too long has the scientist lived in an ivory tower of his own creation. For far too long he lived the captive life of the djinn of Aladdin's Lamp. He must change his own attitudes before he can ever see the goal of world development fully realized." (Abdus Salam, Pakistan.)

"We, scientists who have each of us embarked on vessels over which we have no control, have at least the right and the duty of saying publicly that in aiding the under-developed countries, the industrialized countries should not only give away their superfluity or their surpluses but should be ready to deprive themselves and give until it hurts." (Henri Laugier, France.)

"Today, when science is exerting enormous influences on life, scientists appreciate their responsibility for the way their knowledge is being applied." (Fedorov, U.S.S.R.)

This, however, was not just a conference of soul-searching but of life-giving. In the twelve sections of the Conference, problems were examined on the most prosaic as well as the most profound levels. In purely material terms,

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countries are underdeveloped because full use has not been made of their natural resources. More often than not, they do not know what natural resources they possess and a great deal of practical consideration (and advice) was given about how those resources should, by modern techniques, be found, charted and made use of.

One of the most critical discussions in this section was on river basin development. Agriculture, rightly in a hungry world, had more papers than any other subject. Industry in all its aspects was examined, with the recognition, continually emphasized that, however preoccupied with increasing its farm yields, no country can enjoy complete independence unless it has a developed industry.

Charting and using a nation's natural resources

Transport and communications are indispensable to "getting a country on the move." Health, nutrition, housing, rural and urban development, were examined and exemplified, with the recurring warnings to avoid the mistakes of the older industrialized countries and reminders that development is not an end in itself but a social purpose.

Planning, it transpired, is no longer a suspect word with ideological inflections. This was one of the most important of all the sections, not only in terms of economic planning but especially of the planning of science and its direction to the needs of countries. Permeating and to some extent dominating all sections was the need for education and the sharing of knowledge and skills and how this is to be done, in terms of international collaboration and new techniques, as the most urgent follow-up of the conference. In this, UNESCO's role, as in the promotion of science for development, was obvious and accepted.

Perhaps the most significant, indeed revolutionary change in thinking was the recognition of the need for "investment in human resources." This is basic to all U.N. thinking and has been embodied in all the work of all the specialized agencies. But here was the recognition that the true "infrastructure" is not that of conventional economics—the building of ports, railways, roads, etc. as a precondition of industrial development, "the gravitational flow of capital." Instead, it is not only "human resources," but "human resourcefulness" which matters. A healthy, better fed, better educated population can hasten everything else. In addition to being the "social beneficiaries," human beings become the economics factors in their own prosperity.

The rising expectations that cannot wait

"Hasten" is the operative word. People are now impatient to give material meaning to their freedom. Delay, as the Geneva Conference insisted, means a worsening of the disparity between the rich and poor—"a slum at the bottom of the rich man's garden," as the President put it.

We are trying to telescope time. Britain, first off the mark in the Industrial Revolution, has the benefits of 200 years of industrialization; Western Europe, of 150 years; the U.S.A., of 100 years; Japan, of 80 years; Russia, since the Soviet Revolution, of 40. If the less-developed countries have to wait 40, those "rising expectations" will be deferred until the twenty-first century. Science and technology, shared and with means to make their possibilities real, can compress the calendar. The World Development Decade, with the Geneva Conference to give it its head-force, is under way.

The University of Ibadan in Nigeria is one of the most modern in Africa. Some 2,000 students attend its faculties: Science, Agronomy and Veterinary Science, Economic and Social Sciences, Letters and Medicine.

Two movements dominate the life of our age. One of these is the growth of knowledge. Vast conceptual changes, new terms for the understanding and definition of nature, have gone hand in hand with spectacular technological results. Man is now clothed with a power which he never previously held—to generate and control energy; to fructify land; to conserve and utilize water; to combat disease; and to draw mankind together in close and constant accessibility.

Together with the growth of knowledge we have celebrated the growth of freedom. The movement of scientific progress has been accompanied by an intense movement of national liberation. More than fifty states, most of them in Africa, have added their flags to the international family within the past two decades.

Fifteen years ago a quarter of the world's population lived in colonies and dependent territories under the rule of imperial powers. Today the emancipation of Asia is almost complete. In Africa the family of independent states has grown from three to thirty-three. All but a few of the 230 million Africans have achieved their sovereignty or are negotiating for its early attainment. Multitudes are newly embarked on the adventure of freedom with its pitfalls and hazards—but also with its deep, enduring satisfactions.

If constitutional freedom could itself guarantee welfare and equality we should now be celebrating mankind's golden age. But in the awakening continents political freedom has not been attended by a parallel liberation of peoples from their social and economic ills. Behind the new emblems of sovereignty millions continue to languish in squalor, illiteracy and disease. Men awaken to learn that they may be free in every constitutional sense and yet lose the essence of their freedom in the throes of famine and want. As the political inequality between nations passes away, a new inequality comes to the fore. It is the inequality between those who inherit the new abundance and those who can only look in upon it from outside.

Now the United Nations conference on the application of science and technology for the benefit of the less developed countries has sharply revealed the extent of the gulf separating those two worlds. In the advanced countries the average per capita income varies between $900 in Europe and $2,500 in North America. In most countries of Asia and Africa it is $50 to $100. In advanced western countries the average life expectancy has reached 68 to 71. In the undeveloped areas it stands between 29 and 39.

In the west industrialization goes forward with swift momentum. In most of the new states it is impeded by the lack of basic technical skills, of power and transport, and of the social and economic infra-structure necessary

FREEDOM WITH KNOWLEDGE

by Abba Eban

'Why are you free? To realize your dreams.' These words are engraved beside this striking mosaic, the work of the Ecuadorian artist, Guyasamin, which decorates one of the Faculty buildings of the University at Quito, Ecuador.
© Holmes-Camera Press

for a technological society. Natural resources are abundant but not developed. The lack of momentum in the educational movement prevents a wider acquisition of technical skills. Debilitating diseases continue to enfeeble the people and set a limit to production. At the same time the expansion of welfare in the advanced countries is swift and headlong. And the gap is becoming wider, with the science and technology of the advanced countries increasing it dynamically year by year. Meanwhile the pressure of population on resources grows more intense.

The disparities in achievement between the advanced and the developing states do not arise from any inherent inequalities in moral and intellectual capacity. Nothing has been achieved by Europe and America of which Africa and Asia are intrinsically incapable. Indeed, if a conference similar to this had been convened some centuries ago, the east would have been defined as the advanced world, the west as the backward region. The truth is that since the scientific revolution began, one part of humanity has been cut off from contact with processes of thought and action which have endowed another part of humanity with the elements of its power.

It might seem that all we need to do is to "export" science and technology from countries in which it is abundant to countries in which it is scarce. Such an easy formulation would distort the truth. Science is a plant which can only grow in certain conditions of social climate and economic soil. It cannot be transferred fully grown. Science is not a monopoly of any social system. It has flourished both in capitalist and in socialist societies. It has prospered in big states, but some of its most eminent representatives and institutions have arisen in small communities. Nevertheless, it is a tree that will only grow in a society which possesses a vision of development, which allows freedom for the creative imagination, and in which education, the pursuit of scientific truth and the penetration of the spectacle of nature are held in profound respect.

Every state, however poor and small, can train enough of its citizens to ensure its own entry into the domain of scientific thought and action. Indeed, the prolonged exclusion of any state from that world is compatible neither with its national dignity nor with its economic and social progress. But the narrowing of the gap between advanced and developing states requires international action going far beyond scientific advice and technical training.

There must be a vast increase in the flow of capital available for developing states. Some of us have joined in calling attention to the improbability of such an increase so long as 150 billion dollars and untold efforts by scientists and technicians are spent annually on the

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Standing on a new threshold

arms race. Even if our hopes in this direction are not fulfilled, something can be achieved by a more logical system of human priorities in the world's scientific effort. How is it possible to justify the expenditure of tens of billions of dollars in prestige projects in outer space, when there is hunger, disease and illiteracy on this planet where the human condition stands to be determined for good or ill? Is it our business to invade the moon or to save the earth for our common humanity?

The advanced states and the international agencies should regard this problem as having a higher priority than it has hitherto enjoyed. If we cannot change the relationship between advanced and backward regions within two decades, the chances of a peaceful and ordered human society may be forever lost. By 2000 a world populated by 6,280 million people will not be able to endure the inequalities which now exist between states. The problem which has engaged the attention of the UNCSAT Conference should be solemnly considered by the heads of all governments interested in international development. The problem is not less urgent than those on which other "summit conferences" have been held.

Nothing of value can be achieved without the initiative of the governments of developing states. These governments must be given a deepened confidence in the modern scientific movement as one of their sources of their progress. The course open to them is clear: Draw up a survey of resources; formulate a ten-year development plan; give the most urgent priority to human resources; establish an indigenous science through the training of a scientific elite: make maximal use of the U.N. Specialized Agencies, of bilateral agreements, and of the specialized assistance which is so patently available to governments seeking accelerated development.

WHO

Largest advanced training centre for Israel's scientists is the Weizmann Institute at Rehovoth founded nearly 30 years ago. Two hundred scientists work here in nuclear physics, experimental biology, electronics, plant genetics and other subjects. Above, in the special cold room (up to -15 degrees C.) of the bio-chemical department research workers wear arctic clothes. Opposite, woman scientist uses an induction heater for research on iron magnetism.

© Paul Almasy, Paris

Let us hope and believe that the leaders of new nations will approach the problems of development and technical progress with the same ardour and perseverance which they have hitherto devoted to the struggle for national liberation.

While I advocate a full use of international machinery, I do not believe that the United Nations should claim a monopoly of initiative and responsibility. The communion between the world of science and the world of national liberation should be sustained at every level. Individual states and scientific institutions should do what they can to stimulate the reciprocal flow of experience and knowledge. Bilateral programmes sometimes have an intimacy and speed which large international agencies cannot always achieve.

Many of the new states have territories and populations too small to constitute viable units of development. Irrigation projects, universities and research institutes—except in such unusual conditions as those which affect my own country, Israel—require a broad demographic and territorial basis. There is a strong case for regional organization of planning and research, especially in Africa. It is not impossible to combine individual sovereignty with collective development.

FUTURE conferences held by the United Nations or in member states should be of more limited scope and should address themselves to clearly defined fields. Believing that soil and water are still the main source of life for millions in the awakening continents, Israel proposes to hold a conference in 1963, bringing experts on agricultural planning and agrarian education together with ministers and officials of developing states concerned with these problems. I believe that similar specialized conferences could usefully consider problems of disease control, technical and scientific education, the use of new energies, initial industrialization and planning and survey techniques. The dialogue held here must be maintained and even intensified, but on an increasingly functional basis.

IF we understand the U.N. Conference in its special context of history, we have no reason to be disappointed. There has never been such a concentration of scientific knowledge and responsibility in the service of humanity's submerged millions—those who have secured the outward form of liberty and now seek its inner content. There is evidence that the world's scientific conscience is being galvanized by the pathos and opportunity of the less developed regions. This is the first generation of mankind in which the elimination of poverty and disease has become objectively possible. Science is the father of this possibility. Scientists do not wish to retreat into their laboratories in an effort to escape the challenge of human anguish and human hope. They have the will and the capacity to transform the human situation.

If we can only fertilize their will and organize their capacity we may yet inaugurate one of the Great Ages of History.

ABBA EBAN *has been president of the Weizmann Institute of Science since* 1958. *He was Israel's representative to the United Nations between* 1948 *and* 1959.

THE PROMISE OF

by Homi Jehangir Bhabha

An adequate supply of energy is the primary requisite for all modern industrialization and for supporting a high standard of living. For the under-developed countries of the world, it is therefore of prime importance to ensure that adequate amounts of energy and power are harnessed at all stages of their development. A sound policy with regard to energy development can be formulated properly only by taking a long view of the broad energy requirements for quite some time into the future.

In planning for the supply of electricity, it is important to remember that the capital investment in plants and industries required to consume a unit of electricity is on the average roughly seven times the capital investment in plant required to produce a unit of electricity. Thus, in any industrial complex the investment in power producing industries is generally only about 10 to 15% of the total investment.

A conclusion to be drawn from this important fact is that when making large investments in power production it must be assured that several times this amount, say five to seven times, is available for investment in new industries to utilise this power. Otherwise, some of the investment made in producing new power will lie unutilized. A second and equally important conclusion to be drawn is that while the investment in power has to be roughly one-seventh of the total industrial investment, one should always ensure that the investment in power-producing industries is somewhat more rather than less than the optimum figure of about one-seventh. Under-supply of power has a much more adverse effect than an over-supply.

When discussing the economics of utilizing alternative energy resources, the present levels of energy consumption the growth in demands for energy and the availability of the different energy resources have to be taken into account. For an examination of these factors, it is convenient to divide the world into nine groups of countries as follows: North America, comprising essentially the United States and Canada; Oceania, consisting of Australia and the Pacific Ocean islands; U.S.S.R.; Western and Eastern Europe; Africa excluding Egypt; Latin America including Mexico and countries south of it; South Asia and the Far East, including all countries of Asia excluding the Middle East and China; The Middle East, including Iran, Turkey, Egypt and other Arab countries, and China.

A tabulation of the per capita consumption of commercial energy, electricity production and installed electrical capacity for these regions shows that the per capita energy consumption for North America is about 7.8 tons of coal equivalent per annum, and that for Europe, Oceania, and the U.S.S.R. is about 3 tons. These areas comprise the industrially advanced countries of the world today.

On the other hand, Latin America, Africa, South Asia and the Far East, the Middle East and China, which comprises areas that may be termed as "underdeveloped", have a per capita consumption of less than 0.7 tons coal equivalent. The disparity in these figures points to the

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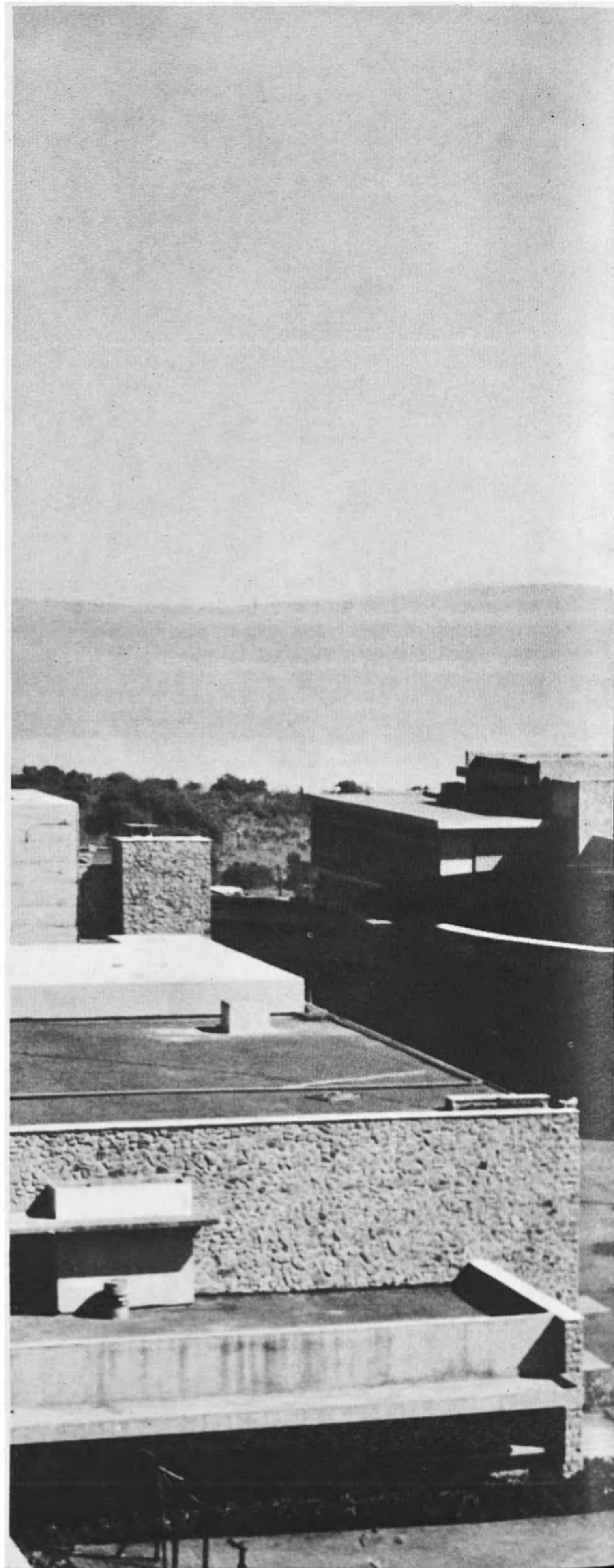
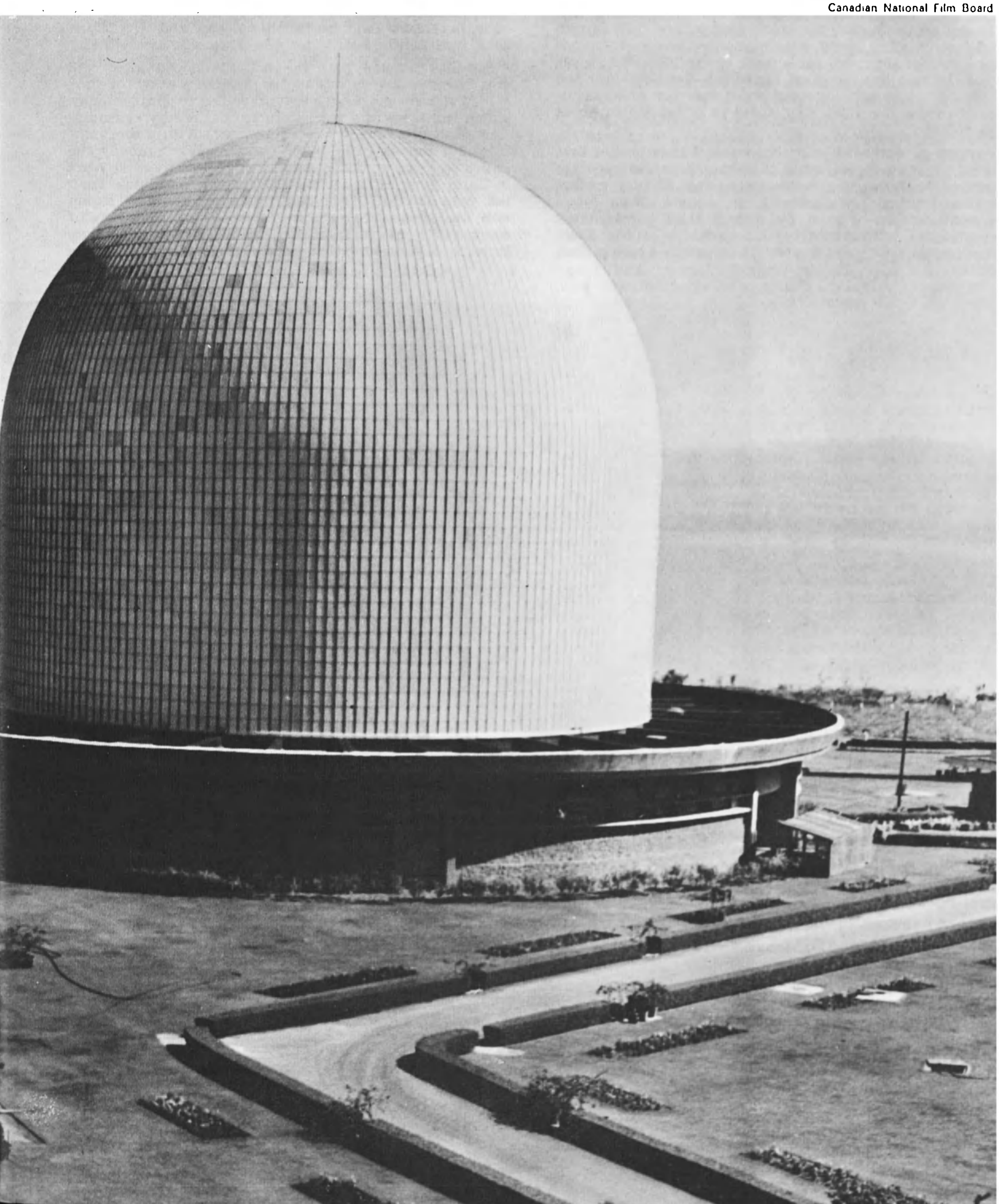


NUCLEAR ENERGY

India is basing plans for its future industrial development on the use of nuclear energy. It began surveys of its nuclear fuel resources—uranium and thorium—as far back as 1949 and, as part of its programme of nuclear research, began to operate its first reactor, the "Apsara", or water nymph, at Trombay, near Bombay in 1957. It now has three research reactors at Trombay, including the Canada-India Reactor whose huge steel protective dome is shown here, and in addition it is planning to build two nuclear power stations.

Canadian National Film Board



Coal and oil exhausted in 75 years

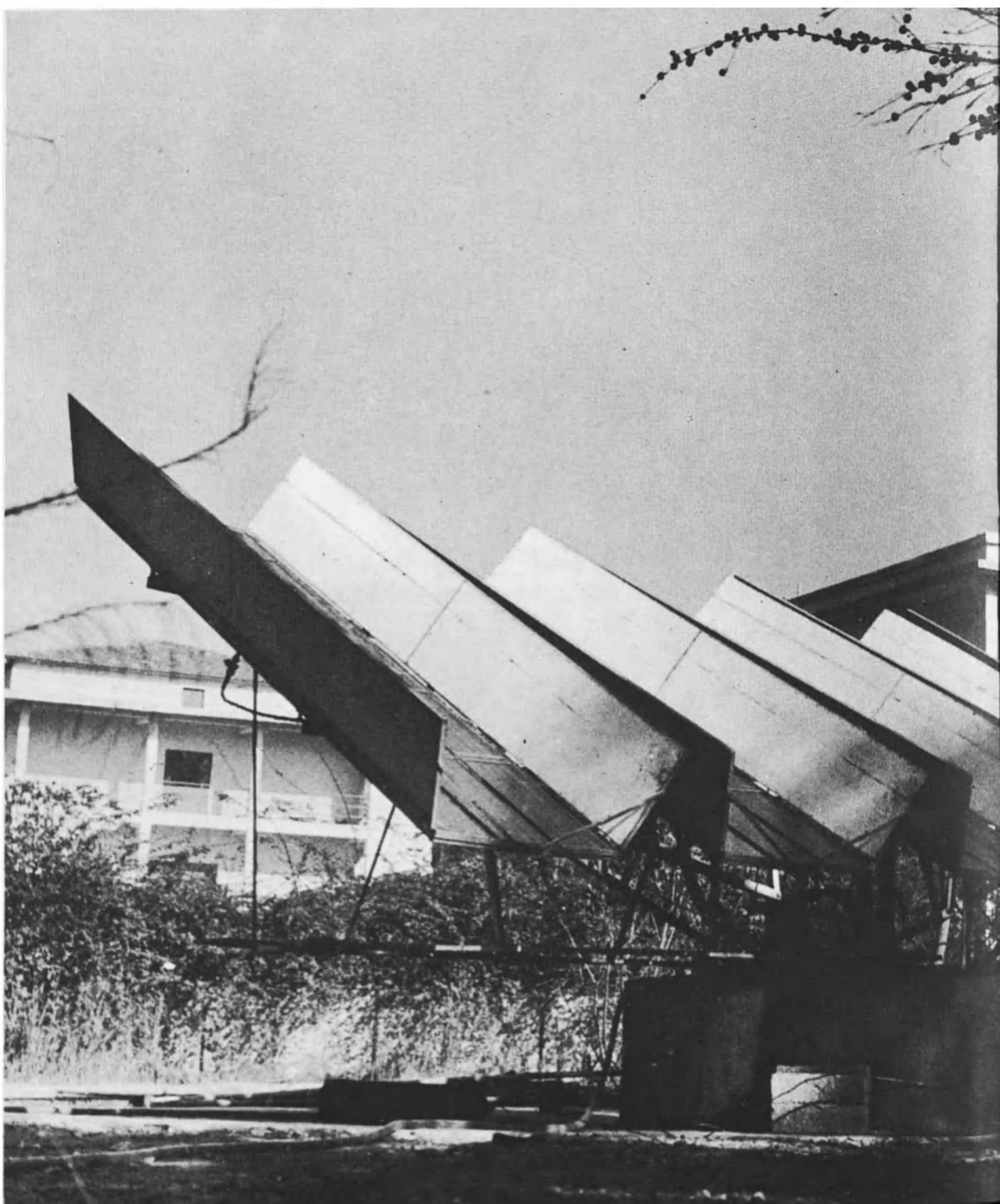
enormous increases in energy production that will be required as the underdeveloped regions industrialize themselves. Moreover, the underdeveloped regions contain the bulk of the world's population—some 2,139 million out of a total of roughly 3,000 million.

According to a recent survey by the World Power Conference, it is estimated that the total reserves of fossil fuel in the world that could be economically recovered are about 3½ million million tons. On the other hand, the total consumption of commercial sources of energy in the world in 1960 was about 4,200 million tons of coal equivalent. The world consumption of energy increased at a rate of about 5% per annum in the 1955-1960 period, and the rate has increased above this figure in 1959 and 1960. On this basis the estimated reserves of economically recoverable fossil fuel would be exhausted in about 75 years.

So far as water power is concerned, it is estimated that if all the sites in the world that have been surveyed are utilized, it should be possible to generate about 5 million million Kw hours of electricity per annum. This forms a small portion of even the present total world energy consumption and would be less than 3% of the likely consumption 30 years hence. It therefore appears that within the foreseeable future, the world will have to go in for a massive utilization of nuclear energy or other non-conventional resources.

A tabulation of the total reserves of conventional resources, both measured and inferred, for different regions of the world, reveals the striking fact that the underdeveloped areas of the world are also those with the least per capita resources of conventional energy. The reserves are under 400 tons of coal equivalent per capita for the underdeveloped areas, 1,400 tons for Europe, over 8,000 tons for North America and over 25,000 tons for the U.S.S.R.

We may assume that the underdeveloped areas will aim at achieving as rapidly as possible a stage of development corresponding to that prevailing in Europe today, which would mean a per capita annual energy consumption of about 3 tons of coal equivalent. With a consumption of 3 tons per capita for these regions annually the entire reserves would be exhausted in less than 40 years in Latin America, less than 65 years in the Middle East, less than 30 years in the South Asia and Far East region and less than 133 years in Africa. This does not, of course, take into account the steadily rising population. It is clear therefore that in the underdeveloped areas,



POWER FROM THE SUN. Energy captured from sunshine may one day be used to run entire factories. For the moment there is an immediate need for small solar power units that can be used to pump water from wells and underground streams in the world's arid areas. Research on such batteries of mirrors is going forward in many countries. This photo shows recent installation at the University of Dakar, Senegal.

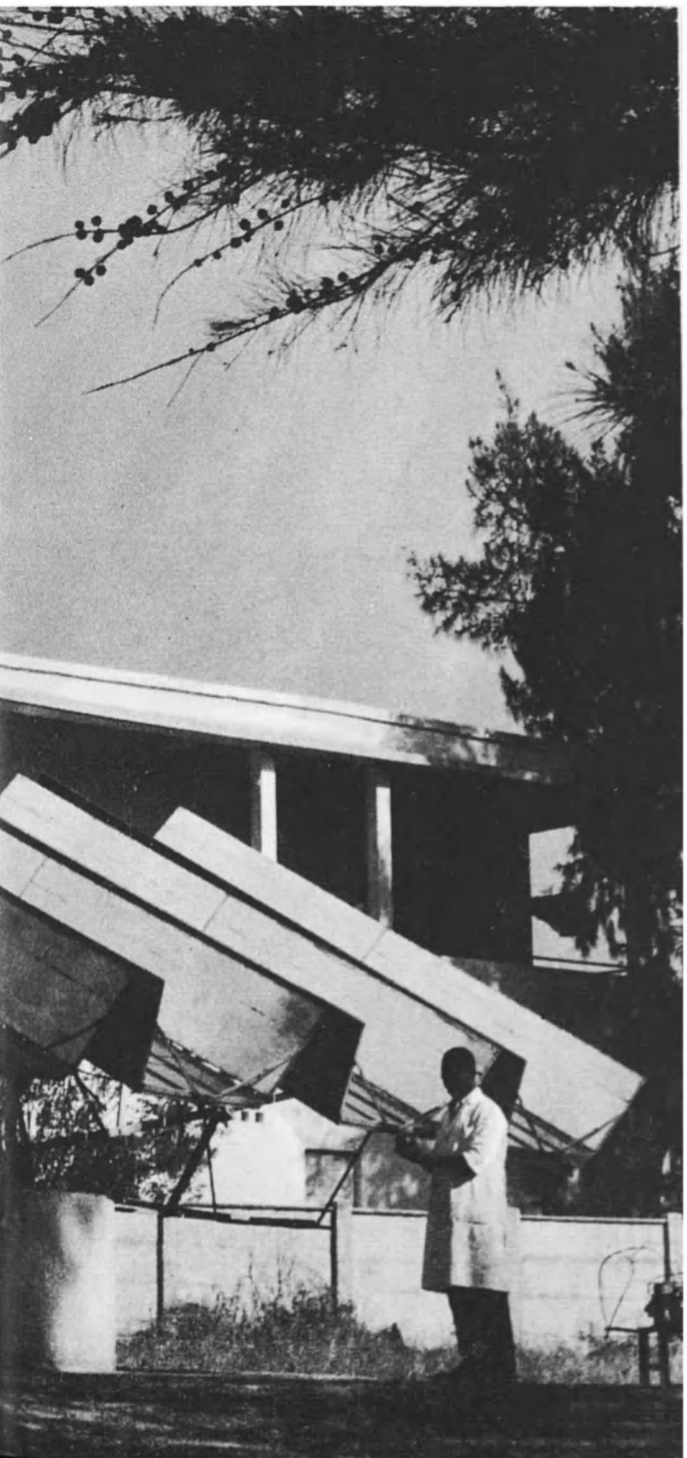
the conventional reserves will not be sufficient to support a developed economy for any significant length of time and that recourse will have to be made either to nuclear energy or to imports of fuel on a massive scale in the near future.

The area which is worst endowed with conventional resources is the South Asia and Far East region which with a present population of 925 million will therefore require the use of nuclear energy at the earliest date of all.

The cost of commercial energy depends on two factors; first, the intrinsic cost of the energy in the fuel used, and secondly the cost of the plant necessary for extracting this energy from the fuel and converting it into a commercially useful form, such as electricity.

If the cost of coal is $4 a ton, the cost of energy in it comes to 20 US cents per million British Thermal Units. Transport may more than double the cost of energy. For furnace oil at $16 per ton, the cost of energy contained in it is 40 US cents per million BTU. The cost of nuclear fuel is higher, for we have to include the cost of bringing the ore to the surface of extracting the uranium content in it and then fabricating this uranium into fuel elements of the desired type. This may result in fuel elements costing anything from $30,000 to $60,000 per ton.

On the other hand, the amount of energy that can be extracted from each ton, even with today's technology, is so enormous that the cost of energy from uranium may vary between 8 and 20 cents per million BTU. In other words, the intrinsic cost of energy from nuclear fuel is almost invariably lower than the cost of energy from conventional fuel, and may in many cases be less than half the cost of energy from coal even at the pit heads.



This general situation could have an important bearing on fuel policy. If fuel has to be imported in any case, then it is much cheaper in terms of the energy obtained to import nuclear fuel rather than conventional fuel. The known reserves of conventional fuels in most of the underdeveloped areas are relatively so small that the full industrialization of these areas will have to depend either on a large scale import of fuel or on using nuclear energy. In view of the markedly low cost of energy in nuclear fuel the necessity to import fuel in very big amounts will itself tip the balance in favour of going in for nuclear energy. Thus, we come to the conclusion that the full industrialization of the underdeveloped areas will in the long run take place only on the basis of atomic energy, whether the fuel is imported or obtained indigeneously.

If the generation of electricity from nuclear energy is not already much cheaper than from conventional fuels it is entirely because the technology is still in its infancy and the cost of plant required to utilize nuclear fuel is greater than the cost of plant required to use conventional fuel. However, the cost of nuclear power stations has been coming down rapidly, so much so that in many areas of the world electricity from atomic energy has already become competitive with electricity from conventional fuels. A major portion of India, which is remote from the coal fields, falls within this category, and certain high fuel cost regions of the United States are probably also in the same class.

In conclusion it is necessary to make a few general observations. Should a study of the economics of the situation in a particular underdeveloped area show that it would be expedient to go in for nuclear production, this could be done initially on the basis of imported equipment. It is neither necessary nor desirable for every such country to go in immediately for the design and manufacture of nuclear equipment, as the necessary technical effort may well take away scarce personnel from more urgent problems.

On the other hand, every new industrial project, whether in the nuclear field or otherwise, should be made the starting point for the training of personnel, not only for operating such plants but for wider purposes. Each industry should be used to make its contribution directly and indirectly towards the development of technical personnel in a wider context than merely required for its operation.

It is not necessary for every country, especially a small one, to produce everything, but it must be able to produce some things containing a high technological content which can be sold in return for other things which may be needed. A balance cannot be maintained only by trading raw materials for industrial equipment. In the last analysis, the most important asset of the highly industrialized countries is their educated and trained manpower in all fields, in particular their large number of scientists, technologists and skilled labour. It is this resource which the underdeveloped countries must build for themselves as quickly as possible, if they are to cease lagging behind, and to pull their own weight in the forward march of humanity.

Homi Jehangir Bhabha *is one of India's most distinguished men of science. Chairman of the Indian Atomic Energy Commission since* 1961, *he is also a member of the U.N. Scientific Advisory Committee and was president of the first International Conference on the Peaceful Uses of Atomic Energy in* 1955. *He gained distinction through his original research in theoretical nuclear physics and in particular on the quantum theory and on cosmic radiation.*

World Bank

Mauritania, a largely desert country in northwest Africa, is twice the size of France, but has a population of less than one million. Today, new opportunities for economic growth in Mauritania have been created by the discovery of one of the world's richest deposits of high-quality iron ore near Fort Gouraud in the Sahara. A $66 million loan from the International Bank for Reconstruction and Development is helping Mauritania to build a township in the mining area, port installations at Port Etienne on the Atlantic Coast and a railway—fed from stockpiles of rails like these—which will link Port Etienne with Fort Gouraud.

INDEX OF PROSPERITY

S.T.P.

(Scientific & Technical Potential)

by Victor A. Kovda

Science is the most dynamic cultural force in the modern world. The impact of science has revolutionized habits of dress, speech, travel and communication, cities and villages. At a deeper level it has affected philosophy through its new concepts of causality. And by making human want technologically obsolete it has brought into relief the moral responsibility of its use for constructive rather than destructive ends. A country without scientists and engineers cannot be in the main stream of modern life.

A developing country can begin to meet its most immediate economical needs by importing scientists from abroad, but it will never be really independent until it has created its own national pool of highly trained scientists and engineers, and its own scientific institutions.

The economic progress out of which the cultural well-being of a country will grow depends to a great extent upon natural resources: climate and topography, flora and fauna, soil and water, and mineral riches. Therefore the very first requirement is scientific knowledge of a country's natural environment and its resources. A detailed knowledge of geographical conditions and energy sources, for example, must precede economic and industrial planning.

This scientific knowledge can be obtained only through a series of systematic studies and surveys of natural resources. This is a task of paramount importance because it can provide both the basis for the elaboration, of economically profitable schemes of exploitation and for rational plans of conservation.

The number and type of resources having economic importance are very variable, depending on the natural history of the territory and of the continent where the country is located. It is characteristic for natural resources to be distributed very irregularly. Thus we find a concentration of important mineral deposits in one country and a total absence of the same type of deposits in a neighbouring country.

The experience of the scientifically advanced countries shows that no country is really "poor in natural resources" in the absolute sense. The absence of one resource can be compensated for by the presence of another no less valuable, but this obviously requires the development of human resources, of the individuals within the country who are capable of directing both studies and development because they have the scientific knowledge to do so.

One of the most important of the new concepts which UNESCO is now using is that of a country's scientific and technical potential or S.T.P. S.T.P. is the totality of a country's resources for formulating and solving problems of national, regional and international importance in the field of science and the application of science.

In determining a nation's S.T.P. six factors have to be considered:

The number of scientists and engineers. We have suggested that an index should be established showing the number of scientists per million population. The more developed countries have from 500 to 4,000 scientists per million population. If we take as a target for the scientifically less developed an average of 1,000 scientists per million population, then a country with a population of 5 million should have 5,000 scientists; one with a population of 30 million should have 30,000 scientists; a continent with a population of 200 million should have 200,000 scientists.

CONT'D ON NEXT PAGE

ENGINEERS FOR IRAN'S NEW INDUSTRIES

Future engineers for Iran's new industries are seen here on the grounds of the Teheran Polytechnic during a break in classes. Left, a brunette Iranian teacher explains the operation of textile machinery to students. Far right, a Unesco expert in a practical course on textile engineering. The Polytechnic was set up with Unesco and U.N. Special Fund aid. Unesco has provided specialists in building construction and in textile, electrical and mechanical engineering. It has awarded fellowships to Iranians in these fields and has supplied large quantities of equipment. The Polytechnic has four Institutes where special emphasis is placed on practical skills not only in workshop and laboratory work, but in actual training within industry.

S. T. P. *(Cont'd)*

Minimum target : 1,000 scientists per million population

Judging from the experience of the most developed industrial countries, the number of engineers should be from five to ten times as great. The United States, with a population of 185 million, has 1,000 scientists per million population and 4,000 engineers per million population.

The Soviet Union, with a population of 200 million, has 1,800 scientists and 20,000 engineers and agronomists per million population. France, with a population of 46,000,000 had (in 1955) 360 scientists and 2,608 engineers per million population.

These figures can be used by any country to estimate its ultimate needs for scientists and engineers. But to achieve this proportion will take one or two generations.

The number and equipment of national research institutes. The next index of a country's S.T.P. is the number, equipment and system of organization of national research institutes, universities and laboratories. We are studying this question and propose to publish monographs on the organization of science in a number of typical countries, such as Belgium, Czechoslovakia and Norway. Talks are also taking place with India and the Ukraine. The more numerous and the better equipped a country's scientific institutes are the greater is that country's S.T.P.

It is also important to know whether a country has research centres in mathematics, physics, chemistry, mining and geology, chemical technology, economics and statistics.

National production of scientific apparatus, measuring instruments and special equipment. This index illustrates a country's capacity constantly to renew and improve the scientific apparatus and equipment needed for research. Scientific equipment becomes obsolete approximately every ten to fifteen years, and has to be replaced by new, more improved types. Today, production of scientific apparatus and precision instruments is mainly concentrated in twelve to fifteen of the most developed countries.

At the present stage of scientific development, it is very important that a country should be able, if not to produce, at least to repair and service the technical equipment it requires, for example, isotopes, electronic computers, television, and so on.

Network of scientific documentation centres. Scientific libraries, microfilm libraries, map collections, scientific museums, translation and bibliographical services are a revealing index of a country's S.T.P.

The range and number of national scientific publications. Periodicals, textbooks and works of scientific popularization are another important element of a country's scientific planning and research programmes.

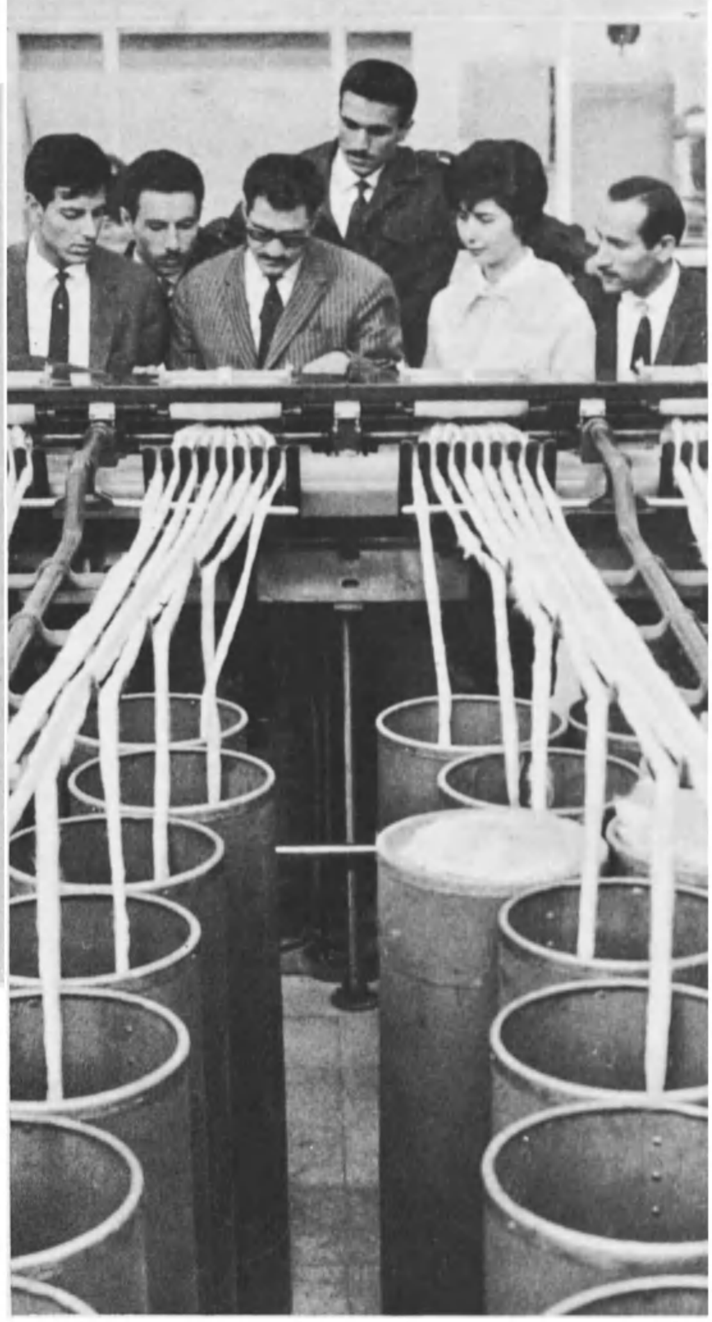
Scientific vocabulary. The existence or lack of a national scientific vocabulary, of a scientific terminology, and of appropriate concepts in the national language are another important index of a country's S.T.P.

A nation's level of literacy, the general level of education, and the extent to which education is compulsory should also be taken into account. This does not mean that all these factors are necessarily of equal importance or incontrovertible, especially since it is not quantity so much as quality which is the decisive factor. Unesco will intensify research in this field, and in particular will attempt to determine the absolute and relative importance of all these factors, which constitute a nation's S.T.P.

A national scientific policy may be defined as a system of measures taken by a government to carry out a long-term (fifteen to twenty-five years) programme for science and its applications aimed at achieving the maximum socio-economic and cultural effects for the benefit of its people. In this sense a national scientific policy becomes an integral part of the government's economic policy.

Many of the countries which have recently attained independence are endeavouring to establish a network of scientific establishments, to set up a guiding scientific

Photos Unesco-Paul Almasy



body in the government, and to assign a regular part of the budget to training scientists and to scientific research.

UNESCO's Department of Natural Sciences is conducting extensive studies of the existing situation with regard to national scientific policies. Of UNESCO's 113 Member States, twenty-five do not now have any central bodies to guide or co-ordinate the activities of scientific establishments. About thirty have relatively ineffective national centres or councils responsible for the planning and development of science.

An increasing number of requests are being received from the governments of UNESCO Member States for assistance in preparing legislation for the establishment of national scientific councils, centres or academies. For instance, at the time of the opening of the Geneva Conference, the Parliament and President of the Republic of Lebanon approved a law (prepared with the help of UNESCO) establishing a national council for the direction of science in that country.

We feel that assistance to governments in working out national scientific policy and scientific organization will be one of UNESCO's most important tasks during the next few years. We are already helping several governments to prepare appropriate legislation and programmes, as in the case of Lebanon.

The size of State expenditure on national scientific institutions is an equally important element of State policy in the field of science. Every government should determine the total financial outlay on science and its apportionment among basic, technical and social sciences. The size of expenditure and its allocation depend, of course, on the historical, social and natural conditions in each particular country.

Economically and scientifically advanced countries allocate from 1 to 5 percent of their annual national income to development of science. European industrialized countries allocate on an average 2.5 per cent of the national income. Some large countries which have recently achieved independence spend about 0.25 per cent of the national income on science, but most of the independent countries of Asia, Africa and Latin America spend less.

Available statistics obviously do not show the full picture. Further research and improved methods of collection, processing and also evaluation of the available figures are necessary. But even now it is safe to say that the less developed countries do not spend enough on science. Much greater efforts are required of the countries themselves and of the international organizations of the United Nations family.

The third basic element of national policy in the field of science is the laying down of the main lines of scientific research, the planned creation of scientific institutions on a long-term basis, the establishment of priorities and time limits, having regard to the economic and natural conditions of the country and its individual regions. This is particularly important in the case of large multinational States with vast territories and a heterogeneous population.

The assessment of immediate and long-term requirements as regards the training of scientific staff and teachers is the further important element of State policy in the field of science. The growth and development of science are inseparable from the creative activity of the scientist. The talents and working capacity of the

CONT'D ON NEXT PAGE

UNESCO EXPANDS ITS

THE United Nations Development Decade has set out to mobilize the world's technological and economic resources in a vast, peaceful offensive in support of developing countries in all parts of the world. Following the United Nations Conference on the Application of Science and Technology for the Benefit of the Less-Developed Areas, held in Geneva last February, Unesco is now reshaping its activities and its thinking in order to play its part in this offensive.

The UNCSAT Conference in Geneva clearly brought out the fact that the "application of science and technology" is not keeping pace with the present growth of the world's new nations. It is the urgency of this problem created by the ever-increasing immediate and long-term needs of the developing countries that has led Unesco to plan a reinforcement of its activities in science and technology for the benefit of these nations.

As presently proposed by Unesco's Director-General, Mr. René Maheu, the new Unesco programme (for 1965-66) will give to science an importance similar to that now accorded to education. Unesco's budget for science, technology and their applications will amount to about $7.3 million for two years as compared with $4.3 million for the current programme. About 60% of the budget will be concentrated on activities of direct importance to developing countries, helping them to set up national scientific and technological institutions and universities, to make studies of natural resources and to train engineers, research workers and university professors.

To carry out this vastly expanded work new units will be created within Unesco to direct a multi-sided programme in science teaching at all levels, in research and training in the engineering sciences and in studies and training related to natural resources.

Unesco's reinforced Department of Natural Sciences will then have broadly two main responsibilities: the international promotion of science and the application of science to problems of economic development. In addition, a post of Assistant Unesco Director-General for Science and Technology will be set up.

Moreover, Unesco will be able to count on financial and organizational help from the United Nations Technical Assistance Programme and the United Nations Special Fund which are expected to provide, through Unesco, between 20 and 25 million dollars during 1965-66. This will make possible the creation of new faculties and institutions, the recruitment of specialists and the purchase of equipment.

The new programme was considered in broad outline by Unesco's Executive Board in May and will be given further study by the Board in October. In its final form the expanded plan will be submitted for approval to the Unesco General Conference in 1964.

Its adoption, however, will in no way diminish Unesco's continually evolving programme in the field of international scientific co-operation. About 40% of the expanded regular budget for science will be devoted to the basic and earth sciences.

The new programme proposes a considerable expansion of international activities in astronomy, atmospheric sciences, geology, ecology and pedology. A reinforced and expanded programme in the life sciences—in biology and brain research, for example—will be carried out. Research in outer space sciences and oceanography will be maintained and expanded. An important new project in scientific hydrology—The International Hydrological Decade, which will be of long-term value to all countries—will be started.

In drawing up its plans for 1965-66, Unesco has taken into consideration many of the facts and the recommendations received from national, regional and international scientific organizations as well as from special advisory groups. Many valuable suggestion were offered by an advisory committee which met in Paris in April to discuss specifically Unesco's role and functions in the use of science for economic development.

This committee brought together top-level scientists and technologists from seven countries under the chairmanship of Prof. M. S. Thacker, of the Indian Government's Planning Commission, who presided over the UNCSAT Conference in Geneva (1).

Noting that Unesco is the only U.N. Agency with a general mandate in the field of science and that as such it has an extremely important role to play, this committee declared that increased emphasis should be placed upon science and technology not only in view of economic development, but also as a component of education and of culture.

The committee urged Unesco to emphasize technological and scientific education at all levels and in all branches, from the secondary to the post-university level. It asked Unesco to continue its aid to countries establishing national research councils and other similar policy-making bodies. Unesco should further encourage local scientists to share in the work of international scientific and technological associations and foster increased interest by these associations of problems facing developing areas.

S. T. P. *(Cont'd)*

The head and eyes of science

scientist are precious qualities which must first be recognized and brought out in a young man or woman and then developed and trained.

Plans for the training of scientists and university professors must always be prepared and carried out well ahead of current needs and in anticipation of future needs. It is necessary, for example, to allow for the inevitable elimination of some students and scientific workers in the initial stages. The increasing need for scientific staff follows a geometrical progression, and this too must be met.

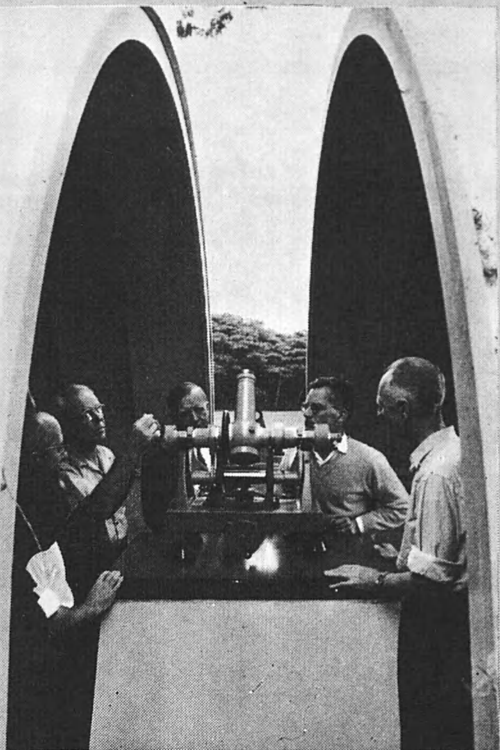
Of 100 boys and girls in schools, only ten to fifteen will attend a university. Of 100 university students only ten to fifteen are likely to become scientists—if they are given the opportunity. But of 100 scientists perhaps only two or three will be innovators of outstanding merit and significance in science.

If a student is to grow into a true and creative scientist, he will need fifteen to twenty and sometimes twenty-five years for education and training and also to learn how to work as an individual researcher.

As part of its national policy in science and technology, each country must decide what proportion of theoretical scientists and technical experts it wishes to have in various branches and special subjects. Each country, however, will always require good mathematicians, physicists, chemists, geologists, geographers, biologists and technical experts.

The Department of Natural Sciences of UNESCO, together with international associations of scientists is preparing optimum types of scientific curricula, and suggestions for laboratory equipment and educational experiments to assist less-developed countries in establishing faculties of science and in training scientists in the basic branches of learning.

SCIENCE PROGRAMME



United Nations

The Central African Institute of Scientific Research at Liviro, Republic of the Congo (Leopoldville) boasts one of the best equipped seismological and geophysical laboratories in all Africa. Here a team of Unesco specialists inspects the observatory installations there during a recent tour which they made of scientific research and training facilities in ten African countries.

Today Unesco is making a large reappraisal of its resources in science so as to give maximum support to the vast United Nations effort that is implied by the Geneva Conference. However, the urgency of the problems evoked by that Conference were recognized by Unesco's General Conference three years ago, when it approved a ten-year programme for science, stressing the special importance of all forms of assistance, through science and technology, for the accelerated industrialization of developing countries.

The Conference named three priorities in this ten-year (1960-70) programme.

- Co-ordination of scientific activities on both national and international levels ;
- Exploration of the earth, methods for drawing up an inventory of natural resources, and the study of scientific problems related to the exploitation of these resources.
- Application of science and technology for industrialization.

In Unesco's current (1963-64) programme for science, all forms of assistance to Member States for the creation of national scientific institutions, universities, industrial research laboratories and polytechnic institutes, have been greatly increased in comparison with past years. About 250 specialists are now working in research and training institutes that are being established with the aid of Unesco and the United Nations. Between 30 and 35 new scientific institutions, faculties of engineering and applied research centres are being created with Unesco's help and the use of U.N. special funds.

While looking to the future and planning its action on a new scale and with greater scope, Unesco can now draw on a decade of working experience in this field.

Institutions like the Indian Institute of Technology in Bombay or the Middle East Technical University at Ankara show what can be achieved by large-scale national effort (in this case by India and Turkey) with a backing of international technological aid supplied by Unesco.

Unesco specialists have trained geologists who are working to solve the water problems of Brazil's Polygon of Drought, they have taught physics in Indonesia, they have gone to earthquake-prone areas to advise on sound construction methods for building and public works and they have set up a world network of centres to make available the documentation which is the lifeblood of science.

In these and many other ways, Unesco is working to accomplish aid programmes in scientific research and training and in the applications of scientific and technological knowledge. It is thus responding to requests for aid from many newly-independent countries who realize that real political and economic independence can only be achieved by the parallel creation of scientific institutions and universities carrying out research and studies on vital problems related to economic and cultural welfare.

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(1) Other members of the committee were: Prof. Harrison Brown, of the California Institute of Technology, in the U.S.A.; Mr. Raymond Cheradame, director of studies at the Ecole Polytechnique in Paris; Professor V.C. Emilianov, head of the U.S.S.R. Agency for the Utilization of Atomic Energy; Dr. Rolando Victor Garcia, dean of the Faculty of Sciences, University of Buenos Aires; Prof. James Greig, of the University of London; Dr. Eni Njoku, vice-chancellor of the Nigerian Federal University at Lagos; and Lord Todd of Cambridge University.

Is the most ultra-modern equipment (automation, electronics, radio-isotopes, television, etc.) really needed for industrializing the less-developed countries and for developing their economy and science? Unesco has studied this question and has concluded that these things really are essential. The economic reconstruction of the newly-independent countries will have to be completed rapidly in the life-time of one or at the most two generations. They must now bridge the gap separating them from economically developed nations. Thus, Unesco believes that the development of industry, transport, agriculture and forestry should be based on economically viable foundations which are scientifically and technically the most advanced and also adapted to local conditions.

This view is shared by many Unesco Member States; for example India, whose Government has co-operated with Unesco in establishing a first-class polytechnic institute in Bombay; or Turkey, where a Middle East Technical University is being established by Unesco and the Turkish Government with the assistance of the United Nations Special Fund. Institutes of the same kind and highly developed scientific centres are being established co-operatively by national governments and Unesco. True, this process is only just beginning. We shall have to establish these centres not only by ones and twos but by dozens, and in the future perhaps by hundreds.

The next question is whether or not there should be any functional division between scientific research and the application of scientific discoveries. What I have in mind here is not economic investment, nor the practical aspects of industrialization—planning for industrialization and executing these plans. Obviously these are not matters for Unesco. What I am thinking about is the indivisibility of research, the training of a scientist or an engineer, and the practical application of science in the national economy.

It often happens that the application of science leads to new theoretical discoveries or to new general theories. It is the role of the scientist himself to suggest the best possible ways of applying scientific discoveries in practice. If we separate theory from practical application, science will have lost its brain and eyes. If we separate reasoned application from scientific theory, then the theory will lose all meaning.

Victor A. Kovda *is director of the Unesco Department of Natural Sciences. A soil scientist, he is a corresponding member of the U.S.S.R. Academy of Sciences.*

330 MILLION BR

A fully-equipped language-teaching laboratory complete with separate booths, tape-recorders and playback machines is now used at the University of Dakar in Senegal.

AINS FOR A NEW ERA

by René Maheu

Director-General of Unesco

WHEN looked at from the standpoint of education the major factor underlying underdevelopment is the absence, for much of a given population, of the minimum of schooling required to learn those basic signs and characters which are the key to the intellectual and technical creations of our civilization. This major factor, in short, is illiteracy.

There are today an estimated 700 million adults—or more than two-fifths of the world's total population—who are illiterate (the word adult here being taken to mean persons 15 years of age or older). And it is in the less developed regions that most of these adult illiterates live.

As for children of primary school age (5 to 15 years), 47 per cent did not attend school during 1960 in the countries of Latin America, Africa, the Middle East and Asia. If we add to this figure those children who are going to school now but who will drop out before they master reading and writing and hence will grow up illiterate, we can say that there are today 150 million future illiterates in these countries and that there will be an additional 20 to 25 million illiterates added to the world's adult population in the next 6 or 7 years.

It is in the light of this general context of educational under-development that the special problem of training scientific and technical personnel in the less developed regions must be viewed.

First of all let me emphasize what a frightful loss of mindpower these hundreds of millions of illiterates represent for technological progress. Who can say how many scientists, engineers and technicians potentially existed among all these forsaken adults as well as the children consigned from birth to the shadows of ignorance.

There is certainly no need for me to make the point that an illiterate person never ceases to be a human being endowed with his own natural dignity and ability. I have personally known individuals who, despite the fact that they were illiterate, possessed unusual intelligence, keen judgement and a high standard of culture. The realm of signs and characters does not encompass the whole gamut of human experience. Nevertheless, illiteracy by the very fact that it makes science and technology a closed book makes active participation in modern civilization impossible. The millions of illiterates I have referred to submit to history, they do not make it.

THE question then is raised—why isn't a big international campaign started to help these countries to get rid of this blight, since to allow it to continue is an absurdity in terms of economic efficiency as much as it is a disgrace on the moral conscience of the world. UNESCO considers that the political, economic and technical conditions are at the present time such as to make a campaign of this kind possible, if we so desire it.

At the end of last year, after a series of consultations with many experts on the question, I submitted a plan to the UNESCO General Conference for making some 300 million adults between the ages of 15 and 50 literate within 10 years. The plan applied to illiterates living in Africa, Asia and Latin America.

The real question is, are we willing to undertake such a job? We cannot blink the fact that it will be a very expensive operation. UNESCO has calculated that it will cost about 1,900 million dollars for the ten years, four-fifths of which will have to come from national budgets. But is it not much more expensive to allow 330 million brains to go to waste? And are there not other types of expenditure which are also very costly but which our planet could well afford to do without?

A country with a high percentage of illiterates does not only suffer an intrinsic loss in terms of wasted man and mindpower; the progress of the educated segment of the population is equally slowed down and made more difficult. It is a well-established fact that the degree of education of the adult population as a whole has a direct bearing on the lasting effects of the education given to children in school.

We can no longer afford to have, as we unfortnately do in many of the developing countries, an enormous gulf separating one group or generation from another, that is, those who have had a full, modern education from those who are illiterate. Such an unhealthy state of affairs disrupts the equilibrium and unity of a country and completely defeats any effort to create a nation-wide positive attitude toward scientific thinking and technology without which there can be no real development.

AN educational system is or purports to be an organic whole, both intellectually and administratively, the different parts of which at their various levels are mutually dependent and intrinsically related. Hence it is neither desirable nor possible to plan the improvement or expansion of one particular stage of education in isolation from all the others. Obviously this does not mean that emphasis and resources must be equally divided throughout the entire school system. Priorities do exist, depending on the circumstances and situation of a country, and these of course make for differences. But it does mean that no serious reform should be contemplated or carried out even in a priority area of the school programme except within the framework of an overall reform of the educational system as a whole.

In my opinion there is one principle which is basic to the organic unity of education and its administration, namely, that the general always conditions and prepares the specialized. In the context of our discussion this means that specialized technical training always presupposes a general technical education just as this in turn implies a grounding in general science. And general science too must itself be viewed as an integral part of general education.

To turn now to the question of educational planning as a national policy, I am convinced that such planning is not only justified but absolutely indispensable. Three considerations lead me to make this statement.

In the first place educational planning follows logically from the idea I have just referred to, namely, the organic unity of education. For obviously if students are to advance rationally from one stage of education to another within a total framework there must be some kind of plan.

Secondly, planning carries with it the very great advan-

CONT'D ON NEXT PAGE

Education's new role in a modern society

tage of not neglecting the importance of time as a factor in education, first determining the time available and then putting it to the best advantage. Educational planning, therefore, has a special added function for the developing countries, that of providing a much-needed standard or yardstick to gauge the future.

In these countries, where the past offered little opportunity for advancement, where the present is fraught with impatience and the future charged with emotion, educational planning serves as a measure of caution since the practical necessity of making the best use of available resources is usually out of all proportion to actual needs. But it also commends itself, perhaps even to a greater extent, as an invaluable mental exercise to prepare the way for the building of a sound future. It serves as a reminder to the developing countries that anything at all cannot happen at any time whatever and that even acceleration must obey the rule of rhythm and order.

Thirdly, educational planning is now being increasingly recognized as an integral part of the planning of economic and social development as a whole; an essential part since it is basic to all the others and so broad in scope, but nonetheless only a part, which should be perceived as such. When it is so integrated, educational planning is of the greatest value in helping a country speed up its development since it becomes possible to gear the educational system to the specific needs and potentialities of the nation. This is especially true for the training of scientific and technical personnel for they are the ones who will be most directly involved in the actual development process.

One of the most striking and encouraging aspects of the change taking place in the world's educational thinking in recent years has been the growing recognition of precisely this threefold need for educational planning.

UNESCO is proud of the part it has played here and will intensify its activities in this priority area of its programme. This year, for instance, UNESCO is setting up an international institute with the specific purpose of training top-level specialists and promoting research in educational planning; and its regional centres now in operation or about to start functioning, mostly in conjunction with the planning institutes of the U.N. Regional Economic Commissions, have the same purpose. I am certain that these institutions will all play a tremendous role in advancing the theory and practice of educational planning which is still in its infancy, and will be able to help the member countries of UNESCO in setting up their own national centres and in training their own leaders in this field.

A knowledge of what the organic unity of the education system implies together with methodical planning—these then are the frames of reference and the basic requisites for any realistic approach to the special problems facing the less developed countries in the training of scientific and technical personnel.

Broadly speaking, there are three areas of major difficulty—technical education, university training and methods of science teaching.

Probably the greatest need for expansion and improvement lies in the field of technical and vocational education, particularly at the secondary school level since this is certainly the part of the school system of the most immediate importance for the growth of the developing countries.

Here UNESCO has devoted considerable effort in recent years to helping the developing countries in two different ways: by working on international standards for technical education, and by direct aid in the field. For three full years a UNESCO team of experts studied the question of standards, and in 1962 the UNESCO General Conference approved the terms of an international Recommendation one section of which specifically deals with standards of scientific and technical education. The drafting of this Recommendation was carried out in consultation with the International Labour Office concurrently with the revision of a similar Recommendation on vocational education by the International Labour Organization.

IN its operation activities in the field, UNESCO has been giving its member states direct aid in setting up or developing national schools for post-secondary or higher technical education, thanks to large financial contributions made by the U.N. Special Fund. At present UNESCO is the Special Fund's executive agency for 22 projects (totalling about $24,500,000) for the establishment of trade schools and higher institutes of technology. This work, on what I would call the general technology level supports and serves as a basic foundation for that of the other bodies of the U.N. family who are engaged in specialized technological training in specific fields.

As for the role of universities in training senior scientific and technical personnel, the importance of which cannot be stressed too strongly, it varies considerably since conditions in the less developed countries are by no means uniform.

In certain countries the problem is chiefly one of quantity. Here the key word is shortage: a shortage of universities, a shortage of instructors and professors, a shortage of equipment, mainly laboratory equipment, even a shortage at times of adequately prepared students arising from the inadequacies of secondary education.

In other countries the problem is chiefly one of quality, that is, lack of organization and guidance services with the result that higher education is poorly adapted to the needs of a modern economy and technology. Thus most of the university students in these countries are advised to prepare for degrees in traditional subjects; and those who do major in science and technology often do so by chance or for personal reasons that have little to do with the real top-priority problems of economic and social development in their country.

As a result, though these countries can boast eminent scientists in no way inferior to those of the more developed countries, such men are few in number and lack sufficient fellow scientists and technicians to work with them or under them and on whom they can count or who can follow in their footsteps. In other words what is missing is the rank and file for the teams of scientists which are now becoming a standard feature of scientific work and a prerequisite for optimum results.

And so, though we find a need for new universities in one place, for expansion in another and reform elsewhere, everywhere the development of universities remains an urgent, vital problem. Foreign study grants or scholarships no matter how generously endowed or wisely planned can never really compensate for the basic deficiencies I have just outlined. The evil of underdevelopment must be attacked at its very root by creating national structures for training qualified personnel where they do not exist and strengthening and improving them where they do.

In the present state of things in the world there is no question but that study abroad is absolutely essential. But if practised indiscriminately it has a serious drawback in that it separates the fellowship holder from his native land and environment and may eventually detach him from his own country and its needs. In point of fact it often happens that the student who goes abroad finds it difficult to fit into the pattern of his home country for psychological, social or economic reasons. He rarely uses more than a fraction of the knowledge and techniques acquired abroad after his return. Sometimes he simply never returns, and so an erosion or draining-off process begins with the most talented minds migrating from the underdeveloped nations to the developed ones.

In reality training abroad is required chiefly to enable technicians and other specialists of an advanced or even professional level to acquire additional technological skills, and as such serves its full purpose only as an adjunct of the studies carried out at home within the pattern of the nation's cultural, economic and social requirements.

If a country is to build a sound foundation for its technological development it is of paramount importance that science be taught in the schools at every level. For the point cannot be too often made that only meagre, superficial and short-lived progress can be achieved by the acquisition of technical skills or knowledge when the people of a nation are almost untutored in science. The real basis for development is a scientific civilization. Merely importing techniques without the science which produces and serves them will not in itself equip the underdeveloped countries for the full utilization of their natural and human resources whereby they hope to achieve their great transformation. And though the importing of techniques results in a number of immediate improvements in certain domains it prolongs and reinforces the state of dependency of the general economy of these countries.

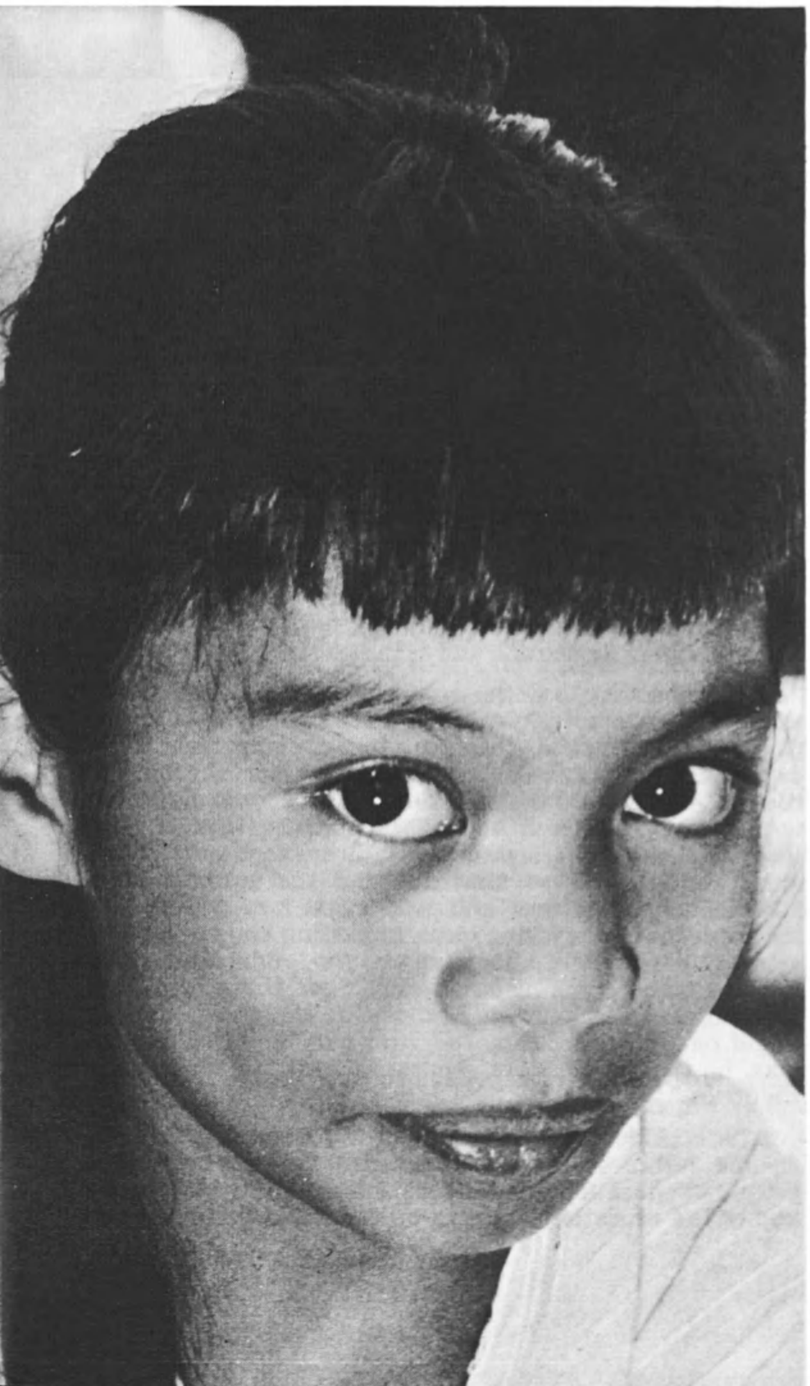
Now it can hardly be denied that, as a general rule, there are many things wrong with science teaching in the underdeveloped countries and that something must be done about it as quickly as possible.

Too often there is a tendency in science classes to overstress the importance of knowledge as such, especially practical knowledge, to the detriment of scientific thinking and the scientific attitude of mind. As a result very little of the real scientific attitude is more than superficially apparent in the thinking of the technical and other supervisory personnel who occupy subordinate and intermediate positions in society. In most cases the only thing learned from science is a series of formulas and prescriptions applied mechanically and unthinkingly.

Teaching of this sort, which puts exercise of memory before the cultivation of the mind seems closer to trained-seal-learning than to genuine education. It is the very antithesis of science which seeks in essence to achieve the liberation of the mind as well as the mastery of nature... In the same manner it is the antithesis of everything that the less-developed countries require most in order to regain control of their own destinies.

This wide-eyed Philippines schoolgirl is one of the world's lucky children. In countries of Latin America, Africa, the Middle East and Asia, 47% of the children of school age have no schools to attend. This is the measure of underdevelopment in education which each year condemns millions of children to adult illiteray. How many potential scientists, engineers and technicians are thereby lost?

Unesco - Pierre A. Pittet



There is much talk of the disequilibrium and tensions brought about in these countries by the conflict between the imported scientific and technological civilization and the traditional national cultures. This certainly constitutes a problem such as arises whenever a society is subjected to a process of swift change under the impact of outside factors. But the resultant conflict and tensions are chiefly due to the fact that science does not appear to these countries in its true guise, that is, as a civilization—indeed the only civilization of potential universality—but as a kind of alien magic imparting sudden power. And if the civilization aspect of science is not apparent to those whose eyes are chiefly fixed on its more practical technological consequences, it is fundamentally because the heart of the matter—the scientific spirit and its methods—is neglected in the teaching of science.

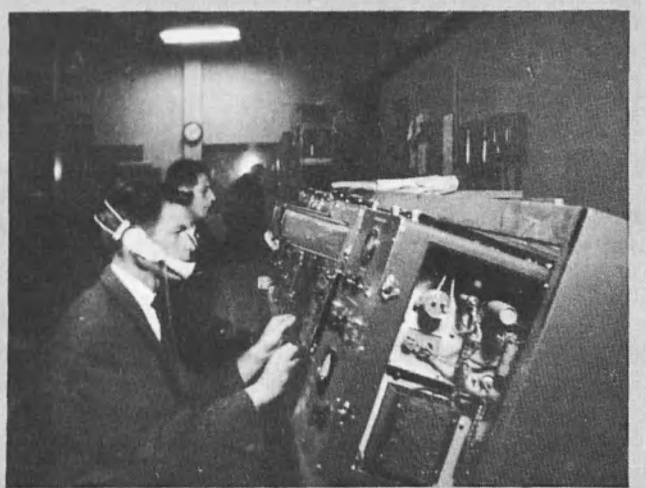
This teaching is particularly defective as regards the practice of the experimental method and the understanding of its significance as a general mental discipline. Training in the experimental method, which is the most effective initiation to modern civilization for both young minds and young societies ardently desirous of progress, must contend with many obstacles in these countries. Some are due to local circumstances in that there is often a distressing shortage of even the most essential laboratory equipment for schools and universities, and purchases and gifts are not always wisely made.

But the educational system is responsible for other obstacles which are no less serious for being less directly apparent and can be overcome only by sustained effort. In many cases, curricula are ill-conceived, textbooks and teachers' handbooks are not suited to local conditions, either material or psychological, and the training of teachers leaves a very great deal to be desired, turning to little account the substantial progress made over the past few years in both the psychology and technology of education. In all these spheres, Unesco is at pains to promote and back up the efforts of its member states. Everywhere the results are heartening, but like the funds available, they are limited. Far greater resources must be marshalled by international aid for this vital contribution to progress.

CONT'D ON NEXT PAGE

TV LESSONS FOR 1,500 COLOMBIAN SCHOOLS

Photos R.I.T. Bogota



Colombia boasts the largest TV network in all Latin America. This year a special transmitter, *Televisora Educativa*, will begin to televise a series of educational programmes to classrooms of 1,500 schools, many of them in isolated villages high up in the Andes. More than half Colombia's population lives in rugged mountain terrain, but TV engineers have overcome communications problems this presents by siting transmission stations high up on the mountain sides. Today TV programmes cover 90 % of the country. New experimental and teacher-training telecasts are due to begin this autumn and the regular school programmes next February. Above, announcer introduces an educational programme which is followed (left) on studio control panel. Right, studio teacher in "What do we know ?" programme.

BRAINS FOR A NEW ERA *(Cont'd)*

Catching up with science's dizzy pace

However, it is questionable whether, even if national efforts and foreign aid, both bilateral and international, are stepped up considerably, the educational system, as it is run at present and with its existing teaching methods, is capable of meeting the tremendous quantitative and qualitative needs of technological development in our modern era of population explosion and quickened scientific progress.

To this question, which it is the duty of educational leaders to ponder most seriously, I for one must resolutely answer no. I do not believe that the educational system, with its present organization and methods, can meet the demands of the growth of our civilization in the developed countries, let alone those in the underdeveloped areas. It is far too costly in terms of money and still more so in terms of qualified personnel, and the returns are not high enough.

Education cannot make its full and decisive contribution to the technological revolution which must take place in the less developed countries unless it itself drastically overhauls its own technology, which in many respects is out of date.

Changes are needed both in the utilization of staff and in the use of teaching aids.

So far as staff is concerned, we all know what a long and costly process the training of teachers is at no matter what level. There can be no question of economizing in this vital field; far from it. But it is rational to keep such qualified personnel for the most vital tasks in education. Experience has shown that for the performance of other duties, assistants, with a far less advanced training, are quite adequate. The savings made in this way may be quite considerable.

Even the machines now being tried out for programmed instruction, by increasing the contribution made by the pupil's or student's own efforts, reduce proportionately the need for personal coaching by the teacher and thus enable him to concentrate on the truly decisive steps in education.

As for teaching aids, the audio-visual media for the recording and dissemination of information that have been created by modern technology over the past fifty years and are constantly being perfected open up for school and university education as well as for the out-of-school education of young people and adults tremendous possibilities as yet insufficiently explored and only half-heartedly exploited. It is undoubtedly at this point that the all too belated technological revolution of modern education should be carried through, particularly in those fields relating to scientific and technical training.

Nowhere is the wholesale, systematic use of audio-visual media more natural and surer of having a strong psychological impact than in those countries where, owing to the high proportion of illiterates, the image and the spoken word are the traditional media for the acquisition, preservation and appreciation of knowledge. The cinema, radio and television—not to overlook such valuable teaching aids as filmstrips and the gramophone—have demonstrated over and over, again how potent they are as means of conveying ideas, imparting knowledge, and expressing emotions and passions, too. Educators must lose no further time in discovering what the professional entertainers and political propagandists have already found out in other fields, the vital part these media can play in the progress of education in the developing countries.

After considering the question of the training of scientific and technical personnel against the general background of educational underdevelopment, on the one hand, and of the educational system on the other, one must also

view it in the light of the demands of science itself and of its offshoot technology.

The inexorable consequence of the quickened pace of progress in knowledge, is the speed—which increases with each higher degree of specialization—with which the content of scientific education and technical training becomes unusable. I mean that the knowledge and practices acquired through this education and training are being ever more rapidly outstripped by the constant advance of science and technology and must accordingly be revised and renewed. We have taken quite a long time to realize this, but in one generation the phenomenon has assumed such proportions that by now it has revolutionized the position of scientific and technical education.

The obligation to keep scientific and technical knowledge constantly up to date affects teachers and taught alike. Teachers, particularly those at the university level or those concerned with specialized technology, must increasingly be prepared to attend intensive training and refresher courses. The same applies, with even greater force to those actually engaged in technical work. As for the general educated public which merely aspires to understanding the scientific factors underlying modern civilization, and accordingly to keeping in a position to play an active part in the life of this civilization, a veritable permanent education must now be planned and organized for it. In neither case can scientific and technical education stop short at the end of their formal studies.

Does this mean that these studies should be extended and diversified so as to cover all the ever-growing expanse of science itself? Not at all. This would be an utterly exhausting and fruitless endeavour for schools and universities, which are already showing all too many symptoms of hypertrophy and take up too much time and energy. No, they must deliberately confine themselves to providing a relatively general training, leaving more specialized knowledge to be acquired later in direct contact with practical life.

In my opinion it is not in schools or universities (though both can continue to promote educational activities beyond their scope) that this renewal or extension of scientific education and technical training must be effected. It must take place wherever the main part of an adult's life and energies are spent—at a place of work and during leisure hours.

Places of work are ideal centres for specialized scientific and technical education on a continuing basis. The major undertakings are becoming increasingly aware of this educational responsibility which they bear and which has incomparably wider implications than the immediate concern of improving production and fostering harmonious relations between employers and workers. This is a task on a scale commensurate with modern society as a whole. The fact is that the major industrial and commercial concerns are bound to assume more and more the character of specialized training establishments supplementing the work of schools and universities. The university, far from ignoring or vying with them, is in duty bound to keep in very close touch with them in order to stimulate and guide them, for they are its natural extension.

As for the considerable amount of leisure made available by industrialization, it is being increasingly taken over or at least controlled by the mass communication media. It is already clear that it is from these media that the vast majority of adults and even a proportion of those at school and university derive the bulk of what I would term their scientific and technical culture.

While the diversity of situations which distinguish the less-developed countries from the industrialized ones call for different approaches to the problems of development, there are, however, no ways and means too novel or modern for the less developed countries in applying the solutions adopted for those problems. Quite the contrary. And this is why the training of scientific and technical personnel is so urgent a necessity for them. For on this personnel depends whether or not they are to play a real part on the contemporary scene.

SENSIBLE SHOPPING IN THE SUPERMARKET OF SCIENCE

by Patrick M. S. Blackett

Nobel Prize for Physics

PROBLEMS of formulating practical and realistic plans for the application of science and technology today face the government of many a newly emerging country. I specifically have in mind the new African nations, since, for various historic reasons, they are very short of trained manpower.

The first thing which must strike, say, the Prime Minister or Minister of Finance of such a young nation, is that science and scientists are expensive and that their financial demands clash with the innumerable other demands on a country's very limited financial resources, and still more limited foreign currency. Even in the field of scientific and technical education alone, there will be the choice to be made of the proper allocation of finance between primary, secondary and higher education; or between training science teachers, scientifically trained administrators, research workers in pure and applied science, and engineers and technologists. Then there are, of course, the essential problems as to what the scientist and technologist should be used for.

It is important to note that these main decisions have to be made by the Government. For the Government alone, in general, has the financial resources to carry out any worthwhile programme. Even when financial aid from other countries is available for specific educational and scientific projects, government assessment and approval will generally be necessary.

So today a great deal of very detailed decision-making in the scientific and technical field will fall on the government of these newly-emerging countries, and just at a time when vital political, economic, and social problems have to be solved. It is evident that a high priority for the educational system of an emerging country is the training of an adequate number of scientifically and technologically minded executives, able to make these complex and difficult decisions.

Any minister or other high official from an emerging country attending the U.N. conference on science and technology will, no doubt, be in two minds about the vast display of scientific and technological developments which are dealt with in the hundreds of communications. On the one hand, the conference will make clear the great possibilities, inherent in modern scientific industrialization and agriculture, for the raising of the material standards of life of the emerging countries. On the other hand, it will confront such a statesman or official with a frightening number of decisions which must be taken. For, even leaving new research and development out of account, the sheer bulk of advanced technology which is available to be bought in the world today, by a nation with the cash, is staggering.

Even rich countries like the United Kingdom do not buy every process, plant, machine tool or vehicle on sale. How much more must this be true of the newly-emerging countries, with their very limited resources both of finance and of trained manpower! Their representatives may feel like window-shoppers, admiring the riches of modern technology through the plate glass window of their limited resources in money and men. Moreover, when they have some money in their pockets they must clearly be very discriminating purchasers.

In considering the formulation of national policy in relation to the application of science and technology to the increase of material wealth, it is useful here to distinguish three main aspects.

The first is that of known and available technology. Most of the most urgent needs of the emerging countries in the early stages of development come into this category. To set up a motor bus service, it is necessary to have the foreign exchange to buy the vehicles and fuel, and the technical schools to train the drivers and repair personnel, but no research or development at all is needed. Nor is new research and development required to set up an airline, or a television system, or an electricity supply, or a sewage system and piped water supply, or the majority of normal manufacturing plants.

Though such projects do not involve any appreciable research and development, they do require a large supply of technically and scientifically-trained personnel to run them. A big increase of indigenous-trained scientific, technological and administrative personnel will be needed before a country can make full use of the known technologies without undue and expensive reliance on foreign personnel. A major task of a new nation's educational system must be to provide as soon as possible the necessary technological intelligentsia to make use of all the known and available technology which the country can afford to buy.

Prominent among the vital tasks which such trained people will have to tackle is the formulation of a sensible "shopping list"—I mean by this homely phrase the decision as to what to buy and what not to buy in the world's well-stocked supermarket for production goods and processes. In one sense the UNCSAT conference is a catalogue of what is available, and so should be of great value to the citizens of the emerging countries who have the responsibility for making these decisions. One cannot over-emphasize the importance of recognising the necessity for wise choice of what to buy. Incidentally, the mere reading and digesting of the mountainous mass of the conference documents will provide a major task for the scientists and engineers of the emerging countries.

THE second most important aspect of the application of science and technology to a less developed country is that concerned with problems which are related to the special conditions of the country, and the solution of which must be done on the spot. Prominent among these, of course, are those special aspects of agriculture and medicine which have specific local significance and so cannot be studied elsewhere. Then there are many problems in meteorology, geology, geophysical surveying, road building and housing, where original research and development related to local conditions is required. In addition, many new technological problems arise in the setting up of local industries, due to the special properties of the local fuels, raw materials, textiles, foodstuffs, etc.

In relation to these problems, the importance of a first rate information service is vital. It must be made as easy as possible for the research and development personnel to be kept continuously aware of the state of general world knowledge on a particular subject, so as not to be led by ignorance into expensive researches to find out what is already well known. The opposite danger is to assume too easily that some process, technique or method, which has long been in successful use in some other country, can be transferred without modification to new

AN OLD TWIST

This African leather craftsman posseses no machine of any kind for processing the animal skins he uses in his trade. To soften the skins he uses an age-old method of his people which consists of stringing up the undressed hides to a tree, attaching a heavy weight to them and then twisting and turning them until they are in a workable state.

© Paul Almasy, Paris

surroundings. Some of the most valuable research projects in the early stages of a country's development will surely lie in the imaginative adaption of known methods to local conditions.

There is one ever imminent danger in such fields as medicine and agriculture. This is, that the policy-makers may become so impressed by the latest triumphs of science that the more humdrum requirements of public health and good husbandry may get too little emphasis. The danger of relying on wonder drugs and neglecting the plumbing is very real. Historians of the future may be amazed that our present epoch had the genius to discover penicillin, but had not the wit to give the majority of mankind a sewage system up to the technological level of River Valley civilization 5,000 years ago.

The third aspect is the group of new technologies which are not yet in general use but are still under development, mainly in the technologically advanced countries. I refer, for instance, to such things as solar heat, fuel cells, desalination of water, and hosts of improved processes and manufactured goods. Though a close watch must be kept on these developments, I am convinced that the national economic and technological planning of a new country's development, over the next decade or so, should be based on what is now known.

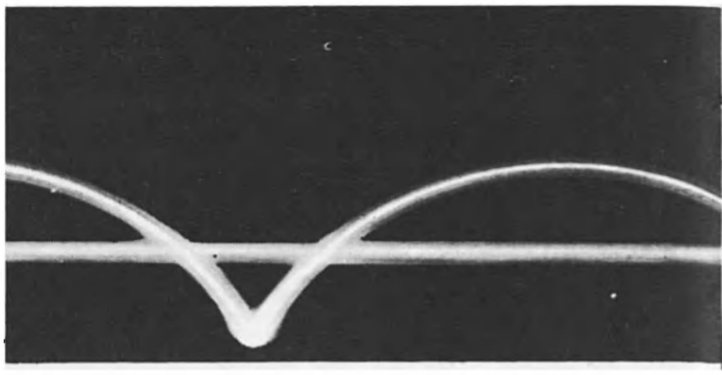
Useful technological innovation, when it arises, should be welcomed as a windfall profit: it should not be relied on for planning purposes. In fact, most of the now emerging new technologies are likely to be of only marginal economic importance to those countries, which are in the early stages of development, compared with the possible gains from fully utilizing existing technologies. For often, but not always, new developments like nuclear power, desalination of water, etc., are expensive in capital cost—and it is capital, particularly in the form of foreign exchange, that emerging countries tend to be most short of.

It is essential that the applied scientists and technologists of the emerging countries develop a sound sense of the economic realities of the related phases of *research, development* and *production.* The first two stages are expensive. Only when the last stage of production is reached is there any increase in material wealth. Though no one would admit to believing that modern science is a magic wand to be waved over a poor country to convert it into a rich one, not a few seem to act as if it were true! In fact the advance of scientific technology can only be a part of a concerted national programme of educational, economic, industrial and social change. Only when integrated into such a plan will the full fruits of scientific technology be reaped.

PATRICK M.S. BLACKETT *of Great Britain was awarded the Nobel Prize for Physics in* 1948. *Since* 1953 *he has been professor of physics at the Imperial College for Science and Technology, University of London.*

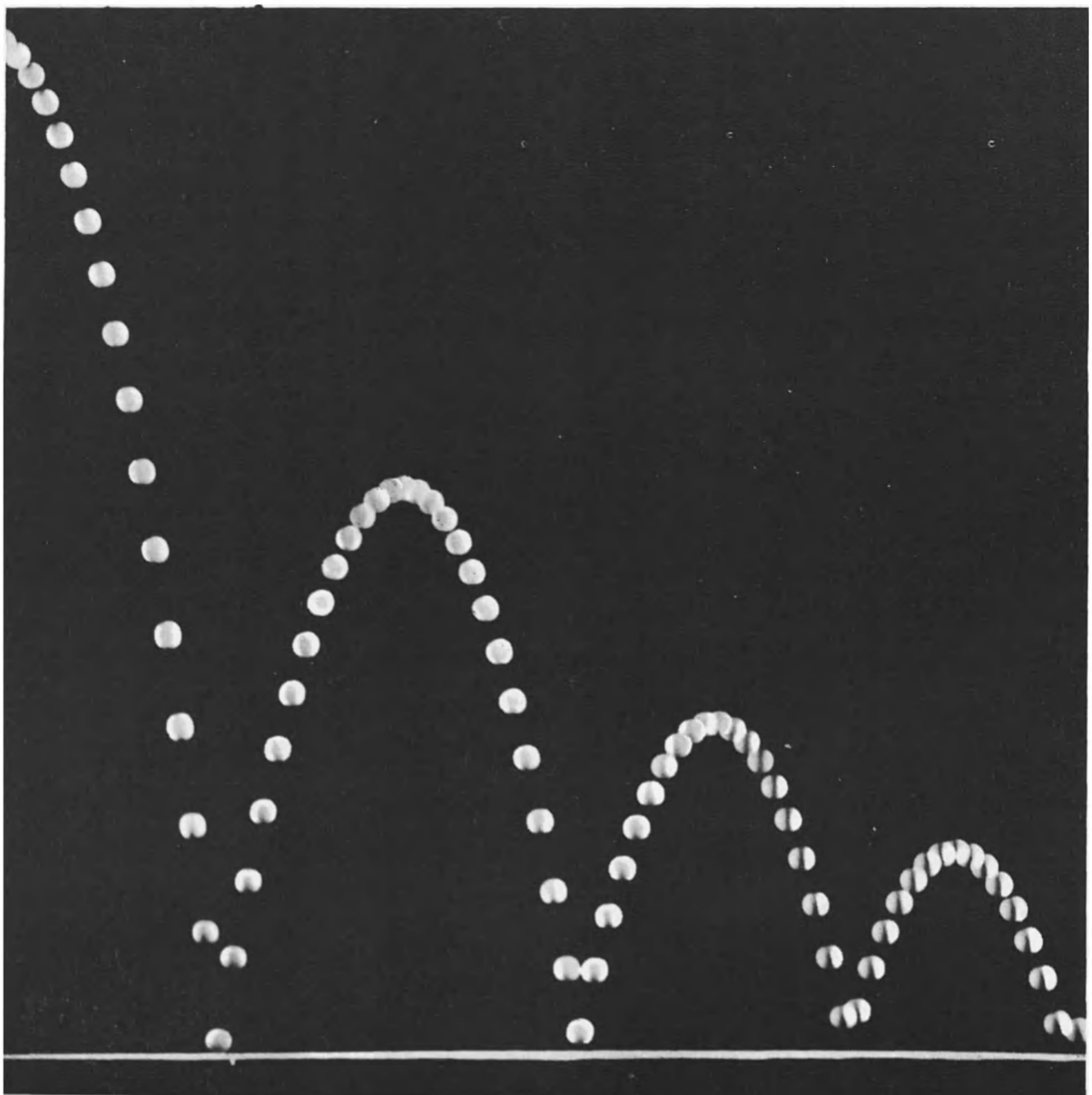
A FACE-LIFT FOR THE SCI

Among the new mass media techniques (such as films, recordings, TV, radio) which are revolutionizing modern teaching, specialized photography is also proving itself a precious auxiliary in many subjects, particularly science. The photos on these and the following pages were made to illustrate a new secondary school course on the fundamental laws of physics, recently developed by the Physical Science Study Group, a group of American physicists and teachers under the auspices of the Massachusetts Institute of Technology. The course is taught in some 1,000 U.S. high schools and has been adapted for use in schools of developing countries. It also uses slow motion films and gives not only future scientists but all students an appreciation of the methods, beauty and development of science.



This time exposure shows the student that motion is *described differently on the frame of reference* of the observer. Lights were fixed to the axis and the rim of a moving wheel. To the camera—or to an observer standing alongside—the point of light on the rim describes a complicated curve called a cycloid. Similarly, in respect to the axis of the wheel, the same point describes a circle.

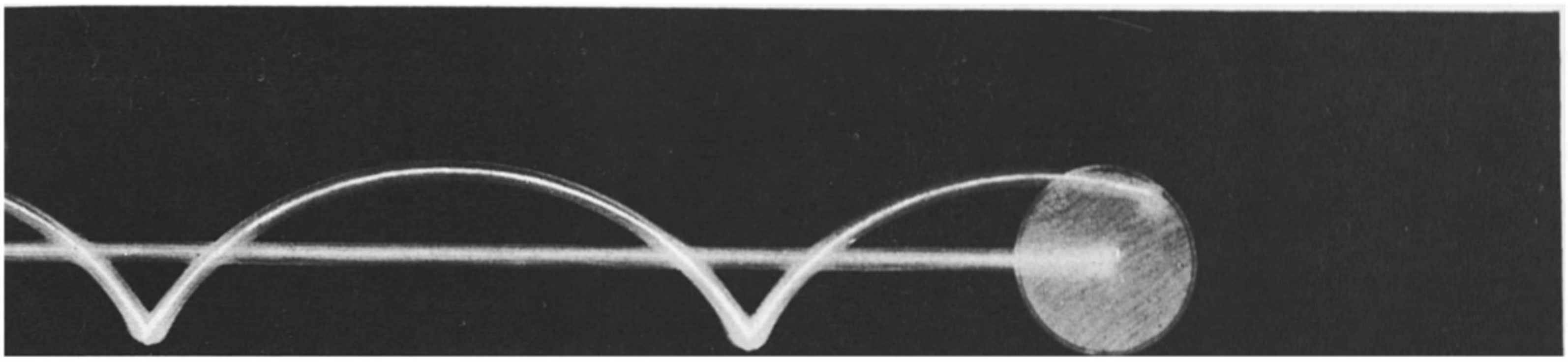
Photos Berenice Abbott - USIS



This photograph of a *bouncing ball* is a portrait of various natural laws of physics—the action of force on a body, the principles of momentum, impulse, kinetic and potential energy, the conservation of energy. These principles govern the motion of bodies as large as the sun and as small as an atomic particle.

ENCE CURRICULUM

by Jerome B. Wiesner



SOCIETY today is in an evolutionary state, in which each advance of our knowledge of the natural world has a series of consequences, frequently unforeseen and probably unforeseeable in detail.

For example, one consequence of the automobile not written in the original specifications is the congested city. Improved health measures may mean a greatly reduced mortality rate, but without accompanying improvements in agricultural methods or the industrial base, they may result in greater impoverishment. Widespread use of nuclear energy for industrial purposes may provide an answer to some problems of development, but as we can already see, it may also pose the serious problem of contamination of our environment.

Each of these advances therefore poses new problems and new challenges, forcing man through science and technology to make hard choices as to how he will use his technical advances. The wiser and better informed these decisions, the more chance we have of moving towards better social conditions and of avoiding the fate of the dinosaur.

I do not want to minimize the problems of transfer and adaptation of technology from one culture to another. Indeed, the variety of cultures offers opportunity for experimentation in the application of science and technology to development. With the increasing number of independent countries we can have a variety of experiments with new approaches to old and new problems.

The problem of transfer may indeed work both ways. I have not attempted to differentiate between the more and less developed countries for, in fact, all countries are faced with the same need for wise application of science and technology to solution of their problems.

Many of the presently less developed countries have an opportunity to leap-frog the problems and patterns encountered in the economically advanced countries. This age is newer than many of us realize; we should not commit the error of copying old ways that are being replaced by new ones. Many new countries have the opportunity to experiment and produce something better; in the older countries we should like to be in the position of being able to copy their innovations. For example, the communications satellite will soon be available and in many situations will be superior to present techniques for internal communications.

It is obvious that an adequate level of education is an absolute prerequisite to enable any society to incorporate new ideas and attitudes into its development process. But a more subtle and exciting observation is that education itself can benefit from the application of research.

Here the needs are monumental in all countries and the field ripe for the kind of systematic research and development on the educational process itself that has only recently begun.

I have become convinced that if we pool our best efforts dramatic improvements in teaching and learning are possible. I can speak on this subject with some feeling. We in the United States have come to realize that our educational system has not kept pace in the way we feel necessary with the world created by scientific and technological advance. Accordingly a number of the scientists and technologists in our universities, who heretofore have limited their efforts to traditional fields of research, are now applying the methods of organized research and development to education, not only in the universities, but also at primary and secondary levels.

As a result of their initiative over the past few years it has been demonstrated, repeatedly and on a grand scale, that educational quality in our schools can be vastly improved. I am firmly convinced that the same methods can be applied, taking account of given variations, to greatly improve and speed the development of new educational systems.

ONE aspect of the effort to improve educational quality is the development of new aids for teaching. The blackboard and the textbook have done good service for half a millennium, but that does not mean that the presentation of information cannot profit from a little re-design. In these experimental programmes, we are beginning to make new use of media that until recently have been the province principally of the entertainment industry—film, tape, records, radio and television. And we are also experimenting with teaching devices of an entirely novel character—new methods of instruction and new types of apparatus, not to replace, but to enrich the work of the teacher, the indispensable human factor in education.

Our scientists and technologists also are working on curriculum structure and content. They are seeking to insure that fundamentals are taught; that the informa-

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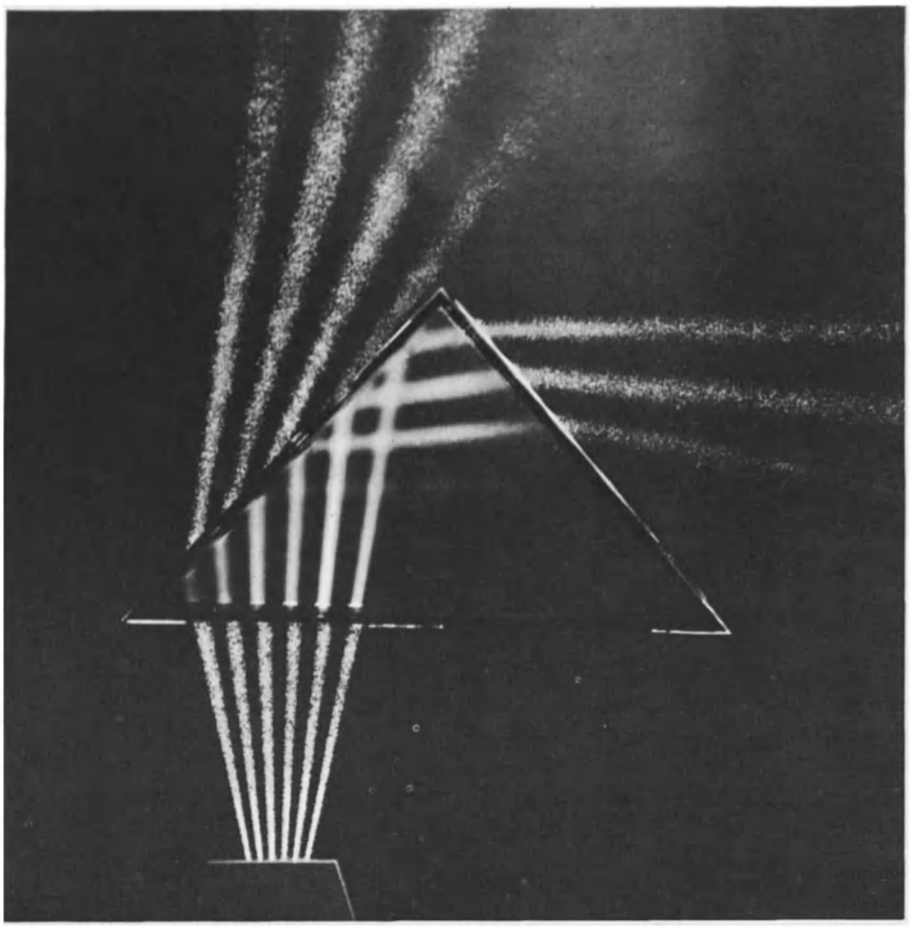
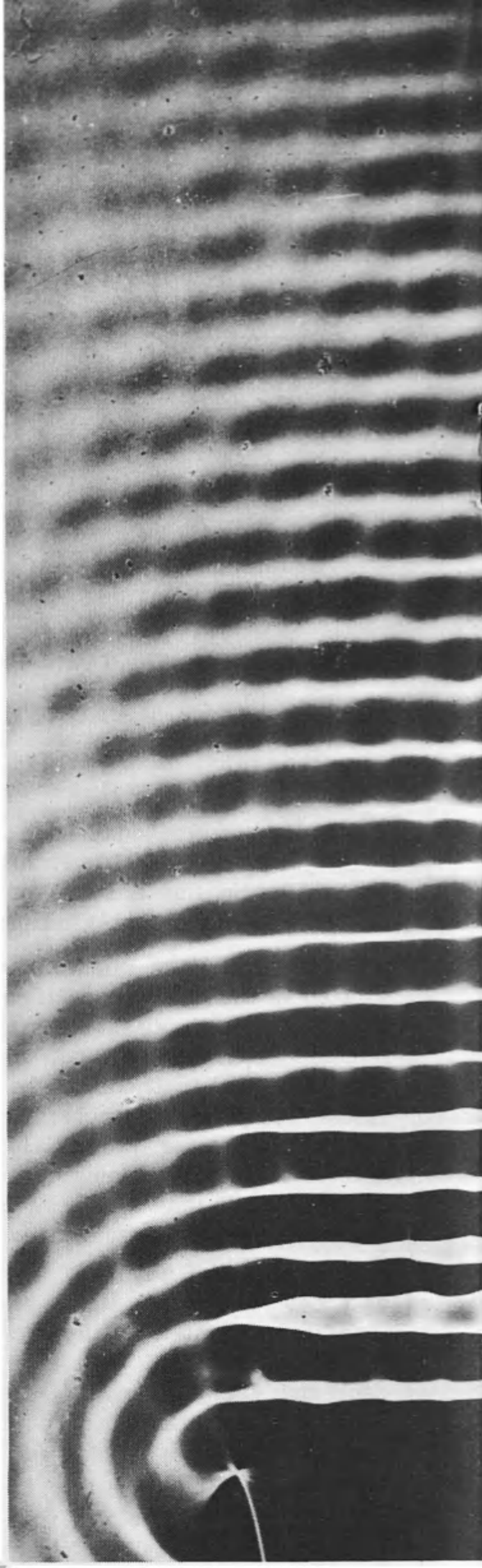
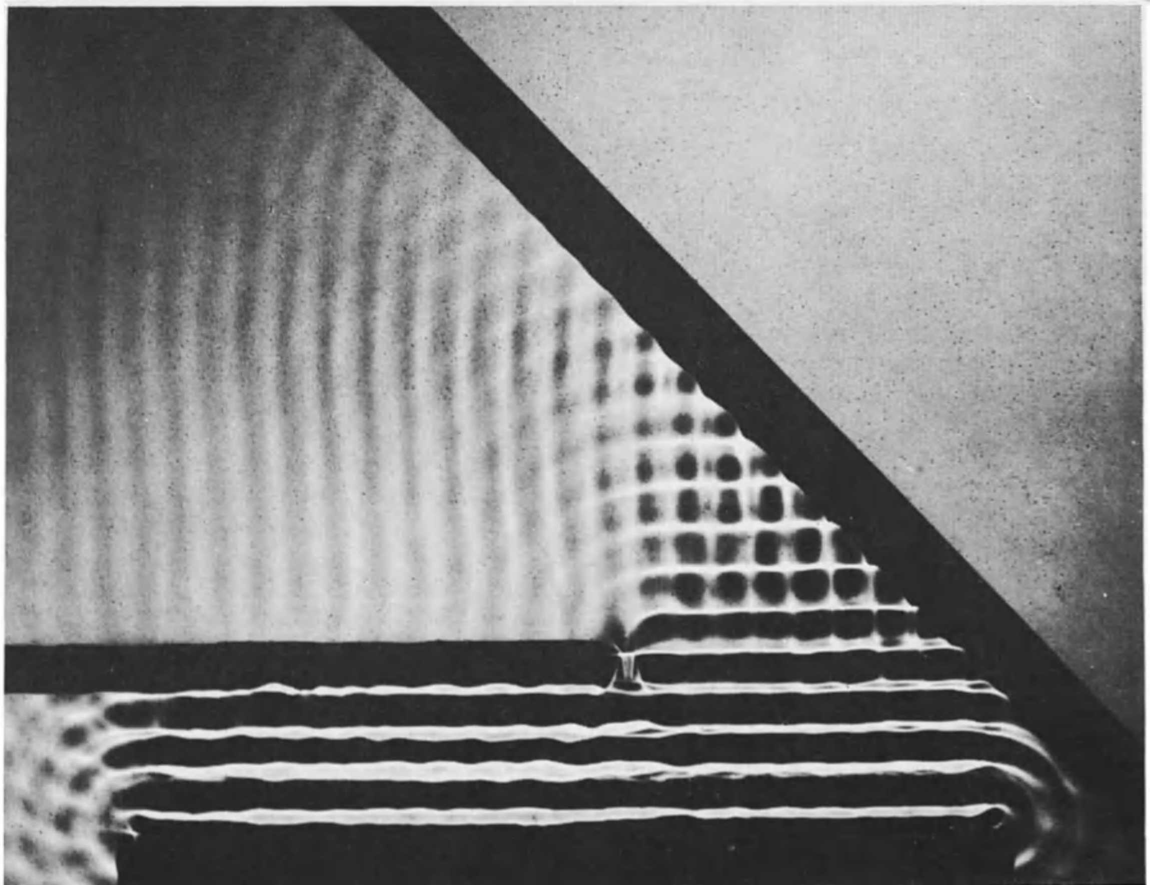


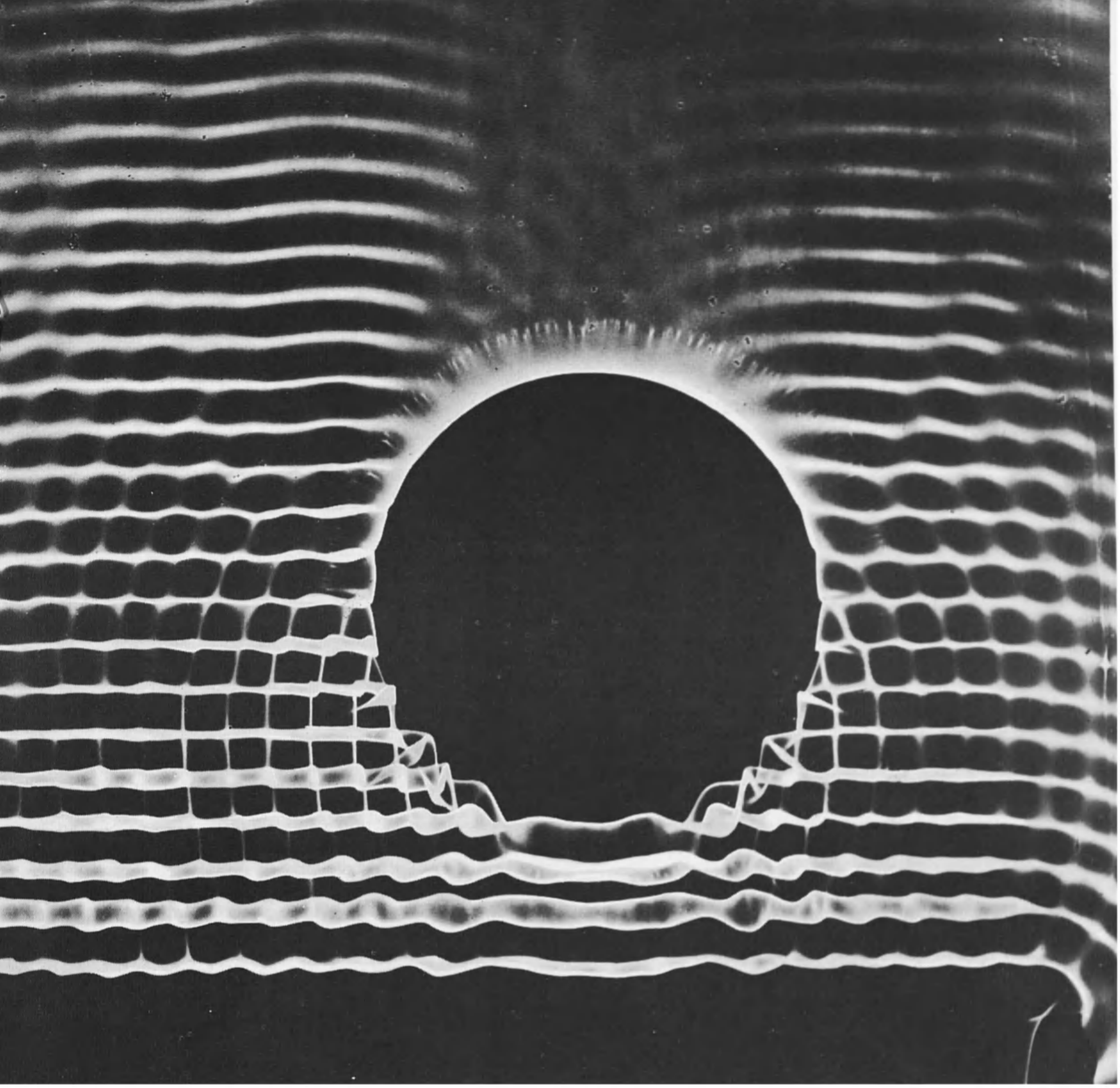
Bending light. Six beams of light plus a plastic box filled with water demonstrate the behaviour of light passing through a prism. The beams, coming from a source at the bottom, are bent or refracted as they pass from air to water and then from water to air. The fourth beam from the left is partly refracted and partly reflected toward the right. Beams five and six are wholly reflected from the face of the prism and then they are refracted as they leave.

A precise view of physics

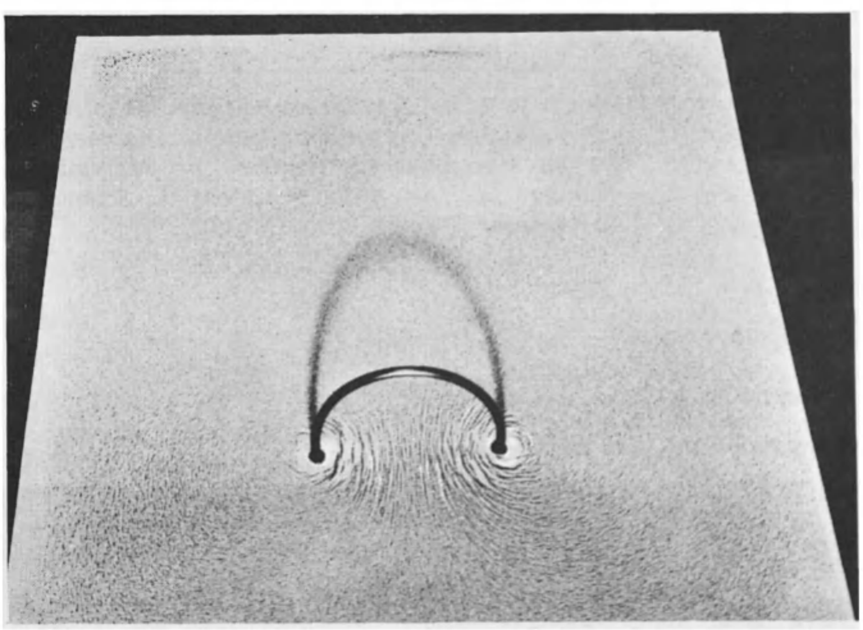




Like light, water waves produce shadows. Above straight waves are incident on a round obstacle placed in a ripple tank. The shadow above the dark disc is readily seen. The shorter the wave length with respect to the size of the object the sharper is the shadow. Experiment (left) shows that reflected water waves, like light, leave the reflecting surface at the same angle at which they approach it. The angle of incidence equals the angle of reflection. Here the straight waves are reflected from a diagonal barrier.



Photos Berenice Abbott - USIS



Iron filings spread on a piece of paper assume this pattern when an electric current is passed through the loop of wire. This pattern indicates the direction and magnitude of the magnetic field. Note that lines are heavier near the wire, indicating a stronger field.

A lesson from the entertainment industry

tion presented is up to date, accurate and in perspective; and that the method of teaching and the content impart the excitement and challenge of the subject to the student —whether he is a potential scientist or mathematician or technologist, or one who will pursue other occupations.

Although our experience has so far concentrated on science and mathematics and foreign languages, we are beginning to extend this approach—to the teaching of social studies, history, writing, literature, and also the practical arts, in order to develop the skills necessary for work in the new industries and in the new agricultural enterprises.

The preparation of first-rate curriculum materials in a subject is a complex operation in research and development. It requires the use of teams of workers from a wide variety of backgrounds. The teams comprise not only the outstanding masters of the field, but also outstanding teachers at the appropriate levels, specialists who have conducted significant research on the learning process, and technicians such as artists, photographers, laboratory and shop workers, who can help in devising new methods of presentation.

Like research and development in other fields, the creation of new educational techniques also requires a large and genuine testing component. New curriculum materials are not made generally available until they are demonstrated to work in the classroom, in an experimental process that can involve many schools over several years.

What are the implications for the less developed lands for this growing experience in improving educational quality? The spirit of innovation, the team approach, the development of new media and techniques, and classroom experimentation would appear applicable to new and old countries alike—with the added advantage for some countries that they are starting relatively fresh in facing their educational problems.

This new approach to education could make possible a massive attack on the problem of illiteracy, from which so many of our countries suffer. To attain basic literacy, as well as scientific literacy, true co-operation is in order. There is no rule saying that the citizens of one country —experts in subject matter and experts in new teaching devices—cannot work with the citizens of another country in developing new materials. People with distinct kinds of special experience may also be necessary on the teams. There may be problems of special frames of reference, for example, exploiting local flora and fauna in a biology course or—to cite a more subtle problem—teaching experimental science in a culture that traditionally depreciates manual labour.

In some cases, especially in mathematics, some of the curriculum materials already developed might be useful directly in other lands. In fact, some efforts for such transfer are already under way, as are some efforts to use teams made up of people from many countries to develop new curriculum materials.

There is one aspect to improving educational quality which dwarfs all others: the preparation of teachers to teach the new courses—both the retraining of teachers now teaching traditional courses, and the education of new teachers. A large number of teachers is needed and so is a large number of teachers of teachers. But if we are willing to experiment a little in finding more efficient ways to prepare people for both tasks, it may not necessarily take generations to build up a large supply of skilled professionals.

Many of our colleges and universities have set up special institutes to retrain teachers, both in short summer programmes and academic year programmes. In some schools we have tried establishing a kind of interneship in education, an arrangement under which the new teacher works for a period of time under the supervision of a master teacher. We are also making use of local broadcasting facilities, using both taped and live programmes, to help teachers on a week-by-week basis in using new instructional materials.

To conclude, I believe that educational development must go hand in hand with scientific and technical developments. Isolated technical projects, however worthy by themselves, do not add up to development unless they fit into an integrated national effort. There is a role in the development process for all branches of science and technology, for all the academic disciplines. We need a better sense of priorities—a closer identification of those problems most in need of technological attention.

In this way the United Nations Specialized Agencies will gain better guidelines for orienting their own programmes of technical assistance in support of the development process.

Jerome B. Wiesner *is Director of the U.S. Office of Science and Technology. A communications engineer on the staff of the Massachusetts Institute of Technology, he is a member of the U.S. Presidential Science Advisory Committee.*

A multi-flash photograph shows the path of a wrench when thrown horizontally. Although it seems to be wildly tumbling, the cross on the handle, marking the centre of mass, belies this. A ruler laid along the line of crosses shows that the centre of mass follows a straight line. The spaces between the crosses are equal, showing that the wrench travels with constant velocity.

Berenice Abbott - USIS

Dr. T. M. A. Pai, founder of the remarkable community entreprise in education at Manipal, South India, at the annual celebration of the Manipur Engineering College, which forms part of his Academy of General Education. With him (on right) is Professeur B. Venkateshgaar, of Mysore University.

A UNIVERSITY TOWN BUILT BY A COUNTRY DOCTOR

Unesco photographer Paul Almasy made special journeys to Asia, Africa and Latin America to take many of the photos in this issue, including the photo-story on the following pages.

IN 1942, Manipal was a village with a few hundred inhabitants on the outskirts of the town of Udipi in the State of Mysore, southern India, hardly distinguishable from scores of similar hamlets in the region. Today, Manipal is a town of nearly 10,000 inhabitants. It has a medical school, an engineering college, a college of arts, letters and science, a college of commerce, a school of music, three elementary schools and a secondary school. How did this obscure village become a thriving town and a vigorous educational and cultural centre?

The transformation of Manipal has come about through the vision and determination of a country doctor named T. M. A. Pai who sparked a remarkable community enterprise in education and science. Dr. Pai, who was born in a village not far from Manipal 67 years ago, studied at the University of Madras and after obtaining his medical degree returned to practise in his native village.

As he went his rounds, Dr. Pai mused on many problems, but the one that preoccupied him most of all was India's lack of schools, not only

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COUNTRY DOCTOR *(Cont'd)*

THE UNBELIEVABLE DREAM COME TRUE

schools to train other doctors like himself, but schools for engineers, technicians and teachers of all kinds. "Knowledge is power" was his guiding maxim.

In his own area there were no facilities for higher education and he knew that many promising young men and women were without the means to continue their education at Mangalore or Madras. How could he help them?

The answer came in 1940 when, after discussing the problem with leading citizens of Udipi, he decided to create an educational co-operative to give the area the schools it needed. Two years later, in 1942, his courageous project came into being with the foundation of the Academy of General Education at Manipal. The first aims of the Academy were to make available technical and commercial education by

A street in Manipal. With the gradual expansion of schools and faculties this tiny village has become a town whose inhabitants now number nearly ten thousand, of whom several thousand are students.

On the building site (left) Doctor Pai and members of his staff study the layout for the foundations of a new library which is the latest addition to the university complex that has been created in the village of Manipal. Right, the entrance to the Kasturba Medical College, established in 1953. In this modern faculty of medicine, lessons are given by some of India's most eminent doctors and scientists.

supporting or building schools and colleges. A vigorous drive was undertaken to enlist support and donations from all sections of the community.

The project started modestly enough with a few vocational courses but soon expanded to include two primary, a higher elementary and a secondary school. By 1949 Dr. Pai was able to enter the field of higher education with the establishment of an Arts and Science College—later named the Mahatma Gandhi Memorial College to honour the memory of the great Indian leader.

Four years later, in 1953, he astounded educationalists by setting up India's first privately-sponsored medical college, the Kasturba Medical College, named after the wife of Mahatma Gandhi. This was one of Dr. Pai's most significant achievements. He and his friends had been moved by the plight of the many young men for whom there were no places in existing medical colleges in India, so they launched the Kasturba Medical College on a co-operative basis, asking the parents of the students who would benefit from its tuition to contribute equal amounts to the project. Sixty-seven per cent of the first class graduated as doctors in 1959.

In 1960 a large teaching hospital was added to the College. This has provided clinical facilities for the students and has helped to relieve some of the region's urgent medical problems.

Today the Academy has 800 medical students, 700 at the Polytechnic School, 1,200 at the College of Arts, Letters and Science, 200 at the School of Commerce. The primary schools founded by Dr. Pai have 900 boys and girls, the secondary school 550 and the School of Music, 350.

Dr. Pai's achievement is a triumph of educational planning and educational financing from co-operative sources, for today the Academy's resources amount to £250,00 ($700,000).

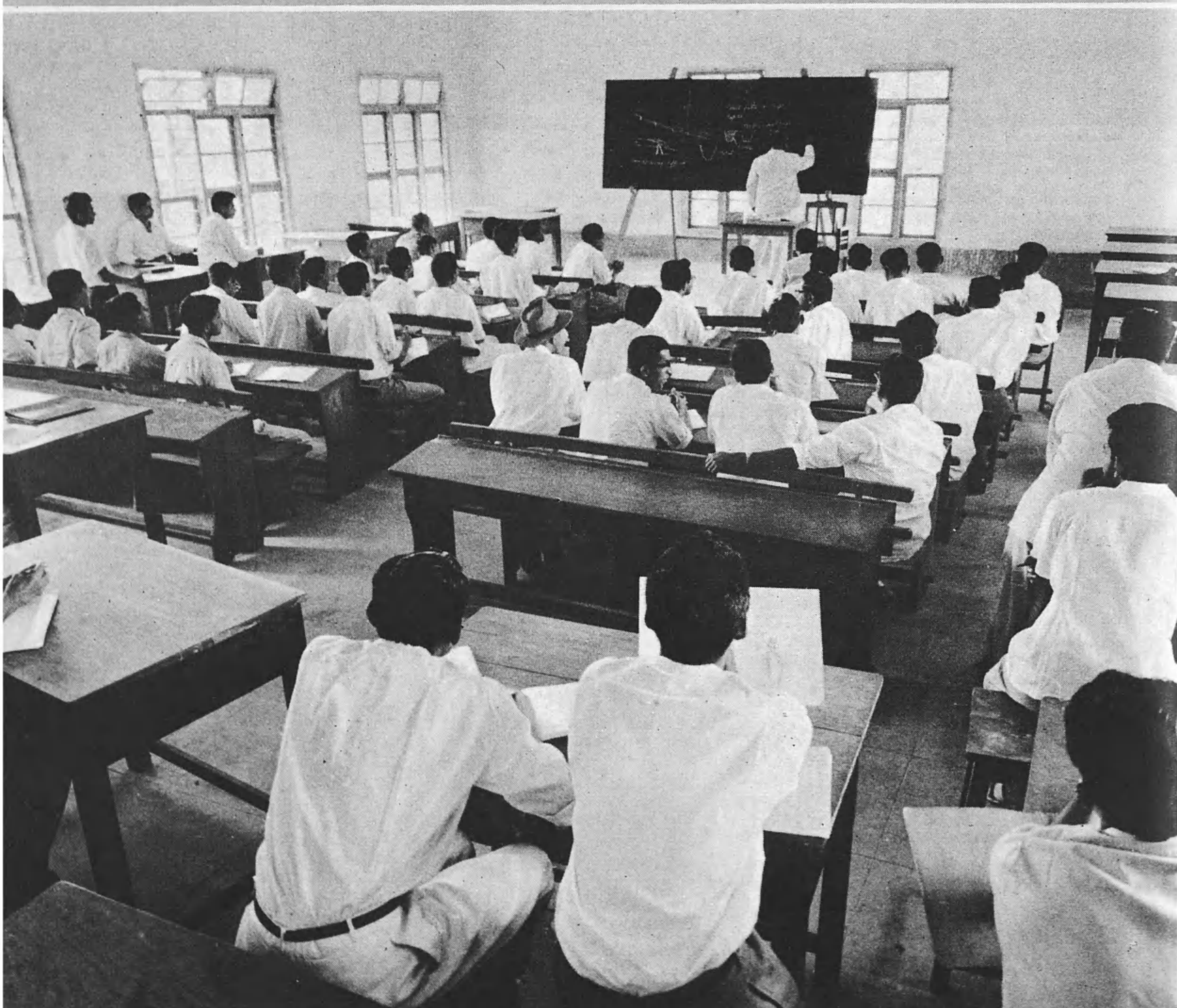
Most men would be satisfied to see their hopes and dreams realized on such a lavish scale. But Doctor Pai is still looking far ahead. Today he is giving Manipal a large modern library of which the Academy's present library will be the nucleus.

"I believe", he said recently, "that it is the duty of everyone to give everything he can to help the development of education."

A nurse gives her report to Dr. Pai as he does the rounds of the hospital at Manipal which has been operating since 1960. It has 600 beds and besides providing clinical facilities for the students, it helps to relieve some of the region's urgent medical problems.

A PEASANT BECOMES AN ENGINEER

Jayakar Shetty, the son of a poor farmer in the Indian state of Mysore, seen here (photo on left) helping his parents, would never have had the chance of a school education if Dr. Pai had not launched his educational project at Manipal. Right, Jayakar now cycles daily from his home to Manipal, ten miles away, to attend courses (below) at the Engineering College.

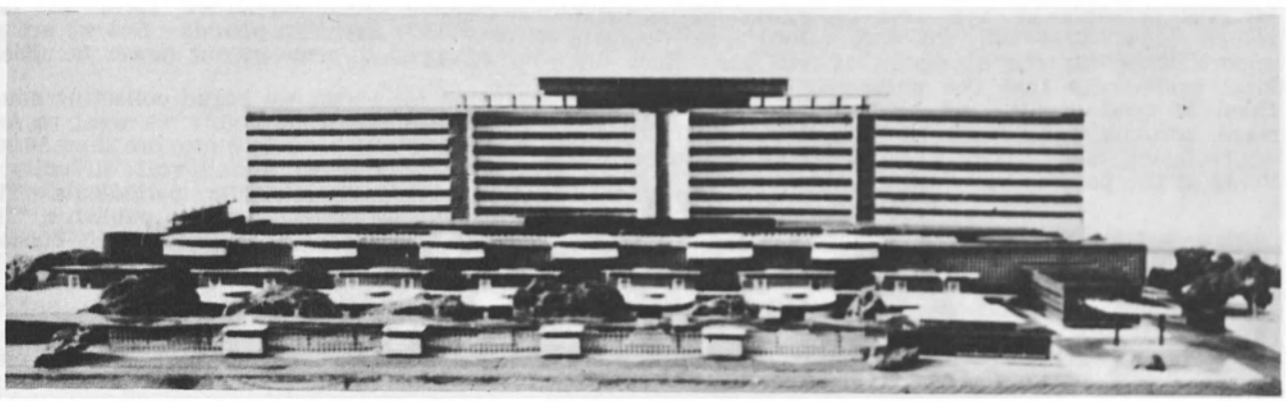


At Assiut the ancient capital of Upper Egypt

A NEW UNIVERSITY IS BORN

by S.A. Huzayyin

Assiut University, the first to be built in Upper Egypt and inaugurated in 1957, will be the most modern in the United Arab Republic when finally completed. Shown here is a model of the teaching hospital complex that will have 1,200 beds and complete facilities for the students and staff.



University of Assiut

In 1957 the United Arab Republic established a new university at Assiut in Upper Egypt.

One of the main problems of a modern university is how to maintain balance between three functions:

- educating the youth and preparing them to assume their role as leading citizens of their country,
- providing the country with a centre of higher thought and culture, and
- making the country's contribution to the development of human knowledge and science through the pursuit of research.

In highly developed countries the last function may tend to outgrow the other two, while in developing countries stress may often have to be laid upon the first. In some cases too, the second function may also either be overlooked or overstressed in a way that diminishes the possibility of national contribution to peaceful human development through the work of the university.

Prior to 1952, the United Arab Republic had three modern universities together with Al-Azhar, the traditional theological university of the Muslim World. These, however, were not enough to meet the needs of the developing country. They were also all concentrated in the north in the two single large cities of the country, Cairo and Alexandria.

This meant that in the provinces of the south the young people were deprived of an equal opportunity to attend university. Only the well-to-do could afford the long journey and the costly life of the far cities. Some 800 kilometres extending along the narrow strip of the Nile valley south of Cairo had no higher educational services. Not a single institute of higher education was established south of the capital. Over six millions of the population had to send their children to Cairo or further north if they were to get any form of higher education. Once in Cairo or Alexandria for university education lasting from four to seven years, students from the southern provinces tended to look for jobs in the north instead of going back to their home areas. This meant a regular depletion of human resources. Indeed the southern part of the country, which was once the seat of power in ancient Egypt, became badly neglected in many respects.

The idea of establishing a university in Assiut, the capital city of the region of Upper Egypt, goes back to 1949. But the effective step to bring the project into existence was taken in 1955. After two years of planning and preparation, two faculties for science and engineering were inaugurated in 1957. In Upper Egypt, the High Dam of Aswan was to be built and schemes for industrial as well as agricultural development had to follow. We had to think of the need for technicians to carry out the vast programmes which were to change the face of this ancient land. This meant the need for faculties of science, engineering, agriculture, medicine, veterinary medicine, business administration, etc.

But the potentialities of the country for the establishment of such a modern university had to be carefully surveyed. A new modern university would need, above all, qualified staff in large numbers for teaching and research work. It was realized that the university would have to be built up in stages, and that priorities in setting up one faculty after another would have to be governed by needs and availability of staff. It was also decided to start with the first year enrolment of students in each faculty and to let it grow year by year.

In 1958 a third faculty, agriculture, was added. In 1960 the faculty of medicine was inaugurated and in 1961 new departments of pharmacy were added. In the same year a new faculty of veterinary medicine was established. This year the faculty of commerce and business administration will be added. In following years new faculties for dentistry and for arts (humanities),

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Campus for 16,000 students

will complete the picture of the university. It is a plan which has been carefully prepared and which will take some 10 to 12 years to implement in full.

At Assiut there were no buildings available as a permanent campus for the new university. A good secondary school building was taken as temporary headquarters.

New land was purchased for the campus within easy reach of different parts of the city, totalling some 370 acres, to comprise the whole campus with its scientific departments, its recreation and sports grounds and a university city to house students and staff. It comprises also the site for university hospitals as well as an experimental farm.

Of course for an agricultural country as densely populated as ours, it was a pity that the university should take such space from the arable land. But it was planned that once the faculty of agriculture was established, it should undertake a project of reclamation covering at least four times as much of desert land in the vicinity. The reclaimed land would then be handed over to landless peasants in the area according to agrarian reform laws. This will not only afford good training opportunities for our students; it will also show the local community that the university did not deprive them of good arable land. It will also help integrate more intimately the work of the university with the efforts being made in the area to raise the standard of living of the people.

A plan was then drawn up for the building of a campus. A careful study was made of present and future requirements with possibility for expansion. It was found that the university would need some 30 buildings for its scientific departments, apart from the public buildings for library, hospitals, recreation, etc. The programme was spread over some 10 years for the principal buildings, with an additional two or three years for the completion of auxiliary buildings.

A professor of architecture was appointed as head of the architecture department of the faculty of engineering and put in charge of the planning of the site and preparation of the draft designs for building. Some of the buildings, such as the hostels for students and the blocks of flats for the staff, were also designed by members of the staff.

It is estimated that the total cost of the campus will be in the neighbourhood of eight million Egyptian pounds. The programme started late in 1958 with the building of large workships for engineering (and where most of our furniture and some of our scientific apparatus is now being manufactured) and part of our recreation grounds. It is hoped that by 1968-1969 the whole campus will be completed. It will accommodate some 12,000 students (attending 8 or 9 faculties), and eventually 16,000 students.

The question of style of buildings was also carefully considered. The idea of a classical style was discarded. We are building a university in the second half of the 20th century, and feel that it should reflect its time and age.

So we adopted a modern style, adapted it to the local conditions of a warm climate (such as double external walls, double roof, good orientation to provide insulation, etc.). The buildings are of a concrete frame, with red-brick outside walls and large glass windows, especially on the shady side.

The purchase of up-to-date scientific equipment is necessary for the proper functioning of any university. As our university at Assiut is composed principally of "science" (rather than humanistic) faculties, more apparatus is needed for this work. That was why we had to start in our building programme with the workshops, which have so far been able to provide us with some of the simpler apparatus for teaching, as well as some of the apparatus especially designed for research.

Equipping a scientific department with apparatus needs very careful planning to avoid waste and make one's funds go as far as possible. It also implies other difficulties connected with obtaining hard currency. Another problem we faced was that we had to get our equipment from different countries, East and West. This entailed special training of technicians and, in some instances, the sending of technicians abroad, or receiving the help of foreign technicians for short terms at Assiut. One other problem which we had to tackle was the repair of instruments. But the workshops of the university were of invaluable help in this respect.

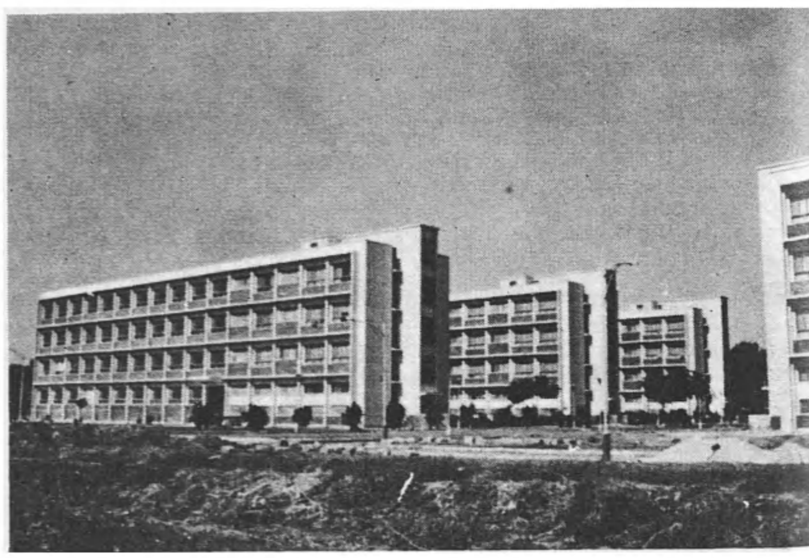
It is difficult to estimate the total cost of apparatus for a new university, for this depends on the number of scientific departments to be equipped and the total of student enrolment. We have so far invested over 1,500,000 Egyptian pounds. But we are still less than half equipped in some of our newer faculties.

As for books, we began collecting some during the two years of planning before we went to Assiut in 1957. We started with a nucleus of more than 50,000 volumes for our library. But we found real difficulty in getting back-numbers of scientific periodicals. The university is setting up its own press to publish a "Bulletin of Science and Technology," as well as text books prepared by the staff and sold to students at cost price.

Staffing of the scientific departments was probably the most difficult of all our problems. Fortunately, when the idea of the university was first conceived in 1949, some 50 graduates from the other universities were sent abroad for Ph. D. work in the various disciplines. They represented the nucleus of our first faculties. The staff of the university was then regularly added to year by year from returning members of missions or by other recruitment for leading posts. Gradually we also received a small number of visiting professors from other countries, mostly through cultural exchange agreements.

In 1955 a vigorous programme for research at universities in Europe and America was started. By the summer of 1962 we already had some 130 men and women doing research abroad, together with another 40 to follow. Some of these have already finished their preparation abroad and are returning to assume teaching posts. Nearly 1,500

At its foundation, the University of Assiut gave priority to science and engineering faculties. Already 500 science and engineering students have graduated to join those now carrying out development programmes in Upper Egypt. Below, buildings of science faculty.



Cuts show the ancient symbol of the union of two lands. The reed of Upper Egypt and the papyrus of the Delta are entwined around a hieroglyph meaning "to unite".

Photos : University of Assiut

Bird's-eye view of future campus of the University of Assiut to be completed in 1969-70. Covering about 250 acres, it will have 30 buildings for science and allied subjects alone and a total student body of 16,000. Dormitories are at lower right below stadium. Humanities faculty is just above tip of minaret. Faculties of science and agriculture line the northern edge alongside irrigation canal and those of engineering and medicine the southern side. At left is the university teaching hospital.

members are now abroad and will occupy teaching or other posts upon their return. Thus the acute problem of staffing the University of Assiut is being gradually solved.

Ours was to be essentially a provincial university. It was decided that our places should be allocated primarily to students taking their secondary school certificate from schools in the five southern provinces of the country. This meant that the new university would alleviate pressure on the universities in Cairo and Alexandria.

Entry into all universities in the United Arab Republic is based upon open competition between students finishing their secondary education. In addition to the numbers accepted from the country, 10% of the total is allocated to students from different Arab and other countries. At present girls make up 8 to 10% of our enrolment, but the percentage is steadily rising.

The establishing of our university in Upper Egypt has provided a new opportunity for girls in this part of the country to obtain a university education. At present nearly 80% of our students are from the five southern provinces of the country. The University of Assiut started with 500 undergraduate students and some 10 research students. The total number (including research students) was nearly 6,000 during the academic year 1962-1963.

As in most other countries, our youth justly feel that we are becoming an engineering society. So most of our boys (and many of our girls) prefer to join the engineering faculty. Next in preference are the faculties of medicine (and pharmacy) and science.

As already mentioned, Assiut is a small provincial city of some 120,000 inhabitants. Before the university was established, the town had limited accomodation for visitors from outside. It was never really a tourist city. It was also not in the tradition of its families to accept strangers as paying guests. So there were difficulties for the university to establish itself in the city. Living conditions were not easy for staff or for students.

Eight blocks of new apartment buildings were rented by the university and converted into hostels for students. The building plan included the construction of the university city already mentioned, to house, when completed, some 3,000 students.

An appeal for funds was made and the sum of 65,000 Egyptian pounds was collected from private donations. This was sufficient to build the first block of buildings for students. Ten more blocks will follow. Also three blocks of flats have already been built for 24 families of the staff. Other blocks will follow. A new housing scheme was also started by the local authorities two years ago. So the face of our little town is quickly being changed. It is estimated that within 10 years or so, the university will have added (directly or indirectly) to this provincial city about 20% of its population. This will give a new pattern to the social life in Assiut.

Life in the campus is gradually taking shape. Ours will be one of the rather rare examples of a complete campus, comprising both academic buildings and living accomodation for a section of the staff and student population. At the same time, recreational amenities are gradually being added. The recreation grounds were actually amongst the earliest facilities to be provided. A stadium is already being used by students and other youth of the city. It is in our plan to have all our facilities open to the public. This includes the stadium, the club, the halls, the theatre, as well as the public library.

The university has its own department of public relations to organize contact with the local community. Extramural activities and extension services include Assiut and the whole region north and south of it. The faculty of agriculture gives advice and guidance to peasants and farm groups. The hospital is designed to serve the whole region and to be a centre for health services and research. Even the workshops of the faculty of engineering are in the service of any citizen who wishes to avail himself to their services at cost price. The university of Assiut is gradually building up its status as a provincial institution in the service of the community and the whole neigbourhood.

Yet even this new university is not limited in its services to the area in which it is located. It is in our tradition in this land to consider ourselves as an integral part of the Arab people as a whole. In addition to the percentage of seats reserved for students from Arab and other neighbouring countries, these students are accorded every care to facilitate their stay with us. Already students from more than 10 countries, coming from as far as Malaya, are studying in this small university. The numbers of students and the countries from which they come are gradually increasing. This is a welcome feature of our university education.

Our university is thus playing an ever-increasing part in our national life and development, as an institution for men and women citizens of a growing nation.

S.A. HUZAYYIN *is Rector of the University of Assiut, United Arab Republic.*

Like other newly-independent nations of West Africa, Ghana is living through a time of construction and fundamental change. Its people are building new paths in technology and industrialization, opening schools, hospitals and technical institutes. But in creating this new fabric of life, they do not forget their ancient past with its culture, crafts and traditional values. Left, stairway of a Ghanian home; right, nurses go on duty at the Sekondi hospital.

All photos with this article, taken by Willis E. Bell, are from " The Roadmakers ", by Efua Sutherland, © Newman Neame Ltd., and Ghana Information Services

AFRICAN METAMORPHOSIS

by E.A.K. Kalitsi

Six years ago, Liberia was the only independent country in West Africa (1). The rest of the area was divided between the British, French, Spanish and Portuguese. Today, only Gambia (a British crown colony) and Portuguese and Spanish Guinea with less than 2% of the population are dependent countries. The rest of the population, totalling more than 80 million inhabitants, is divided among 15 independent states (2) of which Nigeria alone has 40 million people and Ghana six and a half million people.

In spite of ample land, minerals and forest wealth, West Africa remains a poor region. None of the countries has an annual income per head of 200 dollars. Many in fact have only about 100 dollars a head per year.

The main problem of development in West Africa therefore is how to raise the levels of production so that the people can come somewhere near the 800 dollars per head which is earned in Western Europe, not to speak of the 2,000 dollars per head which is earned in the United States. It will require a phenomenal rise in productivity for the real incomes in West Africa to approach those of the developed world.

While the West African leaders and their professional advisers are puzzled about how to tackle this problem, the higher consumption standards of the developed countries are being communicated to West African villagers, who in turn are no longer content to remain without the amenities of good food, good housing, good health and good education for their children. Most of the goods and services which go to satisfy these higher levels of living are still imported goods. The need arises therefore to find the foreign exchange to pay for development as well as current imports if standards of living are not to fall.

West Africa is a producer of primary commodities. Industries are almost non-existent. In each of the countries, the economies have been geared to the needs of European powers with which they were associated. Thus, each country is heavily oriented to the production of one or two commodities only at the expense of a more balanced development in the economy. Ghana is heavily dependent on cocoa, Nigeria on cocoa, oil-palm and ground-nuts, Liberia on rubber, and the former French West African countries on cotton.

The heavy dependence on primary production for export makes these countries victims of the whims of foreign trade, producing in them large fluctuations of income. The bitter experience of cocoa farmers in the 1930's caused a stagnation in the cocoa production of Ghana for some twenty years. One aspect of this pattern of trade is that each European power held a monopoly of the trade of each dependent territory. That is why even today exports and imports of the French-speaking countries of Africa are still almost exclusively with France and those of Nigeria and Ghana with Britain.

These countries have therefore been unable to establish among themselves an internal West African market which could widen their areas of exchange and gain for them the economies of large interdependent production. French West Africa's trade with other West African

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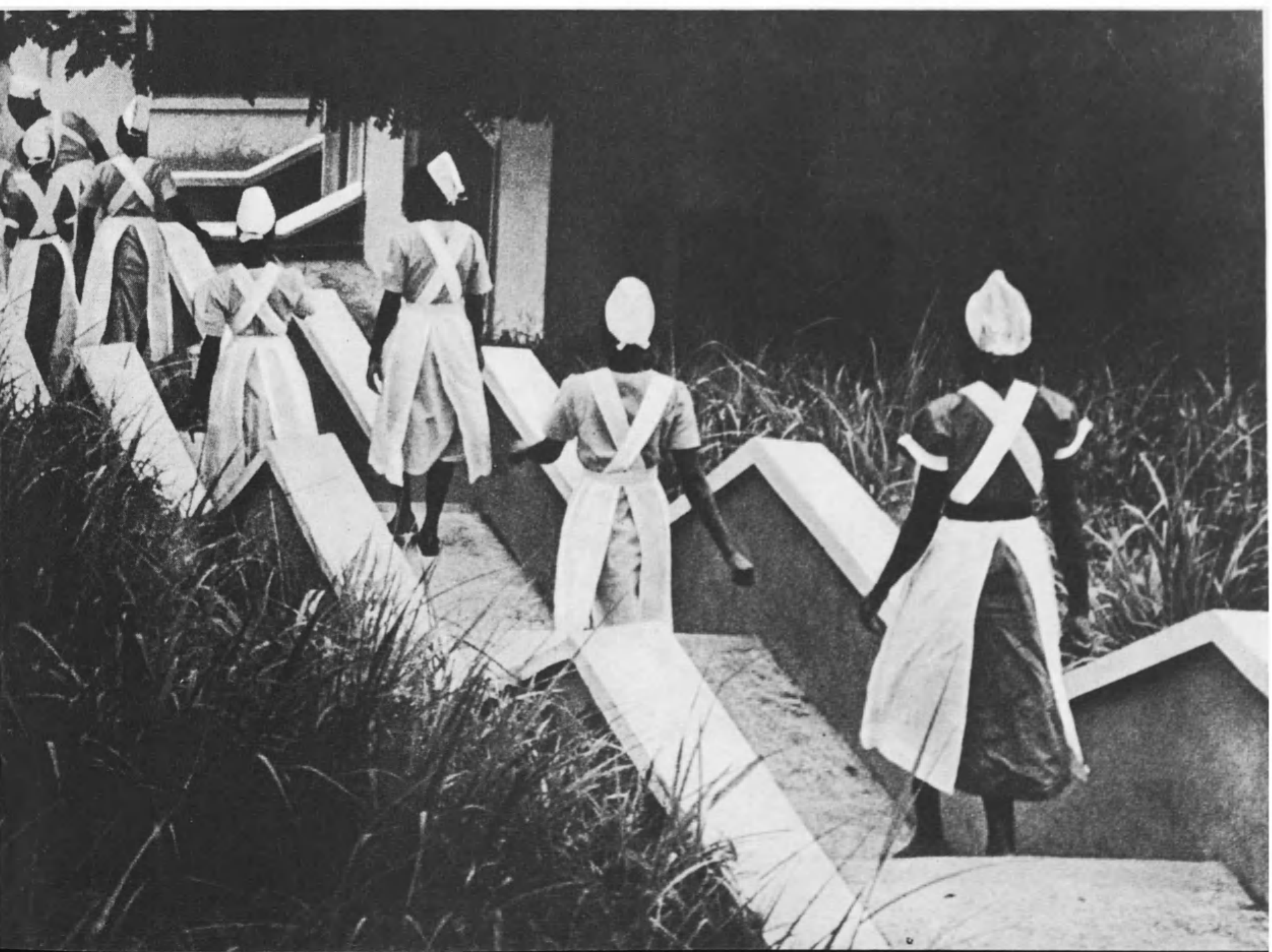
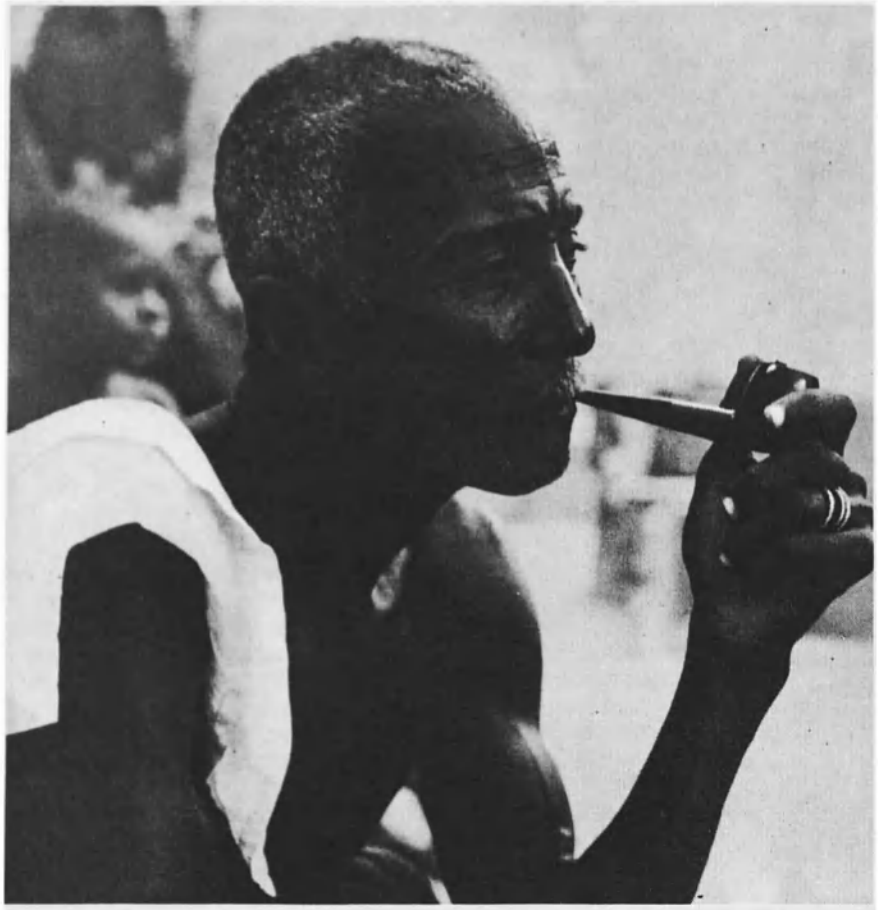
(1) West Africa is here understood as the area stretching 1,700 miles from Cape Verde near Dakar on the west coast to the Cameroons mountains in the east and from the Gulf of Guinea in the south to the northern boundaries lying in the Sahara Desert which starts roughly some 600 to 700 miles from the coast. It covers an area of about 2,400,000 square miles and has a population of about 80 million.

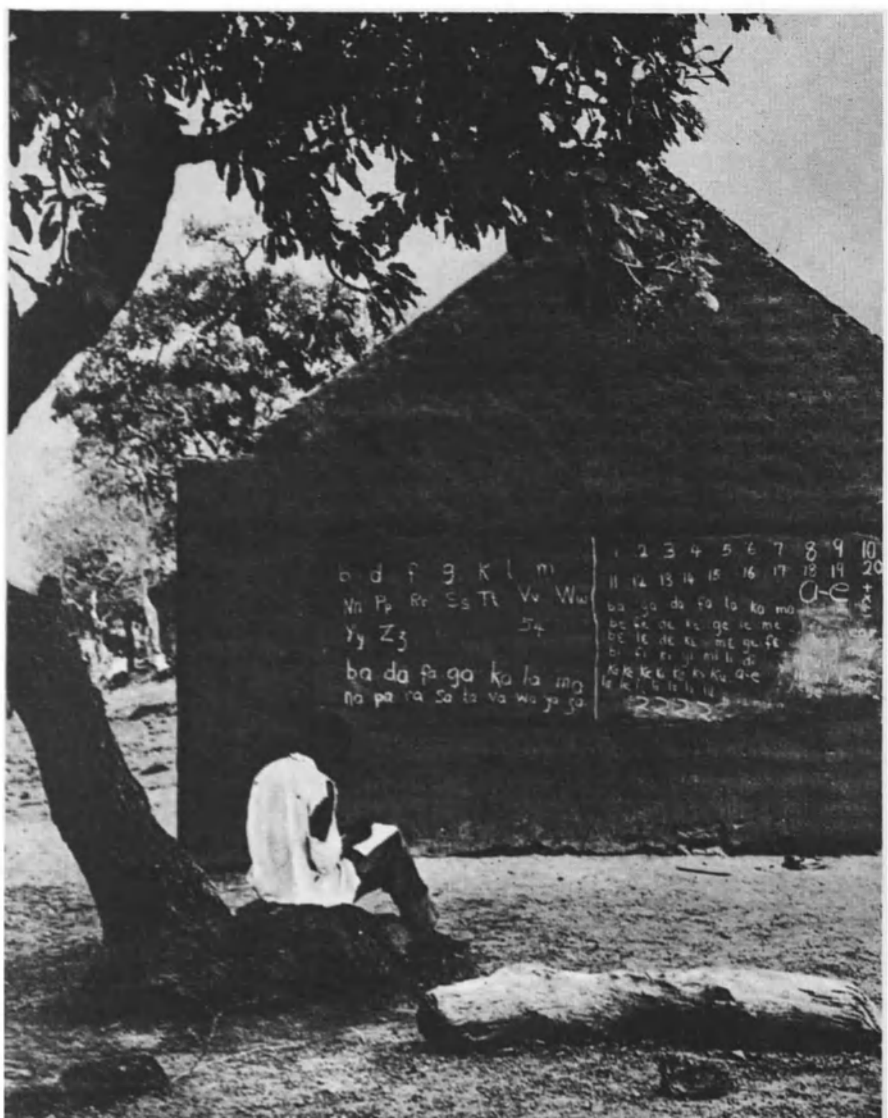
(2) Cameroun, Dahomey, Gabon, Ghana, Guinea, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo and Upper Volta.

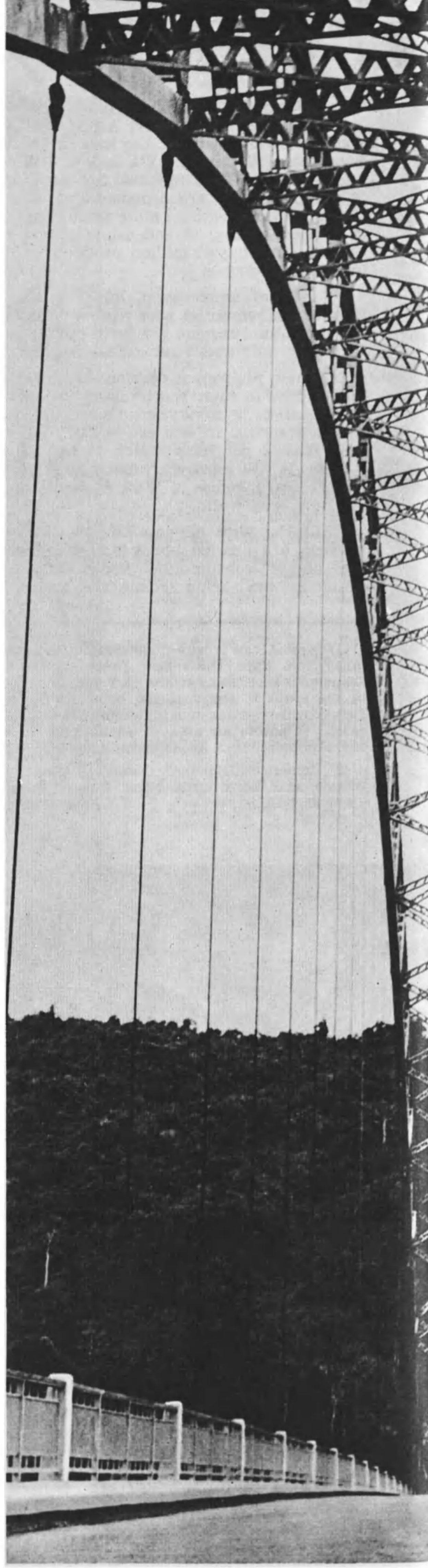


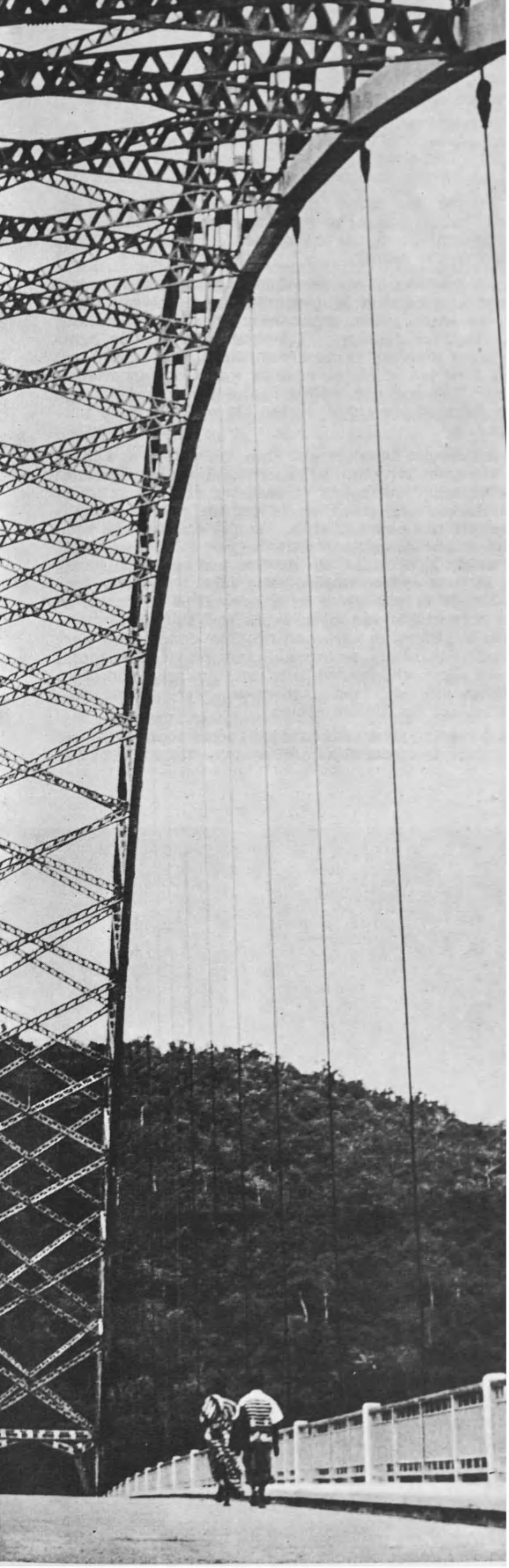


SYMBOLS & WISDOM

"The wisdom and achievement of the past are our guide", say the people of Ghana. Above, the family elder, to whom the household looks for counsel and guidance. Below, from a blackboard on the outside wall of a Ghana village school a young man pursues his studies. Symbol of the age of new development for Ghana is the country's first steel suspension bridge (right) which was completed in 1956, and which now spans the Volta River at Adomi.







Challenge to science: a revolutionary plough

countries is 10% of her total trade, Ghana's is 4% and Nigeria's 1%.

This in itself should not have made any difference were it in fact practicable for the surplus or under-employed population of West Africa to migrate to France and Britain and capital to flow in large volume from Europe to West Africa. If this were possible, the present large disparity in income would not have developed between the European countries and their complementary dependent economies in West Africa.

The United States has the same relation with Puerto Rican trade. But within the last twenty years, Puerto Rico's yearly imports have been exceeding their exports by some 50%. The difference has no doubt been going into the rapid capital formation going on in the country. At the same time, Puerto Rico has transferred during this twenty-year period some 30 to 60,000 of her surplus or under-employed population per year to the United States.

It is not surprising therefore that the same pattern of trade should produce in a little, resource-poor island of 2-1/2 millions a per capita income of 565 dollars while producing in the large relatively rich region of West Africa with 80 million people under 100 dollars per head per year. As West Africa has not the advantages of Puerto Rico therefore, the problem arises how best to develop an internal West African market large enough to stimulate all-round production while retaining the present expert products upon which the countries depend at the moment.

What of the resource situation in West Africa? Unlike Asia, fortunately, West Africa's population is not alarmingly large. But, with the rapid improvements going on in the health of the people, it can be expected that the population will rise, thus creating greater pressure upon the land. At the present over 70% of the people are farmers, mainly peasant subsistence farmers with productivity only about a fifth that of United States farmers. This low productivity of West African agriculture can be explained by the very low level of capital input into agriculture, poor techniques and deficiencies in the land.

The failure of the British attempt to mechanize agriculture in East Africa illustrates in a dramatic way some of the problems of increasing agricultural productivity in West Africa. It has been found, for example that the rock fragments of West African soil are such that a caterpillar tractor only consolidates the surface into a hard macadam layer. Thus is ruled out the majority of mechanical cultivators at present used in temperate countries. Disc ploughs have also been found unsuitable and frequent ploughing only ploughs out all the goodness from the land.

Until agricultural scientists devise suitable equipment and techniques for the soil, therefore, it appears there will be no alternative to the small hoe and shifting cultivation. In spite of those disadvantages, agriculture remains the most important source from which surplus can be generated for other development. Effort is therefore needed to raise this surplus.

In addition to agriculture, there is some evidence of substantial mineral resources in West Africa. Gold and diamonds are at present exploited in Ghana, bauxite in Guinea and Ghana, tin, coal and petroleum in Nigeria.

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Nation-builders in transition

iron in Liberia and Sierra Leone, phosphates in Togoland, manganese in Ghana, and saline salts in Mauritania. Further geological work is required to determine the extent of these deposits.

Although West Africa has ample land and a not ungenerous supply of mineral resources, the countries are still very poorly supplied with capital, whether as fixtures like houses, roads, railways, or as equipment like machines, transport vehicles and agricultural tools. In fact, capital accumulation has been going on at the rate of about 5% a year, but at that rate capital formation can barely keep pace with the rate of population growth, let alone cover any increase in the standard of living.

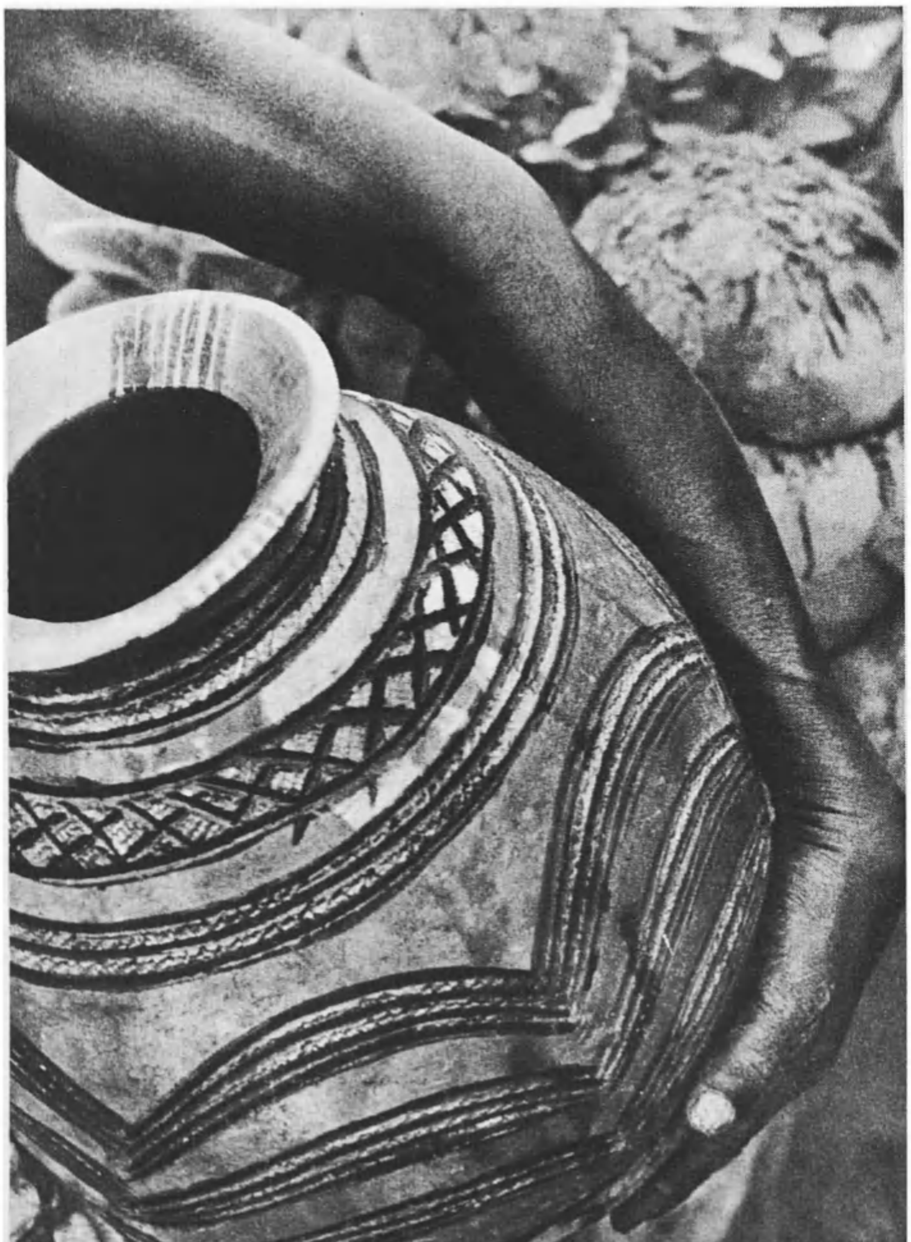
It is considered by some people that the rate of capital formation should be upped to 10% or 15% if development is to accelerate. But with income so low, it is not the easiest thing to save such a large percentage for capital formation. Like other poor countries of the world therefore, West Africa is caught in the proverbial vicious circle of poverty. But how can this circle of low investment and low productivity be broken?

The answer produced by the West African governments was to create the social overhead capital so that directly productive activities can be established or expanded. During Ghana's first five-year development plan, for example, a first class trunk-road system was established running from north to south and from east to west and also linking the major urban areas of the country. Several hundred miles of secondary roads, untarred but quite adequate, radiated to most of the small villages and hamlets in the country.

A new harbour and its 40,000 service township was planned and substantially completed. A university was built, the school system expanded and health centres built throughout the country. Telephone and electric lights more than doubled. This development was carried out during a period when the country was a net exporter of capital. This was due mainly to the good price of cocoa which financed some 90% of the 130 million pound programme.

In the Second Development Plan, the emphasis shifted from the infra-structure to concentration on agricultural improvement, development of industry and expansion of the secondary school system to provide necessary technicians for the new activities. As the country has been dependent upon cocoa production so far, a start was made to diversify agriculture by introducing or encouraging crops such as coffee, bananas, and rubber. At the same time, attention was given to improvement of cocoa. A public corporation was given funds and the authority to develop industries in the country. Tax concessions were provided to investors, factory buildings provided on rental basis for those who needed them, and financial and other assistance offered. Trade agreements were signed with countries like the United States.

The foregoing gives an example of some of the attempts being made to create the conditions for industrialization



Pottery (right) the product of an ancient, individual craft, and newly skilled hands in industry (far right) sum up West Africa's evolution, Now its dominant need is higher production in industry and in the rural economy. Today many people in West African countries earn no more than $100 per year. Over 70% are farmers. In spite of ample lands, mineral riches and forest wealth West Africa will remain a poor region until it exploits these resources and has acquired its own skilled personnel.

in West Africa. As a practical matter, local capital can be gathered only slowly, mainly out of present agriculture and it will take a little while for the local entrepreneurs to acquire the necessary industrial know-how. Foreign capital can help tide over this period of transition in the economy. But the flow has been slow. Most of the foreign investment is locked up in quick-yielding enterprises like import and export trade. What is wanted really is the means to exploit local resources and train adequate personnel. The governments are therefore out of necessity forced to undertake some of the directly productive activities considered necessary for the growth of the economies.

THERE is no doubt that increased capital formation is urgently necessary for West African countries. But we do not want to lay too much stress on that factor alone. The existing capital could be put to a better use and even increased if the illiteracy rate were not so high. It is significant that the new state of Israel, located on a desert, should within a very short time have developed faster than the oil-rich Middle East countries. Not a small part of the explanation is that Israel had a high degree of literacy which enabled the country to train her work force and organize them quickly, free from the crippling inhibitions of tradition-oriented social structure and illiterate communities.

In any case, in West Africa, with some 85% of the people illiterate, any scheme of major development is bound to press hard upon the already limited supply of educated people who are required as legislators, businessmen, engineers and technicians. Fortunately, there have been enough of these people to assume the responsibilities of self-government without a breakdown occuring as has happened elsewhere. However, what constitutes an immediate bottleneck for many of these countries' developments is secondary school graduates for training in the technical and skilled operative level in agriculture and industry. The problem can be tackled as has been done in Ghana by the allocation of more resources to secondary education than before. But it will take time for the teachers, especially in the scientific fields, to emerge.

Of even greater importance is the problem of political stability and the establishment of law and order. Now that most of the countries have become independent, they are faced with the problems of transition. The new institutions have not yet established their full authority. The energies of the leaders are therefore concentrated on political problems of nation-building, leaving them little opportunity to give full attention to problems of economic and technical development.

The bureaucracies trained in the old colonial school to regard their main function as maintenance of law and order are converting even more slowly to their new function of speeding up the economic development of their countries. However, it is noteworthy that the leaders as well as the people of West Africa are all anxious to transform their countries into modern nations. I believe that this enthusiasm for development which can be seen in the brisk and lively cities of the western coast, is perhaps the most important factor which will help clear away some of the problems of developments in West Africa.

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URBAN EXPLOSION IN DEVELOPING NATIONS

by Paul Mercier

In the majority of developing countries, the town (especially the large town) is an entirely new phenomenon which forced itself ruthlessly upon essentially peasant communities. These were village communities in which economic and social relations developed between horizons that were often extremely narrow. In these villages blood relationships were broadly the basis of much of the social life, attachment to the soil was of religious or quasi-religious significance and respect for tradition slowed down the effects of forces of social and cultural change.

The city thus offered an environment radically opposed to the traditional way of life. It is significant that in various regions of Africa south of the Sahara, for instance, visits to the city and a temporary stay have replaced to some extent the reputedly hazardous rites of initiation to which young men formerly had to submit before being admitted to a fully adult status in society. Contact with the city came to be considered as an experience par excellence of a foreign, difficult and hostile world, though one that none the less held many attractions.

For nearly all the developing countries entry into the modern world has meant the creation of towns: administrative centres in colonial territories, commercial centres everywhere and an at first limited number of industrial centres.

Economists were the first to emphasize the importance of these links with the economically-developed nations, links established by these countries for their own needs—as centres of political and economic domination in directly colonized countries or simply for economic control in others.

The limited integration of these towns with the regions they were intended to exploit rather than to serve was also noted. Even today this integration is only proceeding at a slow place. A similar lack of harmony is also found on the social and cultural level, though it is also true that migration to the city has done much to spread its influence widely within a short time.

At first the new towns were rather primitive, and they have still not outgrown this stage in many cases. Building over the urban as whole was sparse and somewhat haphazard. Residential sections looked more like overgrown villages or "encampments." (Today many towns are still unable to provide sufficient housing for their inhabitants.) The creation of municipal administrative services was in its formative stages as also was the labour market.

However, within the last few decades, and especially since the Second World War. many of these towns have diversified their activities and have reached a stage of partial consolidation. This process of diversification is extending today, especially in former colonial territories. The development of trade, industry and administration and of political and educational activities is increasingly combined in many towns.

Ibadan, capital of the Western region of Nigeria, is the largest purely African town south of the Sahara, with a population of nearly three-quarters of a million. Negro Africa's first TV station and Nigeria's first university are in this bustling, rapidly growing city where gleaming apartment and office buildings rise amid a sea of tin-roofed houses. Yet many of Ibadan's people still work as farmers.

The influence of the town as a centre for spreading standards, prototypes and new ways is now penetrating the rural areas more systematically. The development of transport and news and information media of all kinds helps appreciably to reduce the gap between town and country. Some plans for modernization and equipment show clearly the intention of making the towns and their resources the effective servants of the rural areas. Nevertheless, the stabilization of urban populations—essential for the creation of sound economic and social conditions—still creates difficult problems.

Most new towns have heterogeneous populations, heterogeneous from regional, ethnic, linguistic and religious points of view. Thus they facilitate contacts and the mixing of different elements which is especially important to countries striving to achieve unity. However, they are also the scene, for varying periods, of social tensions which sometimes turn into bitter conflicts between indi-

viduals, regional or ethnic groups or even between different castes.

This situation arises all the more frequently because of the lack of arrangements to assimilate these people in urban areas. The individual or group has therefore been driven to congregate with others of similar origin so as to enjoy familiar social relationships. These could to some extent be continued in town and help to lessen the shock of starting an entirely new kind of life. At the same time, the formation of associations of this kind, all aiming basically at mutual aid, partly compensated for the loss of the traditional kinship groupings which had been the very basis for existence in the past, but which could only subsist with difficulty in urban surroundings.

One of the main reasons for the intense migration to towns is rural over-population. However, this is not the only cause, and countries with a very low density of population offer equally spectacular examples of migration. The factors which come into play here include various kinds of social imbalance found in rural areas, economic regression due to special historical circumstances and direct and indirect constraints imposed in colonized countries to make sure of an abundant labour force, and even a manpower surplus which helped to support a low wages policy.

Although migration concerns a large part (often the majority) of the adult male population, most migrants do not settle permanently in towns or have no intention of doing so. Industrial labour studies show that in the majority of developing countries the numbers of men actually employed are small, but that the labour force is continually being renewed.

Industrial workers and town populations are basically of a shifting kind. Recruitment of workers for industry and urban jobs has a "partial" character. The village remains their real "home" and even those who settle more

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Replacing the shanty towns

or less permanently in towns return to the village periodically to visit their relatives, to help with the harvest, to take part in ceremonies and so on. They do not evade the social and religious obligations imposed by the village. Studies in India and Africa revealed many facts of this kind. While there is thus no complete rupture between the town and rural populations the temporary town dwellers or those who remain largely alien to their new environment are nevertheless inadequately equipped to meet the social and economic demands of the town

Migration to the town means a search for work—an often hopeless search, as many migrants discover. Most studies reveal a large proportion of unemployed and even more often, of non-employed persons. If the migrant does not immediately find employment, he stays in town knowing that he will always be able to subsist with the help of "relatives" he will find there.

The man who finds a job is a privileged person; relatives often come to live at his expense and he usually complies with the ancient, still surviving rules of family solidarity. This phenomenon of "family parasitism," found almost everywhere, is an obstacle to the raising of the standard of living of the worker and to any show of initiative by him. Yet at the same time it offers a spontaneous compensation for the effects of urban under-employment.

Some economists have referred to the transfer of under-employment from country to town. We shall return later to the question of the lag that can be observed between the rate of growth or urban populations and the rate of increase in the number of jobs. Not all town dwellers without regular employment are entirely inactive, but the work they do is of an unproductive kind—everywhere there is an abundance of servants, petty traders, middlemen and people who live by doing odd jobs. The enormous increase in the section of the population which does not earn regular salaries reveals the extent of under-employment in towns.

In urban areas which are still poor in resources and where productive activity lags well behind the increase in population, the housing shortage is always acute. Everywhere there are shapeless shanty towns. Even the man with a job often has no more than "a corner to sleep in," and overcrowding is a general rule.

EVEN where vigorous efforts are made to meet this situation there is only a very gradual improvement. Intensive speculation in land, housing and rents has been reported in many towns. Anything (even the "corner to sleep in") is let at an exhorbitant price. Rent eats up far too large a proportion of the budgets of the lowest income groups. This explains why seasonal migrants especially, but sometimes other categories of workers too, are ready to accept overcrowding and poor sanitary conditions or even to share accomodation with others on an "in rotation" basis. This situation, the result of rapid urban expansion, again reveals the limited degree of integration of the townsmen in their new environment.

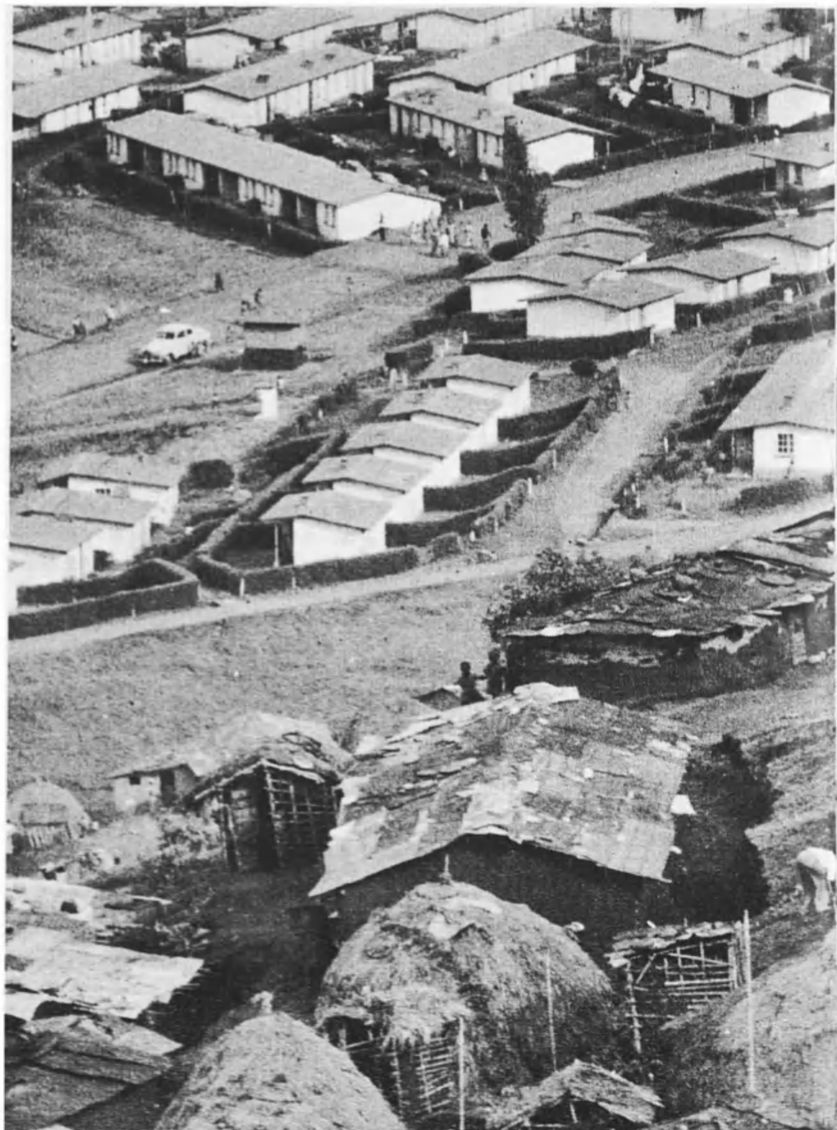
Having developed too quickly the town communities lack administrative structures and show signs of serious disequilibrium. Reports have referred to "formless masses of people." This is an exaggeration, although the fact remains that the individual does lack the social structures which he needs to support and guide him. The groups to which he belongs are unable to give him all the help he needs in the difficult choices confronting him and in his efforts towards adjustment.

Efforts are often made to establish traditional types of groups but these can never be more than fragmentary and relatively ineffective. The basis of a new social structure is still far from firmly established. The small family unit tends to replace the large family group, but this transition creates many problems because people are unprepared for the new kind of relationships which it involves between men and women, children and parents. The fragility of this social structure is only partially offset by the relations that are maintained with the large family groups in the villages from which the migrants came.

We must also remember that many towns had and sometimes still do have very unbalanced demographic structures because of the surplus of men, particularly young men. This is explained by the nature of the migrations and has often lead to a widespread growth of prostitution, along with other social disorders. A Society in which traditional standards no longer apply or are misapplied, in which new rules have not yet taken shape or are not yet properly understood, is a favourable breeding ground for many kinds of disease. In some cases there has been an alarming increase in crime and delinquency.

It has been said that the incorporation of rural peoples into the industrial work force demands a real effort of "conversion" on their part. This is also true of every kind of non-traditional work offered by the town. The migrant who gets a job finds himself facing an entirely new situation which includes a salary system, payment in cash and the breaking down of work into individual tasks. The new conception of economic and social relations in work is instilled only with great difficulty.

Along with the instability of the labour force one finds a lack of skill and low productivity due to a number of



physical, psychological and social factors. While the new townsman learns his job fairly easily, either by following a properly organized training course or "on the job" (which is usually the case), he has more difficulty in adapting himself to its context. His new work lacks the social and religious meaning of traditional occupations; it is specialized and he finds it hard to grasp the process as a whole. This, therefore, mitigates against the introduction of incentives to production.

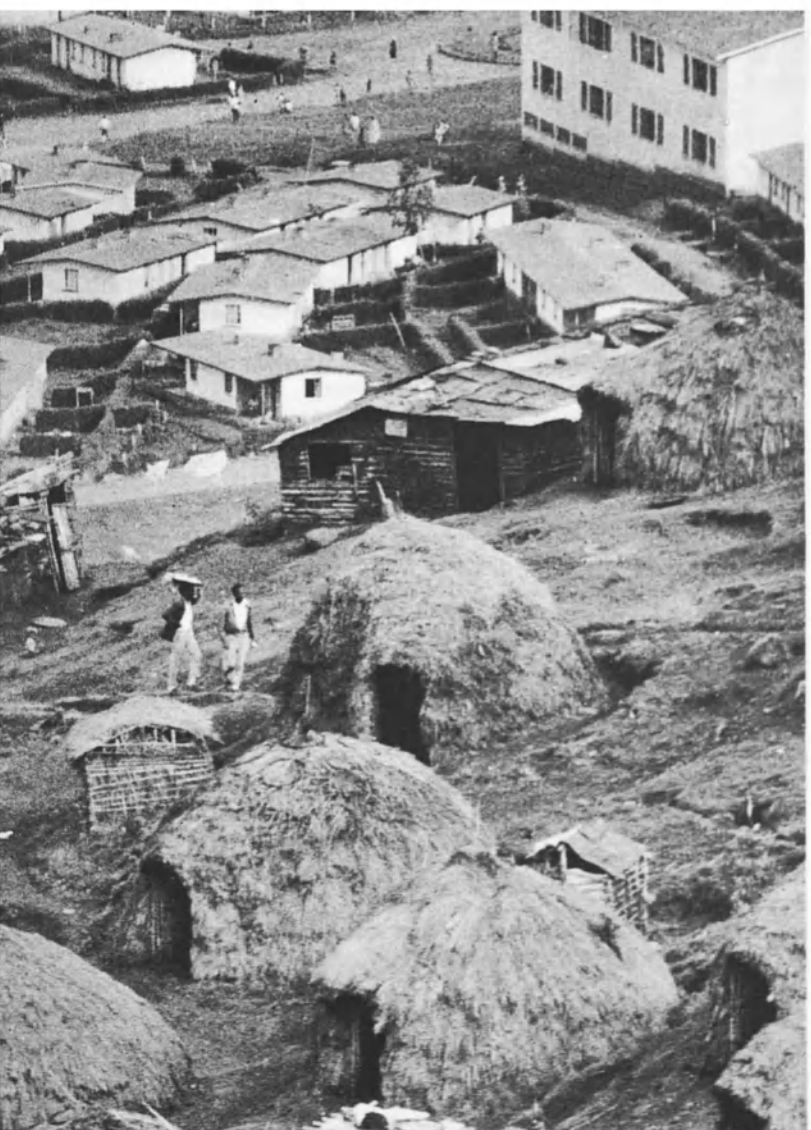
The worker, moreover, is not properly at home in an undertaking which is made up of heterogeneous working groups, sometimes managed by foreigners, and in which he often stays only a comparatively short time. The vocational training which many countries endeavour to develop must not only be vocational but must also comprise an element of "cultural adaptation." The efficacy of such measures depends largely upon the control of migration and by this fact is closely bound up with the whole process of development.

Towns are favourable breeding grounds for new forms of social stratification. Soon it is possible to distinguish several more or less contrasting types of townsmen. Even where a class structure has not fully developed—in present or former colonial territories, for example—the main social groups emerge by reason of their length of residence in town, level of education, professional qualifications, political activities, by their style of living (housing, food and recreational activities becoming status symbols) or by the ties maintained with traditional social forms and values.

This stratification, combined with the creation of new notions of prestige, produces a social breakdown very different from that prevailing in the old communities. The nucleus of townspeople who are firmly established, who have permanent employment and the highest incomes and who have adopted to a large extent the non-traditional ways of life, fills the top ranks of this social structure. These are the people who play a decisive role in political life, not only in town, but in the country as a whole. The town, then, is the chief formative centre of these modern elites and this is an important element of its prestige and of its attraction for the rural populations.

The control of migration to towns (the prerequisite of equilibrium and general development) implies both an expansion of the industrial economy and a rapid improvement in the situation of the rural areas, irrespective of whether or not they suffer from overpopulation.

STRAW IN THE WIND. Dilapidated shacks and straw huts contrast sharply with nearby neatness of new homes built at Katutu in the Republic of the Congo (Leopoldville). Housing is an urgent problem in Africa's burgeoning towns. Most have shapeless shanty towns and "encampments", the homes of hordes of migrants from rural areas.



The difficulties inherent in agrarian reform have already been mentioned. It is significant that those who draw up development plans often include only modest provisions for increasing agricultural production, as, for instance, in the case of India's first two national plans. Many targets, desirable but too costly, have in fact eventually to be abandoned. Except in very limited spheres, educational measures can only be expected to produce long term results. Even some technological enterprises which seemed not overambitious ended in failure because social changes which are part and parcel of such development were not taken sufficiently into account; this has happened in many regions of Africa south of the Sahara.

One good example of the difficulties inherent in the development of the rural economy is the mechanization, at least to a certain extent, of agriculture—one of the methods envisaged in many countries, as a way to increase agricultural production and in particular the production of foodstuffs in short supply.

Mechanization, of course, calls for considerable investment. But foreign or international aid is mostly directed to other sections of the economy, state subsidies are usually small and the ability of the local farmers to save money or to invest is very limited or even non-existent.

In the case of regions where highly profitable crops for export have been introduced, for example, when the revenue earned from agriculture exceeds the amount required for immediate needs, the surplus is used primarily to buy luxury consumer goods or goes on traditional items of expenditure. This is true of many African regions and the money amassed there is (economically speaking) more or less frozen.

Even if mechanization was financially feasible, it would still raise many other problems. It often demands structural changes in the community; people must be trained to look after the new equipment, and peasant habits must be changed. In addition, mechanization in tropical countries may cause still greater deterioration to already fragile soils.

Theoretically, the simplest solution is to increase the area of cultivated land and to put to use virgin lands. It has been said that in the case of Africa south of the Sahara this kind of expansion would be possible and would demand only slight technological changes.

In many regions of Africa, areas which had hitherto been uninhabited or only sparsely populated were turned to cultivation during the colonial period, though not with the aim of increasing the average agricultural production per inhabitant. This was done because the already cultivated lands were becoming exhausted and because new land was needed for bumper export crops which quickly impoverish the soil. Such use of virgin territories without the use of improved land care techniques and proper precautions resulted all too often in a squandering of frail soil.

But the case of Africa is by no means the most serious. In some parts of the world either it is impossible to increase the land under cultivation or such possibilities

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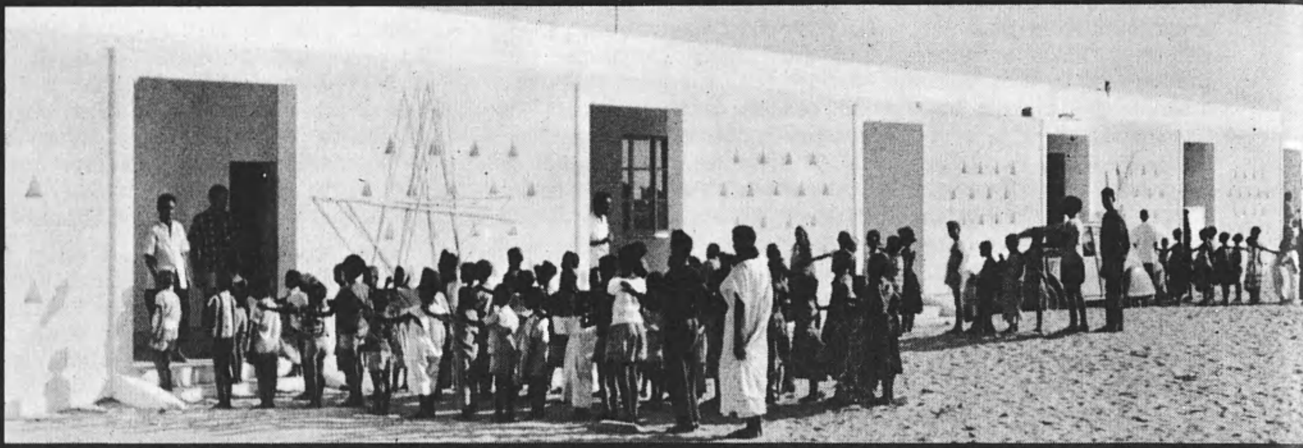
New capital in the desert



URBAN EXPLOSION *(Cont'd)*

Finding new jobs for migrants

are very limited. Egypt's territories outside the Nile Valley cannot be used for agriculture and this is also true of most of the Amazon Basin in Brazil. Even in regions where there are virgin lands their exploitation in the near future will only be possible where cultivation would not entail prior (and too costly) development of communications, irrigation and so on.

It will not be enough simply to throw these lands open for exploitation. The farmers who settle there will need to be led and educated—technically, economically and socially—and migration will have to be carefully controlled, otherwise the immediate benefits gained may well prove illusory.

While it is often difficult to increase the area of land under cultivation, it is possible everywhere to improve methods of exploitation within limits which vary according to each individual case. The dangers of overambitious plans have already been stressed. It is the small-scale agricultural projects, costing comparatively little, which have proved effective in many cases and which have quickly produced an increased yield—by better use of land in terms of its particular qualities, by improved farming methods and by changes in the system of crop rotation.

Larger scale measures which bring long term benefits are irrigation, soil preservation and the rehabilitation of worked-out land. These must be part of an overall plan. The importance of "a broad programme of small undertakings" has been stressed particularly in relation to irrigation. These individual efforts can be accomplished without recourse to large-scale investment and in the familiar setting of a village or group of villages.

This, of course, does not exclude enterprises on a grander scale such as dam building when funds and labour are available. But such projects often involve major changes in social and agrarian structures and also in the way people are housed. And this in turn calls for a concerted programme affecting the entire rural community.

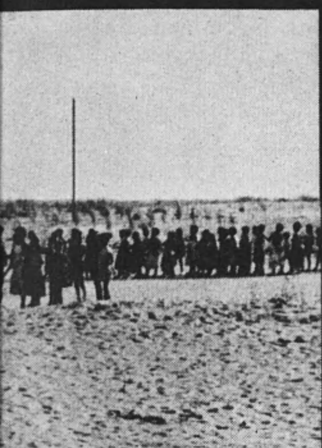
Soil conservation measures may include the use of "green manure" (although this modern technique often meets with opposition from traditionalist farmers) or of chemical fertilizers, though these are expensive and their use in tropical countries needs further study. In the immediate future it looks as though in many cases action will have to be restricted to teaching farmers how to care for their soil.

As regards long term measures, the restoration of exhausted lands for later use can often be achieved at low cost and with existing labour resources, by planting protective rows of trees and building low walls along slopes and so on. But efforts of this kind must be part of a future plan for the complete modernization of agriculture and an intensive educational programme.

Reference has already been made to the existence of a surplus population in areas now in the throes of urbanization and industrial development. This recent industrial growth has been unable to absorb the enormous mass of migrants who have come to the towns in recent

Three years ago, before the Islamic Republic of Mauritania came into existence, Nouakchott was a tiny hamlet, a halting place on the desert caravan routes. Today it is the capital of the Republic and with its new administrative buildings (left), homes and schools it is becoming a new African metropolis. Below, Nouakchott's children file into the classrooms of their modern school. Right, a young Mauritanian mother with her baby outside her newly-built home.

Photos © Paul Almasy, Paris



decades. The increase in the number of jobs is never more than a feeble percentage as compared to the rise in the urban population: about 3% in India, 5% in Africa and 6% in Latin America.

As the proportion of men of working age among the new town dwellers is very high, under-employment in the towns has actually increased. This problem is reflected in national development plans whose target figures for creating new fields of employment are enormous. The second Five Year Plan in India, for example, aimed at creating 15 million new jobs.

But targets of this importance are hard to attain even when priority is given to the development of industries which need large labour forces. Industrialization moves at a slower pace than should be the case, not only because of the general shortage of investment capital, but for other reasons as well. The absorption of individuals and family groups into an industrialized economy does not necessarily give them a higher standard of living. Actually it is often difficult to make statistical comparisons between the living standards of the wage-earning population and those of the rural peoples engaged in a subsistence economy.

A worker with a regular job is regarded as a privileged individual and his commitments increase accordingly. Below a certain level of industrialization the income of the vast majority of wage earners provides only for a precarious existence and does very little to reduce the poverty of the rural populations. The level at which the situation would be reversed is seldom reached.

Industrial development may be carried out in various ways depending on the particular conditions found in each country and upon the choices made by each government for economic and political reasons.

In countries where population pressure is not an immediately urgent problem the only kind of industrialization that can be envisaged (except in a limited number of fields) is a long-term one, priority being given instead to the technological and social transformation of the rural economy. In the majority of cases, however, both policies will have to be pursued simultaneously.

Industrial development aiming at the production of consumer goods is effective only in so far as the rural areas are capable of absorbing a substantial part of these goods. This in turn assumes that a number of conditions will be met. Agricultural production must rise above the ordinary level of subsistence in an ever-increasing number of regions. An adequate network of roads must be constructed. Distribution channels between producer and of industrially-produced goods on rural crafts must be borne in mind.

Finally, efforts must be made to bring about changes in the needs and demands of consumers (often very different from those of people in highly industrialized countries). This is a fundamental need, economically, socially and culturally. Consumer demand is only partially linked with the circulation of money and is only partially aimed at the satisfaction of individual needs.

But any educational effort in this direction will be meaningless unless it becomes part of a global attempt to introduce changes in the traditional ways of life of these peoples. Thus we see once again how necessary it is to consider both industrial development and rural development as an inseparable whole and also to avoid approaching either the one or the other from a too strictly economic point of view.

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HOMO SAPIENS— THAT STRANGE PARADOX

by Daniel Bovet

Nobel Prize for Physiology and Medecine

WHAT is science? What are we scientists trying to accomplish in the work we do in our laboratories and research? When we try to answer this question we come up against the two complementary aspects of the problem. On the one hand, science seen only as part of the development of rational thought and knowledge; on the other the contribution of science to economic and social advancement through the application of new techniques in industry, agriculture and communication.

Even though the classical opposition between pure and applied science is today out of date, the purposes and consequences of science cannot be totally divorced from these two aspects.

If the purpose of scientific knowledge is considered by some to be the enunciation of universal laws, to others it is nothing more than an instrument of practical action.

Whereas Henri Poincaré affirmed that "thought is no more than a flash of light in the darkness of a long night but it is this flash that is everything," Henri Bouasse, not without humour, supported the pragmatic attitude when he wrote "the scientist seeks a pattern into which the facts may be moulded, and science has but one justification for its extreme monotony: to serve an end."

When looked at in terms of economic development (where its results are most apparent) the answer to our question is relatively easy: the growth of new sources of energy, the advances made in telecommunications and methods of transport, automation in industry and factories, the rise in the expectation of life and the almost total disappearance of infectious diseases are but a few of the hundreds of obvious examples of the progress achieved by the second industrial revolution.

But this is not the most important consideration, and if we are not to overlook what is perhaps the crux of the problem we must recognize that the moral, social and even political revolution brought about by the recent development of science is as important as, if not more important than, the technological changes themselves.

Today scientific research has become such an important element of modern society conducted and exploited almost on a par with mineral or land resources, that a real effort must now be made not to forget that this capital asset is really no more than the ideas, the culture, the creative genius—I am tempted to add the flight of fancy—of a few men.

Thus if the stereotyped image of the scientist as a man in an ivory tower lost in incomprehensible experiments, little understood and the butt of many jokes, has not entirely disappeared, it is slowly dying and giving way to the modern notion of the "team of scientists" working in richly endowed institutes, forming a growing army of skilled investigators at the service of important industrial and governmental bodies.

One of the major results of the new policy of planning scientific research is the influence it will have, either consciously or not, on the ultimate equilibrium between the various branches of scientific research.

In the nineteenth century the most audacious theories of science came from the field of biology and it was here that the greatest battles raged between old and new ideas. In our present century the most spectacular and most revolutionary discoveries have been made in the physical sciences—microphysics and our knowledge of the universe. The scope of present-day discussions on both questions of theory and practice lead one to believe that the balance will continue to weigh heavily in favour of the physical sciences for some time to come.

But when we consider the enormous problems facing the biologist and the crucial importance for all mankind of the ultimate solution to these problems it would seem preferable to have the scales of the balance tip once again in favour of the life sciences.

I should like to recall at this point a hypothesis which I formulated some years ago concerning the history of the major trends in human thought. I called it "the hypothesis of the constant or invariability of grey matter". This hypothesis is based exclusively on the experimental method. Thus, of 100 rats raised in my laboratory only ten (or fifteen at the most) are capable of being taught even a slightly complex operation. If I train them to climb on to a perch at a given signal it is unlikely that they will learn to open a door. If I teach them to push a lever in order to get a drop of sugared water they often forget their other skills.

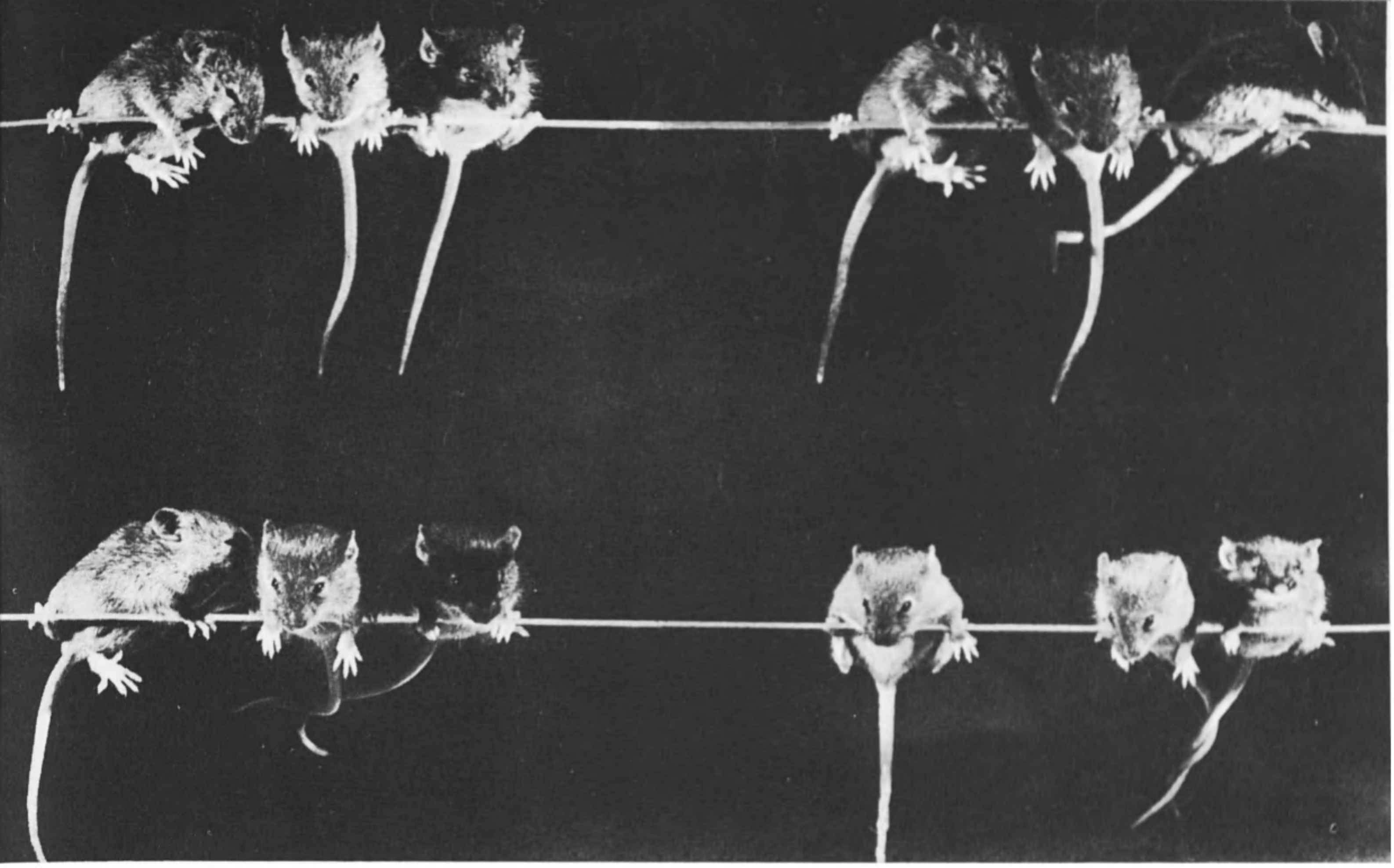
I have sometimes asked myself if this does not also apply to our own human society.

We know that certain colleges and universities have found themselves depleted of staff because of the serious inroads made upon them by industrial laboratories. Can we imagine what would happen if an excessive demand for physicists suddenly deprived us of good biologists and doctors? Do we not have examples in history where cities have suffered from a lack of good statesmen because everyone wanted to be an artist, or where the over-popularity of philosophy deprived a nation of leaders for its defence. This is a subject the reader might carefully ponder.

IT is no longer enough to proclaim that no sphere of knowledge can henceforth remain unexplored; we must also recognize our degree of ignorance regarding the many problems deeply affecting man himself. These embrace a broad field of subjects particularly the vast domain of the basic sciences, molecular biology and biophysics, research into intermediary metabolism and the science of nutrition, neurophysiology, the study of the information processes in the central nervous system, psychology and animal sociology in relation to the study of behaviour.

Man's noblest intellectual and cultural achievements have sprung from the human brain, the organ which controls our behaviour and thought and largely regulates our physical and mental well being. The study of the brain should, therefore, it seems to me, occupy a prominent place in research programmes and be carried out as a co-operative scientific enterprise both on an international and inter-disciplinary scale.

As for the field of pharmacology, particularly familiar to me, I feel that the time is now ripe for a concerted



WHO-Spooner

FROM MICE TO MEN. The behaviour of animals, of mice and rats in particular, has been widely studied by scientists. Biologists have gained valuable knowledge for the life sciences.

attack on the problems of therapeutics and mental and social hygiene just as the research drives of recent years have led to important breakthroughs that have vanquished disease and prolonged human life.

We must work for the prevention and treatment of the degenerative diseases of the brain, mental deficiency and the physical disorders of old age. Certainly after conquering a horde of disease-bearing microbes, chemotherapy is hardly less capable of attacking those more subtle spectres, our hallucinations and obsessions.

Not long ago a biologist formulated the hope that science would produce a "formula to make men good." I for my part believe that since man can never halt on the road of evolution he will be obliged in the future to resolve his own dilemma by choosing between the "Soma" of Huxley's *Brave New World* which will plunge him into a state of stupid beatitude, and the pill which will make him more intelligent by developing his learning capacity and power of retention.

Since I have espoused the cause of biology I dare say I gladly support the seeming paradox which maintains that it is through the study of animal behaviour that we should embark on the study of the human sciences. And I am convinced that biological research offers us the clearest road for understanding how the development of his own knowledge can in fact modify and enrich man's vision of his own destiny.

In human terms then what can we foresee as the result of this new "Operation Scientific Research"?

In contrast to Jean-Jacques Rousseau who denounced the corruption of morals engendered by science, the Encyclopaedists saw in scientific progress the one great hope for mankind and the *raison d'être* of all our endeavours. In the centuries that followed, Rousseau won numerous new supporters as the world witnessed the extraordinary development of science and technology. And even today there are still those who point an accusing finger at science. The narrow intellectual sphere in which the scientist works is roundly denounced and certain groups have even gone so far as to see in the machine and automation a "world conspiracy against all inner life," accusing the scientist of depriving man of his "soul."

And yet the value of science in forming and developing the individual is evident to us every day as teachers. We see it in the drive, the enthusiasm, the perserverance as well as the will and spirit of abnegation of our students and colleagues; we see it in action among our fellow scientists in universities and research institutes; we see it in the determination of so many of them to be an active part of the society they live in, convinced that their deep faith in a supreme truth will help to achieve a much broader ideal of human justice. As scientists we are filled with the feeling that we have received a parcel of the wonderful heritage bequeathed to us by our masters, and which, transcending those now living, continues to enrich us after four centuries of a long, prodigious tradition.

Why is our age, which is barely over the threshold of immense new sources of energy, gripped by a sensation of helplessness bordering on despair? We are so disillusioned by the experience of two world wars and their long aftermaths; so obsessed once again by the feeling of insecurity and so deeply troubled as members of society, that it would seem our generation has lost the courage and the will to believe and work for peace.

As men of science we must proclaim loudly not only that science is not solely responsible for all the evils of our day but that some of the greatest accomplishments of the post-war period have been brought about by science.

Confident as I am in a new humanism, I believe that we can have no sober constructive vision of the future if it is not based on a rational approach to reality, recourse to science to solve the problems facing us, and the search for an ideology and technology worthy of man.

DANIEL BOVET, *of Italy, won the Nobel Prize for Physiology and Medicine in* 1957. *He is director and founder of the Therapeutical Chemistry Laboratory at the Institute of Health in Rome.*

INTO THE W

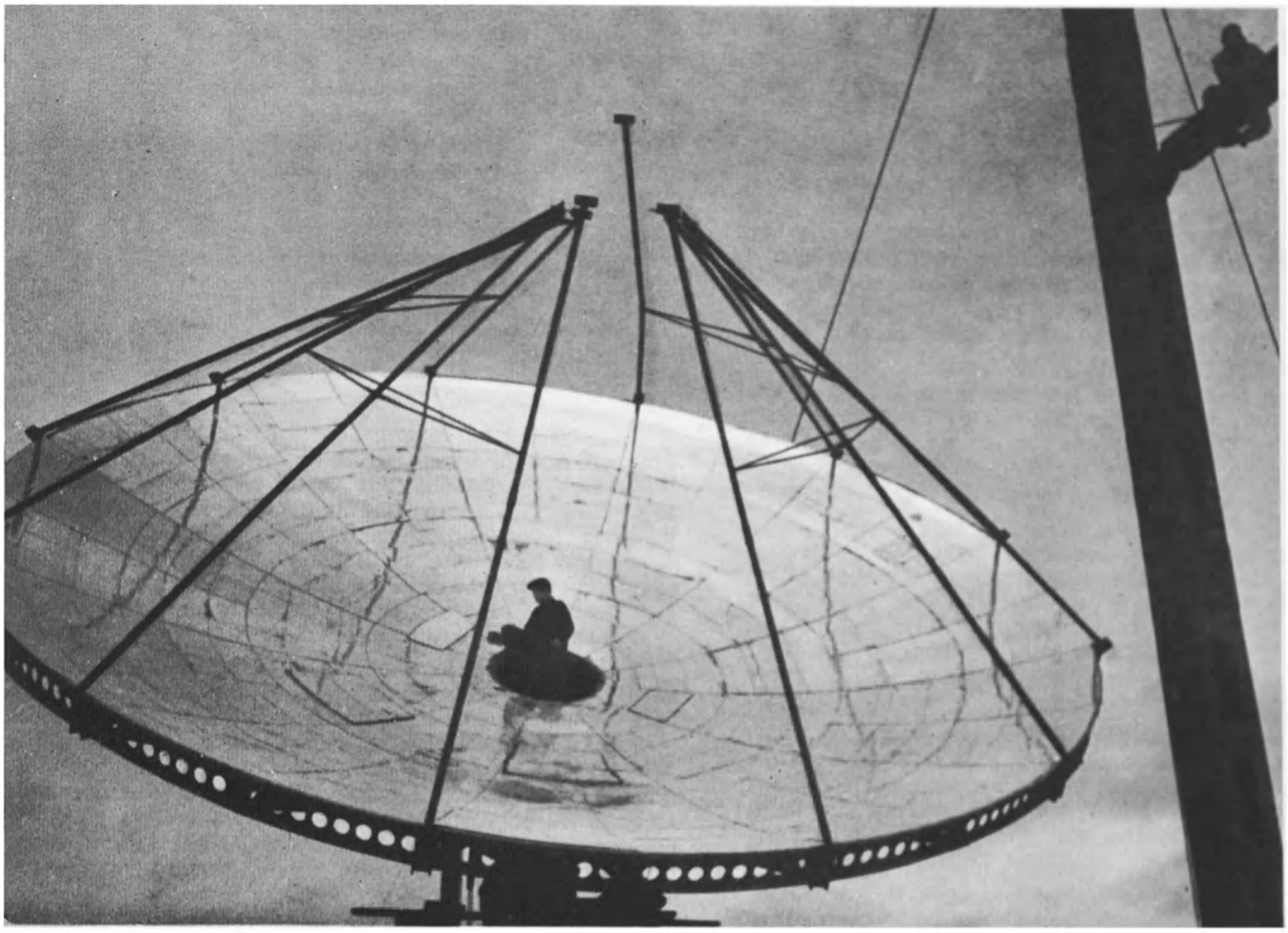
CSF, René Bouillot

Two symbols of today's vast scientific revolution. Above, telemetering equipment for tracking the orbits of satellites in space. Opposite page, completion of a huge parabolic mirror used in helio-technology to capture the rays of the sun and turn them into useful energy.

ORLD OF THE FUTURE

by Nicolai Semenov

Nobel Prize for Chemistry



Soviet photo. SCR photo library. London

WHAT will the world be like 20 or 40 years hence, at the close of the century? What levels, so far unimaginable, will science and technology attain by that time? And what fundamental changes will this have wrought in the world economy? In this age, when science is moving ahead with such amazing speed, it is impossible to predict new scientific discoveries. But we can foresee, with a certain degree of probability, the very considerable practical consequences of scientific trends that are already apparent.

The 19th century is often described as the age of steam and electricity. How are we to describe the 20th century? As the age of nuclear energy, of the conquest of the air and of outer space, of plastics, of radio, television and electronics, or of cybernetics and electronic computers, of chemicalized and mechanized agriculture, of new medical compounds and longevity?

Modern science is ceaselessly producing new and varied types of technique and new kinds of production. The 20th century is characterized not only by the great increase in the volume of scientific knowledge but by the qualitative change in the character of science itself.

Comprehension of the inner structure of matter, the attack on the inner regions of the atom, began in the first 20 years of the 20th century and it was that which started this revolution in natural science. This understanding of the internal structure of matter has made it possible for us consciously to determine some of the characteristics of some materials.

In chemistry this has led to a new method of synthesis, by which we can create new compounds and improve the technology of producing previously known substances.

In physics it has led to a great number of new discoveries in the field of solid bodies, of which we shall mention only a few. They are the emission of electrons under the influence of heat and irradiation by light; the discovery of semiconductors with their astonishing electrical properties; the discovery of the phenomena of the transmission of energy in a solid body and, connected with it, the possibility of coherent radiation of a narrow

CONT'D ON NEXT PAGE

Brief encounter with an 'anti-man'

beams of light and short radio-waves in the so-called lasers and masers.

All this led to the creation of new techniques in very different forms. For example, the discovery of radio-waves, predicted by Maxwell and made by Herz in the 19th century, has acquired very great technical significance only as the result of the application of the discoveries of physics in the 20th century. New fields of science and technology have appeared, such as radiotechnology and electronics.

Many wonderful discoveries were made as a result of the study of the atomic nucleus. When nuclei are being formed a tremendous amount of energy is liberated from the protons and neutrons as a result of the nuclear forces between them. According to the well-known equation formulated by Einstein on the equivalence between mass and energy, the energy liberated corresponds to the loss of mass. Depending on the content and the structure of a nucleus the concentration in the nucleus varies, as a result of which different nuclei have different losses of mass which can be measured. This loss of mass is called the mass defect.

In nuclear reactions the less the mass defect of the initial elements, the greater the energy released. I feel confident that the day is not far off when we shall be able to achieve a controlled thermonuclear reaction which promises quite unprecedented prospects for the development of world energy.

Our galaxy consists of substances built of protons and neutrons in the nucleus, and electrons in the shell of an atom. However, there is a possibility that some other galaxies are made of anti-substances, of anti-protons and anti-neutrons in the nucleus and positrons in the shell of the atom. In these worlds anti-particles will be stable and our particles will be unstable.

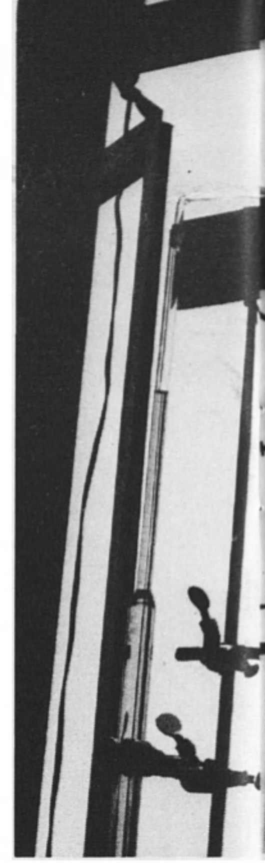
It is noteworthy that all physical and chemical qualities of the atom will be identical in both worlds. In these other worlds we might find the same chemical combinations with the same structure and qualities and it is quite probable that living matter and even human beings similar to those in this world may exist there.

Imagine the meeting of a man and an anti-man somewhere in space. They will be able to study each other and even become bosom friends, but they will not be able to touch each other. If they should try to do so, they would both explode with a power considerably greater than that of a thermonuclear bomb...

THERE need be no doubt that coming decades will see a powerful upsurge in physics which, as is always the case, will have as its "end" result very important technical achievements. In fact, I believe that two fundamental problems stand out in modern natural science. The first concerns the theory of elementary particles in physics, or, in other words, the problem of the primary particles of matter. The second, in contrast, concerns the structure and behaviour of highly organized matter in biology and chemistry.

Animate matter is the most highly organized matter. The revolution which began in physics, and partly in chemistry, in the early years of the century, reached biology about half a century later, some 10 or 15 years ago. Working in concert with physicists and chemists, biologists began to penetrate the inner physical and chemical foundations of the amazing phenomena of life. In these fifteen years we have obtained highly interesting scientific results, and the pace of research is constantly being increased.

Just as in the case of the study of atomic structure, these major scientific discoveries have not had, and probably will not for some time have, serious practical results. But it is beyond doubt that sooner or later they will lead to revolutionary changes in medicine and agriculture. For instance, I feel sure that the problem of cancer can be solved only by developing this trend in biology. And I am equally certain that research in the mechanism of physical and chemical processes in vital activity will likewise lead to a veritable revolution in chemistry.



The very real dangers of air pollution resulting from industrialization are now being studied intensively by scientists in all parts of the world. Here, samples of air are analyzed in a laboratory in Mexico. Universal application of electric power in the future would drastically reduce—even perhaps eliminate altogether—the emission of harmful gases and dust into the atmosphere.

© Paul Almasy, Paris

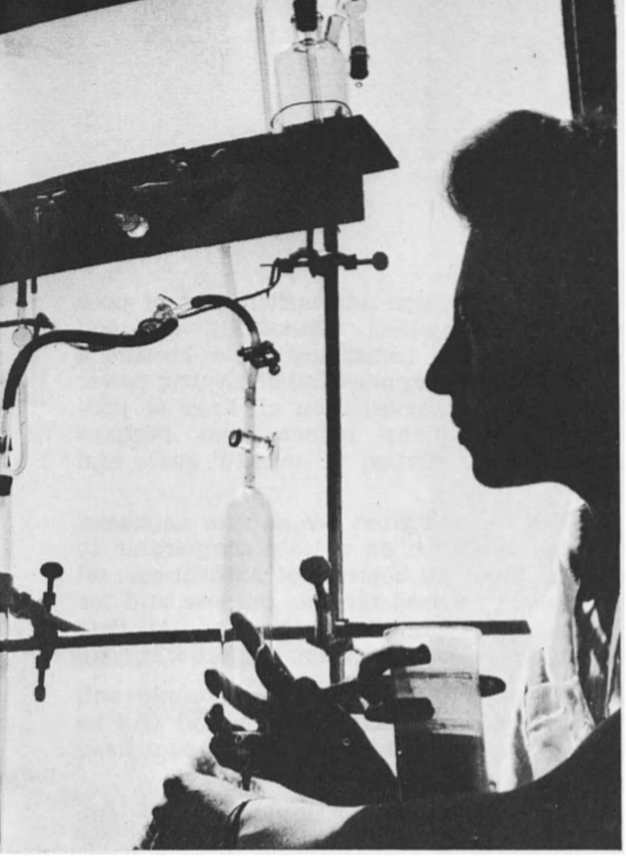
By applying the same principles to inanimate matter we should be able to create catalysts of unprecedented power and specific properties, notably for photochemical processes. We should also be able to design fundamentally new types of machines which, working like muscles, will directly and efficiently convert chemical energy into mechanical energy, etc. That is why I believe that the problem of highly organized matter is the second main problem in the decade ahead.

It is very characteristic of modern science to make a profound investigation of the internal structure of matter and to produce on this basis new unprecedented techniques and new types of production. Research which now seems very abstract and of no practical application, such as the investigation of the properties of matter, sooner or later leads to revolutionary changes in industry. The more purely scientific the research appears, the greater the changes that result. The research that seemed most abstract of all turned out to be that which produced the greatest practical results—the discovery of atomic and thermonuclear energy.

Here, I can only give a brief outline of the gigantic prospects opening up before mankind as a result of the further development of science and its practical application.

Available sources of power, notably electric power and deposits of coal, oil, uranium, thorium, and water power resources will not last forever. They are gradually being exhausted, and though the reserves are great, they are nevertheless limited. In addition, the mining of coal, uranium and thorium, even with maximum automation, will always involve strenuous working conditions. The question therefore arises of the new, more powerful and practically inexhaustible sources which could be developed with relative ease.

At present there are three ways of solving this crucial scientific and technical problem: (1) by controlled thermonuclear reaction: (2) by the utilization of solar energy; and (3) by the utilization of the underground heat of the magmatic stratum below the earth's crust.



Controlled thermonuclear reaction would open up altogether new and incomparable vistas for the human race. However, it seems that a continuously controlled thermonuclear reaction is practically impossible because it releases such tremendous heat and such high temperatures to sustain itself that the walls of the "thermonuclear furnace" would be immediately vaporized.

But physicists have suggested the principle of magnetic isolation, which reduces heat radiation through the walls and makes the process feasible in principle. By using a powerful current impulse they have succeeded in obtaining temperatures close to those required to start a thermonuclear reaction and test the principle of magnetic isolation.

However, to start a self-sustained thermonuclear reaction we shall have to obtain considerably higher temperatures. There are also many other major difficulties, for instance, the problem of effective magnetic isolation in a continuous thermonuclear reaction.

Controlled thermonuclear reaction has not yet been achieved. Undoubtedly its achievement calls for new ideas, new departures. It is hard to say when this cardinal problem will be solved, tomorrow or many years hence. But I believe that solved it will be, and within this century. For all the experience of modern science shows that what is possible in principle soon becomes possible in practice.

Very great prospects would be opened to mankind if we learned to transform solar energy into electric energy with a high efficiency standard. The sun sends to earth 4×10^{13} calories per second. Most of this solar energy is diffused or absorbed by the atmosphere, particularly by clouds. An average of only 30 per cent reaches the earth's surface in any given year—a little more in southern latitudes, a little less in northern latitudes. Yet even one-tenth of what reaches the land surface would suffice to generate thousands of times more power than we have today. This is the second major potential power purveyor, and one that will always be there and will never require mining or expenditure of fuel.

In principle, 100 per cent of solar energy can be converted into electricity, but we are not likely ever to achieve this in practice. However, the progress in photoelectric and thermoelectric research should, within a few decades, enable us to devise new photo- and thermoelements and find special catalysts of photochemical processes. This, in turn, should make it possible to convert solar energy into electricity with an efficiency rate of 30 to 40 per cent. I am convinced that the problem of utilizing solar energy for power purposes can and will be solved before the end of the century.

The third potential and practically inexhaustible source of energy is the underground heat of the magmatic strata of the earth, located about 30 kilometres below the surface and much nearer under the ocean bottom. The chief problem here is effective and economical technological methods of deep boring. Recent years have seen revolutionary changes in boring techniques, but many formidable technical problems have still to be solved before we can tap these underground heat depositories.

Several countries are working on new methods of deep boring, and in some cases they are actually being applied. Given an abundant supply of low-cost electricity and improved transmission techniques, we should be in a position to replace boring by the melting of rock and extraction of the melted substance.

And so, in addition to coal, oil, uranium and thorium, we have other, much more potent suppliers of energy. If we put them to efficient use, all the power requirements of the world's growing population will be fully met, for these new sources are practically limitless. But they can be utilized only if there is a vigorous and concerted effort by scientists and technicians, and, needless to say, by all the peoples of the world.

Thus, I feel sure that by the close of the century all three new sources of energy will have been put to work and the first thermonuclear, solar and underground generating plants will have been built. The 21st century will see the mass construction of such plants. That will bring electricity to every inhabitant of the world, in virtually limitless quantities.

With a superabundance of electric power at its disposal, mankind could tackle and accomplish other, even more ambitious tasks. One example is the regulation of the earth's climate. Temperature and rain control could turn our planet into a flourishing garden.

The auspicious beginning of space travel poses another problem, one which today seems rather far-fetched. I refer to the possible role of thermonuclear energy in the exploration of Mars and other planets of the solar system. We know, of course, that Mars has an atmosphere but, in the first place, it is much more rarefied than the Earth's, and secondly—and more important—it contains a very small proportion of oxygen. Apparently there is water on Mars, but in relatively small quantities. The climate is colder than the Earth's, and that would be an additional drawback.

Let us consider whether or not it is realistic to create on Mars, within a relatively short period (say, a few decades) conditions that would support life. The first requirement for this is to obtain several hundred trillion tons of oxygen, to bring Mars's oxygen content near to that of our own atmosphere. Oxygen can be produced from the water we shall find on Mars. Calculations show that if we build thermonuclear power plants on Mars capable of generating ten thousand times more electricity than is now produced on Earth, and if this energy is used for the electrolysis of water, then we should be able to accumulate the needed oxygen in a few decades.

I do not know whether mankind will ever need to do that. It may well be that it will find better employment for its superabundance of power. But I cite this example to indicate the majestic aims mankind can set itself once it has inexhaustible sources of energy.

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Transistor network on the moon

In discussing the practical problems involved in exploring the solar system, I should like to go a step further in my fantasy and examine opportunities for utilizing the moon to supply power to our planet. The moon is 16 times smaller than the earth, but since it has no atmosphere it gets three times more solar radiation, per unit of territory, than the earth. Consequently, in terms of solar energy absorption, the moon is equivalent to one-fifth of the earth's surface or, what amounts to the same thing, gets nearly as much energy as all our continents.

Thus, if we were able to cover the moon with a network of high-efficiency transistor photo-elements, and if, in addition, we devised ways and means of transmitting this energy (say, via directed radio beams), then the moon would become a huge generating plant serving the earth. It might also become a suitable location for nuclear and thermonuclear power plants that could rid our earth of all radioactive contamination.

Utilization of thermonuclear and solar energy and of underground heat would naturally involve fundamental changes in industry, agriculture and what we sometimes describe as household service. Inorganic chemistry, metallurgy and the building materials industry would, in the main, use high-temperature reactions and arc discharges. There would also be a sharp increase in the use of electrolysis techniques. Super-high temperatures would be obtained either through arc electric furnaces or from thermonuclear reactor waste gas, heated to several thousand degrees.

For example: nitrogenous fertilizers would be obtained chiefly from the air, through a synthesis of nitrogen oxides. All the elements of the Mendeleyev Table could be produced either by electrolysis or by decomposition of ores, effected by high-temperature thermonuclear reactor waste gases. In fact, the very concept "ores" would change, for any combinations, notably those that have not been used hitherto because of their chemical inertia, could be employed as "ores."

On the other hand, utilization and enrichment of poor ores would be greatly simplified. Essentially, any soil treated by high-temperature techniques could become a building material. Universal application of electric power would lead to maximum automation in all lines of production and would drastically reduce—even perhaps eliminate altogether—the emission of harmful gases and dust into the atmosphere.

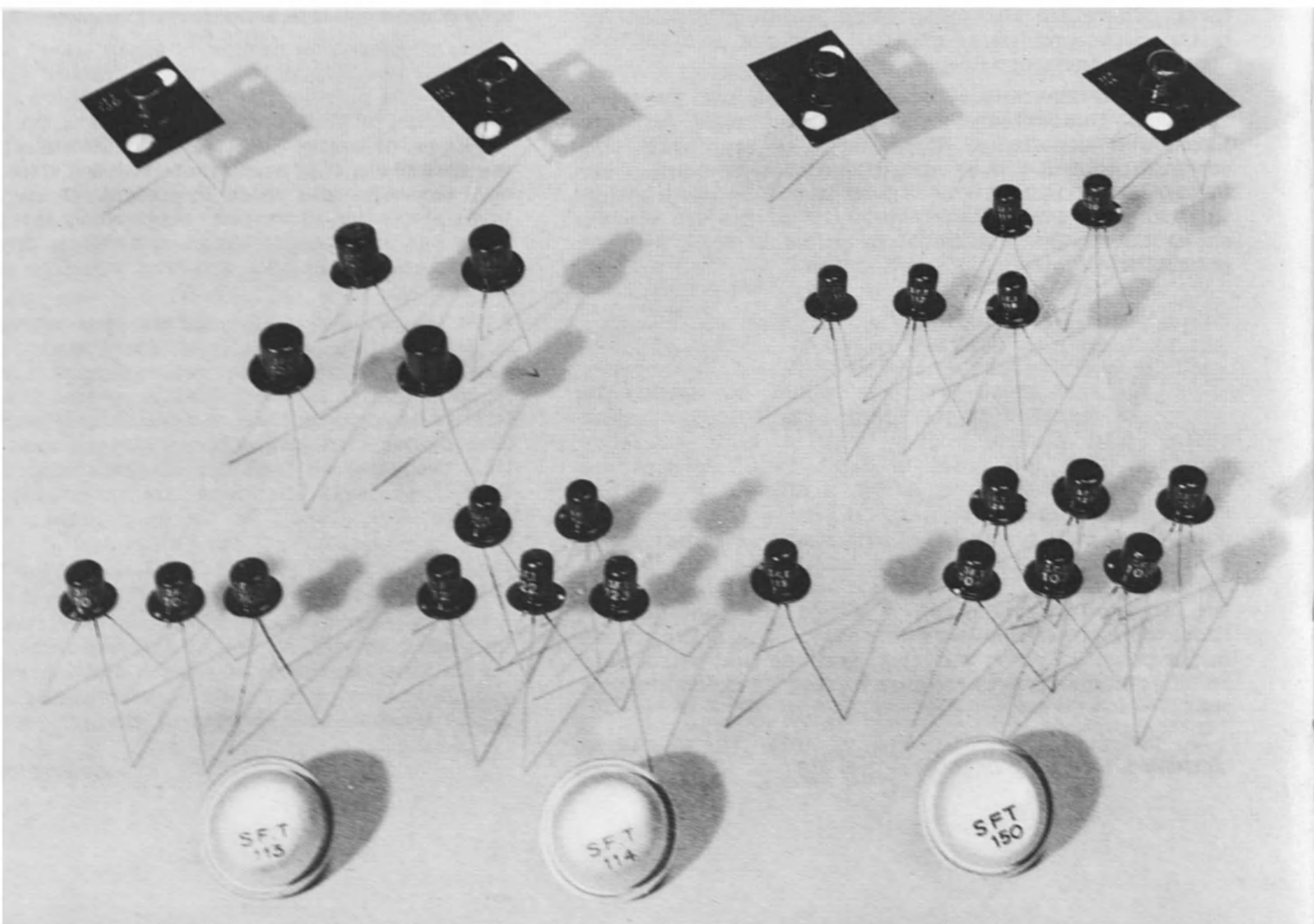
There would, of course, be a great demand for polymers, and their production would be on a scale comparable to the production of metals. All deposits of natural gas, oil and some of coal would be used for this purpose and for obtaining a wide variety of organic substances. All that will be possible when electricity replaces gas, oil and coal.

However, despite total electrification, there would still be automobiles, aircraft and rockets; they would still be using liquid and gaseous fuels; there would still be a need to produce substantial quantities of oil and gas.

The problem can be solved by (1) producing synthetic fuel from inorganic raw materials. This can be done, for instance, by employing electric techniques to obtain hydrazine from nitrogen and hydrogen; (2) by using carbon dioxide and hydrogen for an artificial synthesis of conventional fuels.

Agriculture and the food industry would be electrified and automated throughout. When we have a superabundance of cheap electricity, the production of fertilizers, as I have already pointed out, will be greatly simplified and enlarged. Irrigation, too, would be expanded, by using plastic sheets to retain moisture, both under and over plants.

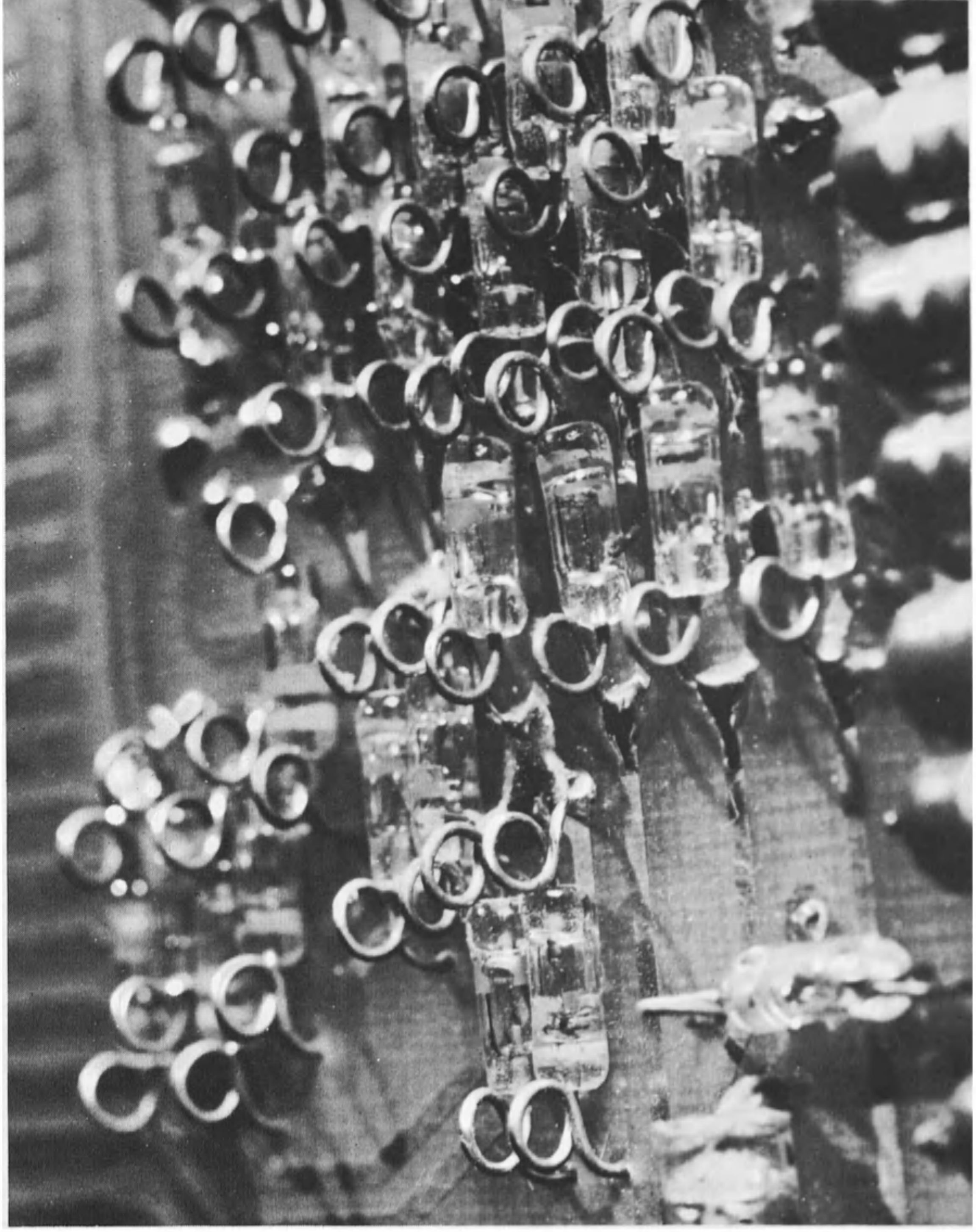
Another development would be soil heating in northern areas and a vast expansion in hot-house cultivation. Combined, these methods would produce high harvests and, in many areas, two harvests annually. Lastly, electricity would be used on a very large scale to augment our fresh-water supply from seas and salt lakes.



ELECTRONIC MARVELS

Today's gigantic technological achievements often have as their basis the tiny electronic components in these photos. Transistors, opposite page, and diodes, right, are the miniature amplifiers and detectors for which almost limitless uses have been found wherever electronics is needed, be it in TV, radar, atomic energy equipment, electronic computers, aeronautics, space research and automation processes in industry. Diodes shown here are sealed glass tubes only six millimetres long, containing a single wire solded to a germanium plate.

Photos CSF, René Bouillot



There is no need to dwell on the fact that electricity adds to our comfort. I will, however, mention two beneficial developments: electric heating and air conditioning in every home in every part of the world.

Universal automation would reduce the working day to three or four hours, leaving many hours for sports, gardening, amateur theatricals, art, literature, civic duties, and for research in excellently equipped public laboratories, which would become centres for bringing science to the people and ensuring its continuous development.

That is how I visualize life in the 21st century: an age of total electrification. That is my vision of the heritage we can and should bequeath to our children, grandchildren and their children.

The ideal of social progress can be approximately defined in the following way: the maximum happiness for the maximum number of people, for almost everybody. The first precondition for this is naturally the full satisfaction of the material and cultural needs of every man on earth.

However, the satisfaction of material needs alone is not enough for a happy life, though it is, of course, the main and necessary precondition for the full spiritual activity of man. But by his nature man is also a creator of material and spiritual values. The need of creative activity is not only one of the noblest but also one of the most important fundamental and ineradicable needs of *homo sapiens*. So our greatest task is to bring varied creative activities within the reach of the mass of the people.

Some people may not agree with my understanding of happiness; they regard happiness not as a creative but as a passive thing. Others regard happiness as a turbulent thing arising out of work or leisure. But I personally believe that such views of happiness are due to spiritual poverty or to the lack of the social conditions necessary for the discovery and development of the creative talents which exist potentially in every normal man.

In a word, to demonstrate his creative ability and to get pleasure from doing so, every man must have a certain level of knowledge, of mental and emotional development, of æsthetic taste, and a moral attitude towards society and himself. This can be achieved if such economic and social conditions are created as to ensure an all-round development of people and their creative labour.

NICOLAI SEMENOV, *Soviet physicist and physical chemist, was the winner of the Nobel Prize for Chemistry in* 1956. *A member of the U.S.S.R. Academy of Sciences, he is professor of physics at Moscow State University.*

From the Unesco Newsroom...

DEPUTY DIRECTOR-GENERAL FOR UNESCO: Dr. Malcolm Adiseshiah, who has been an Assistant Director-General of UNESCO since 1954, has now been appointed as UNESCO's Deputy Director-General. Dr. Adiseshiah, of India, joined UNESCO in 1948. He has been especially concerned with the development of technical assistance activities and has played an important role in the etablishment of educational plans for Asia and Africa.

DIAL 'BOOKS': Thanks to new automation techniques, homes in the U.S.A. will in the next ten years be tied in through equipment no more complicated than the average telephone with local libraries, through them to regional centres and finally to a national centre. All information in these libraries will then become directly available to the householder or businessman. This future prospect is described in a report, "The Library and Information Networks of the Future", prepared by the American Library Association.

UNESCO-SPONSORED COURSES : An international course on soil science and plant biology sponsored by UNESCO will be held at the Universities of Seville and Granada between October 21, 1963, and May 7, 1964. Another UNESCO-sponsored international post-graduate course, in Probability Theory and Mathematical Statistics will open at the Hungarian Academy of Sciences in Budapest on October 15 and will continue until May 15, next year.

WORLD CLASSICS TRANSLATED: Thirty-six classics of world literature are being translated into the principal Indian languages by the Sahitya Akademi (Indian National Academy of Letters). The works include plays by Moliere and Shakespeare, Machiavelli's "The Prince" and works by Thucydides and Confucius. In appreciation of this contribution towards its projects for the mutual appreciation of cultural values in the Occident and the Orient, UNESCO has donated $5,000 worth of printing paper to the Academy for the publication of the works.

ART FILM FESTIVAL: A festival of films on art sponsored by the Canadian National Commission for UNESCO was held in Ottowa recently. At a seminar which accompanied the festival, international specialists led discussions on the use of the film in the study of art, the challenge of TV, and problems of preview, distribution and programming.

DISAPPEARING GRIZZLIES: If Americans were to choose a national animal, says the National Audubon Society, in the United States, the grizzly bear might well win the honour. Yet today grizzlies are being killed off so fast that no more than 600 are left, all but a few in the state of Montana.

RADIOISOTOPES FOR ARAB LANDS: A regional radioisotope centre recently set up in Cairo under the auspices of the International Atomic Energy Agency will be responsible for promoting the use of radioisotopes in Arab countries in the fields of medicine, agriculture, hydrology and industry.

AFRICAN UNIVERSITY EXCHANGES: Six African universities have agreed to join a programme of student exchanges suggested by the University of Ghana. They are higher educational institutions in Tanganyika, Sierra Leone, Morocco, Uganda, Ivory Coast and Ethiopia.

LESSONS BY POST: Correspondence education in the United States has undergone a phenomenal growth in the past few years. There are now 59 accredited private home study or correspondence schools enrolling some 800,000 students from the U.S. itself and many countries around the world. Subjects range from agriculture and accounting to zoology. There are courses for practically all ages and those with special needs, including the blind and handicapped.

INTERNATIONAL SCHOOL FOR IBADAN: An international secondary school which aims to prepare African students for higher education will be opened in October in Ibadan, Nigeria, by the University College. The school will be co-educational and its curriculum will include additional specialized courses such as Nigerian languages, home economics and religious studies. Pupils will also be encouraged to join "hobby" classes. Special efforts will be made to link the school with those in other countries.

HOMAGE TO FIRST SPACEWOMAN: In a statement congratulating the Soviet Union on the success of the twin space flight of the cosmonauts Valery Bykovsky and Valentina Tereshkova, UNESCO's Director-General, Mr René Maheu declared: "It is the human aspect of this exploit—the presence aboard one of the vessels of the young Valentina Tereshkova—that grips one's imagination. Above all, it is a magnificent example of intelligence, endurance and courage, demonstrating that woman is fully man's equal."

CYPRUS CENTRE FOR WORK-CAMPERS: On a site close to Nicosia, in Cyprus, members of the International Student Movement for the United Nations, working with Cypriots, are laying the foundations of a training centre for work-campers from countries in the Eastern Mediterranean region. The centre will offer courses in the theory and practice of international voluntary service, particularly in community development.

POLIO CASES DOWN: The number of known cases of poliomyelitis in the world was reduced by about 65 per cent between 1954-56 and 1960. In Asia, however, the drop has only been 25 per cent and in Africa the number of cases has actually risen by 10 per cent.

TWO MILLION COMPUTER EXPERTS: Within the next 20 years the Soviet Union will need at least two million computer programmers. Work is already beginning on the training of this army of specialists and many secondary schools now include the use of calculating machines in their studies.

News Flashes...

■ *An estimated* 150 *million people suffer from bilharziasis, a serious disease of the tropics caused by snail-borne parasites and passed on to man through rivers and canals in which the snails live, reports the World Health Organization.*

■ *East Africa, which scientists used to consider an earthquake-free area, probably has between* 2,000, *and* 3,000 *local tremors a year, according to a team of* UNESCO *experts who toured the region recently.*

■ *Forty-six countries have now joined the* UNESCO-*sponsored Universal Copyright Convention designed to fill gaps in existing international copyright laws.*

■ *The* UNESCO *Kalinga Prize for the popularization of Sciences has been awarded to Mr Gerard Piel, American science writer and publisher of the "Scientific American", who is the* 11*th winner of the prize.*

THE UNESCO PHILATELIC SERVICE

A slender figure of a bird formed from palm leaves has been used as the design for this 13 cent airmail stamp issued, along with two other airmail stamps in 6 cent and 8 cent denominations, by the United Nations Postal Administration on June 17. As agent in France of the U.N. Postal Administration, UNESCO's Philatelic Service stocks all the U.N. stamps and first day covers currently on sale, and those issued by UNESCO member states to commemorate important events in the history of UNESCO and the U.N. For prices and further details write to The UNESCO Philatelic Service, Place de Fontenoy, Paris (7e).

SCIENTISTS ABROAD

by *Alan J. A. Elliott*

About one third of all fellowships and scholarships offered for study abroad are awarded in the fields of science and technology. This has been revealed by successive analyses of the offers listed in *Study Abroad,* Unesco's international handbook on fellowships, scholarships and educational exchange.

The thirteenth edition of *Study Abroad,* which gave information on awards available in 1962 and 1963, listed over 130,000 individual opportunities. Of these about 10% were for the study of mathematics and natural science. And about 20% were for the study of applied sciences and technology, including engineering, medicine and agriculture. For the sake of comparison, about 14% of awards were offered in the social sciences, and nearly 16% in humanities, liberal arts, linguistics, literature and history.

This means that at least 40,000 scientists and technologists received awards for study abroad during the academic year 1962 alone. In practice the figure may be considerably higher, because 25-30% of the offers made in *Study Abroad* do not specify a field of study. Although the actual allocation of awards is not known with any great accuracy it would be safe to say that at least a quarter of these awards, amounting to about 10,000 were also made to scientists.

Actual examples of fellowship programmes listed in *Study Abroad* are extremely varied. They include the programmes of the Food and Agriculture Organization, Unesco, the World Health Organization, and other organizations of the United Nations system. There are also the programmes of other intergovernmental organizations such as the European Organization for Nuclear Research and the International Computation Centre.

Non-governmental organizations—such as the International Union against Cancer and the International Astronomical Union—contribute their share. Among the national chapters some very important programmes are listed, for example those of the French Centre National de la Recherche Scientifique (CNRS), the United Kingdom Department of Scientific and Industrial Research (DSIR), the United States National Research Council and the U.S.S.R. Academy of Sciences.

On the other end of the scale there are many programmes of limited size and more specialized aims. For instance, Rutgers University, New Jersey (USA), gives one fellowship a year to a young Italian microbiologist. The A.F. Regnell Botanical Donation permits the Swedish Royal Academy of Science to award, at irregular intervals, fellowships to Swedes for study of botany in Brazil or other "intertropical countries."

In between these two extremes are a large number of programmes—involving many thousands of individual awards—directed in general towards the promotion of economic development. Most of these programmes are government-sponsored, accounting for about 50% of all fellowships offered.

It is not always easy, though, to identify the proportion devoted to science and technology. The Government of India offers four "Union Territories Overseas Scholarships" for "any branch of science, engineering, technology or medicine." But the Government of Libya offers 258 State Scholarships for study of "teacher training, agriculture, engineering and other fields" in Europe, the U.S.A. and the United Arab Republic. And among countries offering technical assistance, the U.S. Government, in one of its many programmes, makes approximately 1,900 awards for which the subject of study is "generally unrestricted" to "nationals of most countries having United States diplomatic or consular posts." It is reasonably certain, however, that a high proportion of such awards is made in science or technology.

The fellowship programmes of the U.S.S.R. on the other hand, although fewer in number, make more specific mention of "science, agriculture and medicine" as fields of study.

When attention is turned to the number of scientists studying abroad, regardless of whether or not they are receiving fellowships, it is found once again that they represent a large proportion of all foreign students. Unesco's tenth annual survey of foreign students enrolled in higher education showed a total, in all fields, of over 250,000 in the academic year 1960-1961. In a very general way, the overall situation can be viewed from two main viewpoints. One is the tradition that science, and for that matter all academic learning and research, cannot be restricted to any one nation, and that as long as there have been universities, students and teachers have gone abroad to follow their vocations.

The other—of much more recent origin—concerns the great need for training scientists and technologists from countries undergoing rapid economic development. This second part of the problem is by far the more urgent for practical, present-day purposes; but as it cannot be seen in entire isolation a word needs to be said about the more general problem of scientific exchanges.

In a sense, the phenomenon of scientists studying abroad is only part of the broader problem of the international exchange of scientific information. While it would be wrong to infer that all scientists who go abroad do so for purely professional purposes—there is probably as high a proportion of "educational tourists" among scientists as in any other discipline—it can be assumed that most of them are prompted by the need to acquire knowledge and experience that they cannot obtain at home.

It may be that institutions for scientific study do not even exist in their own countries; or perhaps they have been unable to obtain places in suitable institutions. With respect to the more specialized branches of post-graduate study or research, a student may feel the need to work with a particular teacher abroad. Very few countries are entirely self-sufficient in facilities for scientific research. And even those that are, or nearly so, have a strong tradition of exchanging knowledge with workers in the same fields abroad.

But study abroad is not the only way of exchanging scientific information. From some points of view it is a very ineffective way. For the problem nowadays is not so much one of encouraging scientists to meet each other, but of providing them with a means of access to the very large quantities of articles and papers on a enormous range of subjects appearing in the scientific journals of the world.

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50,000 science fellowships a year

Fellowships for study abroad are by no means the only way of promoting personal contacts. An increasingly important phenomenon is the large number of congresses, conferences and meetings that take place every year. The facilities of air travel, and the financial support of governments and industrial concerns, has made it possible for larger numbers of scientists than ever before to meet each other. At least half a million go abroad every year for such purposes.

This, then, is the general background of international scientific relations against which the problems of study abroad must be seen. But when one turns to the particular problems which face countries in the process of rapid enonomic development a completely new set of factors has to be taken into account. In the past—and even today—some of the greatest scientific developments have been achieved without a very clear definition of goals. In fact, the research scientist often produces his best results through being allowed a maximum freedom of action. Nowadays the drive towards economic and social development demands a very careful statement of objectives. This tendency affects the whole world, but it is particularly drastic in countries which can least afford the luxury of wasted effort.

In two-thirds of the countries of the world, in which many millions live on the borderlines of undernourishment, there is the greatest need for economy of effort and the careful development of human resources. Offers of outside assistance are not lacking, but programmes of technical co-operation cannot achieve the results expected of them unless they are carefully planned and co-ordinated. The development of science and technology is obviously one of the first and foremost needs.

But inevitably projects in the fields must find themselves in competition with other types of projects. Moreover, scientific personnel must be of high intelligence and ability. So there is competition for human resources just when the most desirable prizes may seem to lie in politics or diplomacy rather than in further academic study.

Further than that, there is competition between basic sciences on one hand and technology on the other. If there are not enough scientists it simply means that not much research will be done. If there are not enough technologists there will be no factories or railways. And beyond that there is competition between the different sciences and different technologies. And so on.

WHERE does study abroad fit into this picture? The answer to this is complicated by the fact that whatever its role may have been in the past there must now be a careful assessment of plans for the future. Two major considerations must be taken into account.

The first is derived from the well-known situation in which exceptionally large numbers of science students who go abroad never return home. And of those that do there is much dissatisfaction owing to inability to find employment suitable to the experience acquired abroad.

The second consideration depends on an assessment of where the most serious obstacles to scientific development lie. For the present and immediate future some of the most serious problems lie in general education at the primary and secondary levels, rather than in the specific training of scientists. But in many countries the heart of the problem can be pinpointed as lying in science teaching in secondary schools. And this is not a problem which can be solved by massive programmes for study abroad by scientists.

It is clear that in future there must be a careful selection—in fact, rather more careful than has hitherto been the case—of objectives to which funds will be devoted for study abroad. This must begin with an assessment of the number of qualified scientists who can be produced by domestic training institutions, and decisions as to how these institutions will be developed or supplemented in the future.

To a great extent plans for study abroad must be designed to fill the gaps. Some countries may still have to send relatively large numbers of science students abroad for university degrees, simply because of a present lack of university places. Others may be able to pinpoint their needs to a few specialized post-graduate subjects in which they do not possess—and in which they may probably not find it worthwhile to possess—fully developed research facilities. But above all, the scientist must be assured of worthwhile and remunerative work on his return.

Wherever possible, fellowships for study abroad in scientific or technological fields should be planned so as to achieve very much more effective results than at present. It is worth noting that in UNESCO's fellowship programmes, in which science is given a very high priority, only about one-quarter of the thousand or so awards made each year are in scientific subjects per se. A high proportion of UNESCO fellowships as a whole are for the development of general education.

AMONG the science fellowships awarded by UNESCO there are many examples of the ways in which study programmes are carefully elaborated in relation to clearly-defined needs. One of its programmes, which is operated in collaboration with the International Brain Research Organization, provides for about 30 fellowships through which interdisciplinary studies concerning the brain can be promoted. Fellows may specialize in neuroanatomy, neurochemistry, neuropharmacology or other relevant fields. Plans are being made for a fellow from Japan, for example, who has already been studying at the University of California, to do research on the topic of "Brain Mapping in Birds" at the University of Tübingen.

Another type of fellowship can be found in connexion with projects under the United Nations Special Fund. Whereas the brain research fellowships are intended to promote research at a very advanced level, Special Fund fellowships are designed to give the necessary qualifications to scientists or technologists who will be employed on clearly-defined projects after their return home. Five fellowships of this type, for mathematical study and hydraulic engineering, are being awarded, for example, to candidates from Vietnam and Cambodia in connexion with preliminary studies for the gigantic project of controlling the Mekong River, which flows through Vietnam, Laos, Cambodia and Vietnam, by a series of dams and barrages.

A different example of a Special Fund project can be found in the Japanese International Institute of Seismology and Earthquake Engineering. Fellowships for attendance at the Institute by candidates from seismic zones elsewhere in the world are awarded by both the Government of Japan and by UNESCO.

But an important part of this broader picture is the increasing realization that the application of science and technology for the purposes of economic development is not a one-way process in which the more highly industrialized nations transmit their knowledge and experience to those less advanced. The real key to the problem lies in the creation of institutions in less developed countries which can absorb and utilize experience gained elsewhere.

Once these institutions have begun to take root they are often in a position to contribute to development outside their own frontiers. In scientific matters, as much as any others, much of the success of this process must depend on the sympathetic relationships which can be established between institutions in different countries. As often as not these relationships are of a non-governmental or private nature.

There are many examples of fruitful results from the "pairing" or twinning of universities. The personal contacts established through study abroad on this basis can have far more meaning than when such a system does not exist. In this and similar ways there lie the greatest possibilities of not only assisting developing countries in their more urgent needs, but also of bringing them, to the advantage of all, to the status of full participants in the worldwide scientific community.

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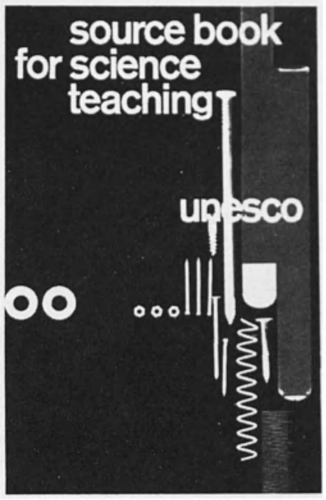

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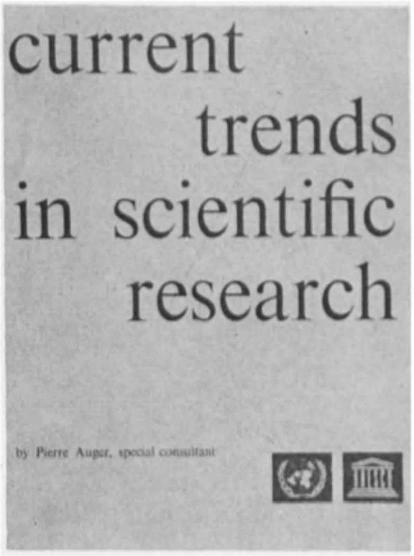

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