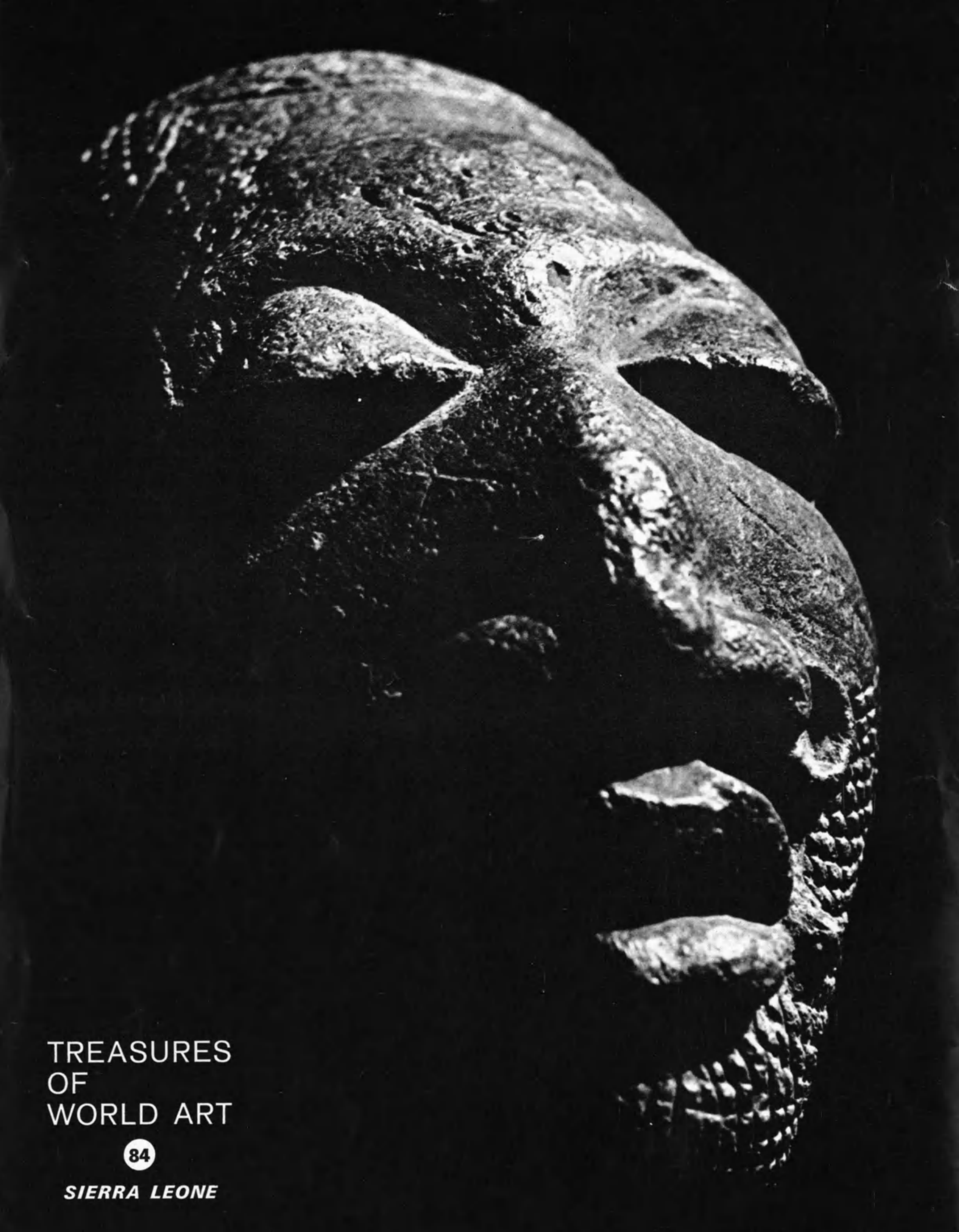
The UNESCO Courier

A window open on the world

January 1974 (27th year) - 2.40 French francs

POWER FROM THE SUN

and world energy sources



TREASURES
OF
WORLD ART

84

SIERRA LEONE

Spirit of the Chief

This imposing life-size stone head was carved by an artist of a West African forest people that disappeared from Sierra Leone centuries ago. The few such heads that exist were all unearthed in the territory of the Mende, a people who moved into Sierra Leone about 300 years ago. The Mende call these heads "Mahen Yafe" (Spirit of the Chief) and credit them with supernatural powers. Head shown here is in the Basel Ethnological Museum (Switzerland).

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WORLD POPULATION YEAR 1974

POWER FROM THE SUN

Page

Cover
The inexhaustible resources of the sun may one day help to plug the energy gap left by the rapid depletion of the world's fossil fuel supplies. Cover specially designed for the "Unesco Courier" by Swiss artist Bernard A. Kesselring, of Zurich, shows giant flares bursting from the sun and a solar reflector on earth below. Flares can erupt to a distance of 600,000 kilometres and more.

OUR DWINDLING ENERGY RESOURCES

Today's oil crisis has highlighted the much broader problem of the world's critical energy shortage—now & in the future

by Harry Lustig

HARRY LUSTIG, *a native of Vienna, is Professor of Physics and Dean of the College of Liberal Arts and Science of the City College of the City University of New York. From 1970 to 1972 he was a member of Unesco's Science Sector. He was Unesco's consultant for the 1973 International Congress, "The Sun in the Service of Mankind" and contributed a major report, "Solar Energy: The State of the Art", for Unesco's working party on solar energy, in June 1973. His article is a condensed version of a chapter from this study.*

Recent world events have focussed attention on the grave energy crisis facing the world. With total energy demand growing at a rate of about five per cent a year and with conventional energy resources rapidly dwindling, the problem is urgent with serious implications not only for the developed but also for the developing countries. World population is expected to have doubled by the year 2000 and merely to maintain this population, with no attempt to raise living standards, will require over three times the current rate of energy production. Power is the key to expanding food and industrial production and to many other vital problems of world development. For this reason world energy needs have for many years been a matter of great concern to the United Nations and Unesco. The following article presents a global energy "balance sheet" from which it becomes clear that our present problems and future requirements call for the speediest possible development of power sources other than fossil fuels. One such power source, solar energy, was the subject of a crucial international conference held last summer at Unesco's Paris headquarters. Other articles in this issue take a look at the possibilities and realities of solar energy over the next decades.

Photo Leonard Freed © Magnum, Paris

TO what extent is the world energy crisis upon us now and how much time do we have before it will reach disastrous proportions? What is the lead time necessary for producing needed technological innovations and economic and social rearrangements?

How reliable are the estimates of fossil fuel reserves? How long will the world's stocks of natural nuclear fuel last and how good are the prospects for controlled fusion? What is the relative availability, exploitability and cost (economic and environmental) of the "natural" substitutes: solar, wind, geothermal and tidal energy?

Is it realistic to expect people in the industrialized countries to change their way of life, so as to use less energy in the future? And is it sensible and moral to ask the developing countries to give up their quest to narrow the energy gap and to begin to approach the standard of living now enjoyed by the developed countries?

It is generally recognized that the future of solar energy will in large measure be determined by the answers given to these questions. This is because in order to utilize solar energy on either a large or a small scale, no fundamental scientific breakthroughs are needed (unlike in the case of nuclear fusion), but what is needed are technological advances and investment policies to bring down the cost. The factors which will determine whether and when sunlight becomes a major source for satisfying man's energy needs are thus largely economic, political, sociological.

Between now and the year 2000, the United States will consume more energy than it has in its entire history: in that year the annual U.S. demand for energy is expected to be double what it is now.

Today the United States, with 6 per cent of the world's population, uses 35 per cent of the world's energy. Its per capita increase in energy consumption is now about 1 per cent per year, while, starting from a much lower base, the world's average is increasing at a rate of 1.3 per cent.

Because of the much faster population growth in some parts of the world, just to keep pace with that growth (and the 1.3 per cent per capita increase) the world-wide energy supply will have to triple, rather than double

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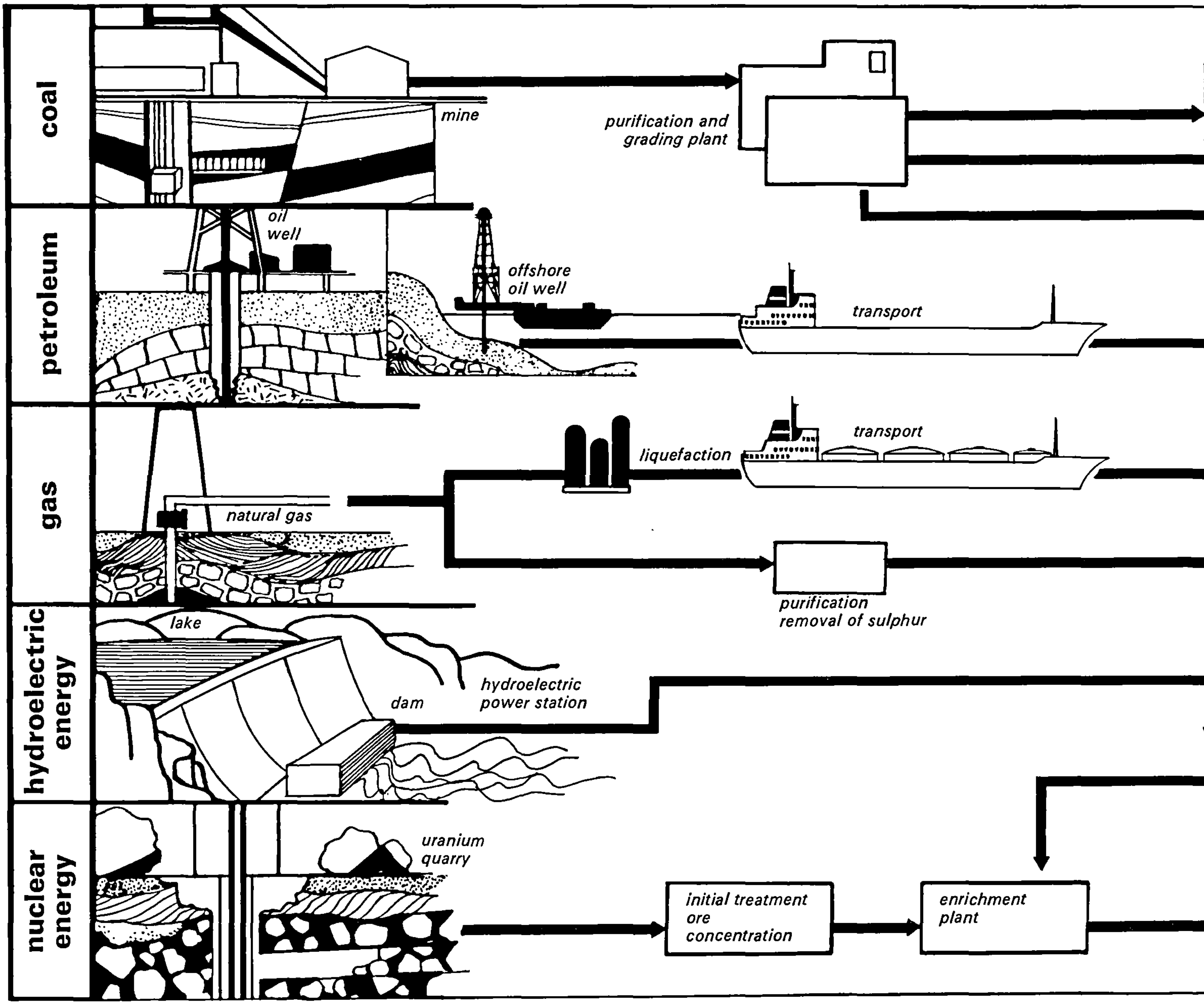
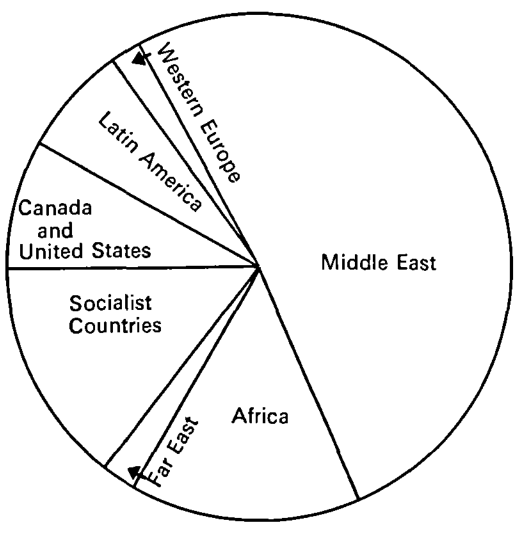
THE BIG FIVE OF





6 Geographical distribution of world petroleum reserves (about 91,000 million tons on 1-1-1973).

World Reserves (1) 1971	Year reserves will be exhausted: Long forecast (2)	Year reserves will be exhausted: Short forecast (3)
COAL 6,641,200 million metric tons	2500 A.D.	2083 A.D.
PETROLEUM 76,200 million metric tons	2100 A.D.	1992 A.D.
NATURAL GAS 49,900,000 million cubic metres	2015 A.D.	1994 A.D.
URANIUM 761,400 metric tons	Exhausted between 1980 and the end of the century, but this would be dramatically extended with the introduction of fast breeder reactors. With nuclear fusion using deuterium, supplies would be virtually unlimited.	
HYDROELECTRIC	Potential use relatively limited, but as a resource hydro power is inexhaustible.	

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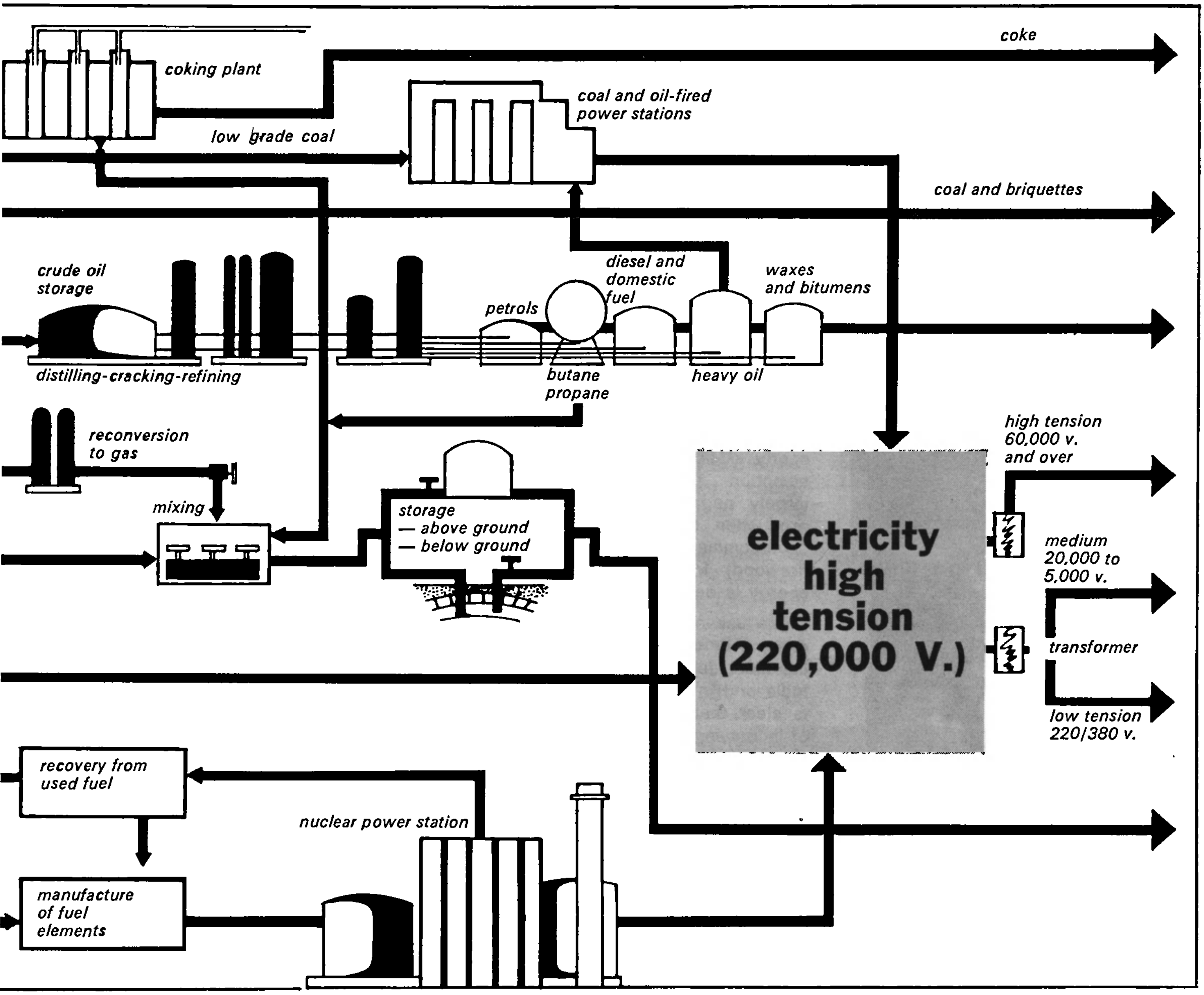
(1) United Nations Statistical Yearbook 1972.

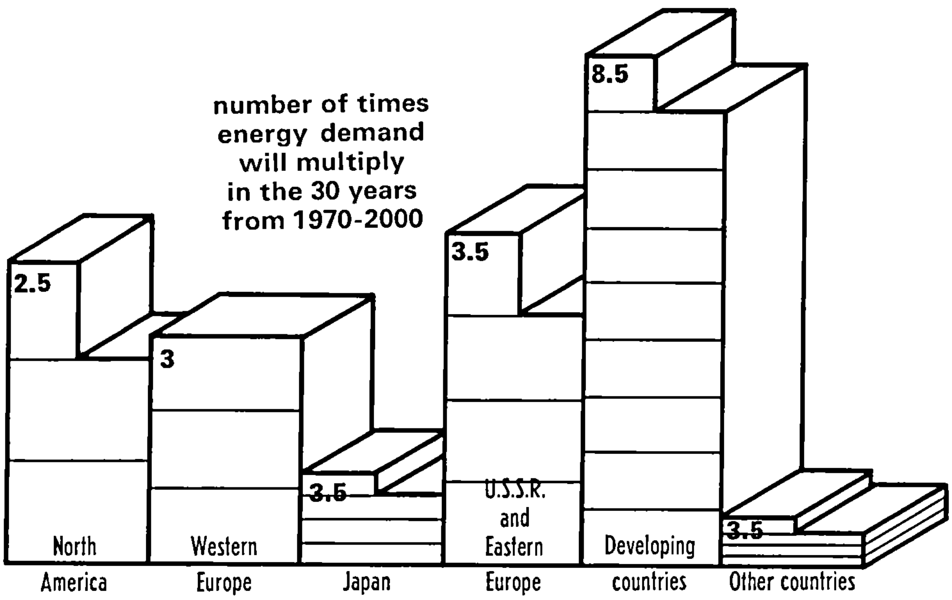
(2) M. King Hubbert, "Scientific American," September 1971.

(3) "The Limits to Growth," Club of Rome report, 1972.

Diagrams taken from "L'Energie," Ministère du Développement Industriel et Scientifique, Paris

WORLD ENERGY





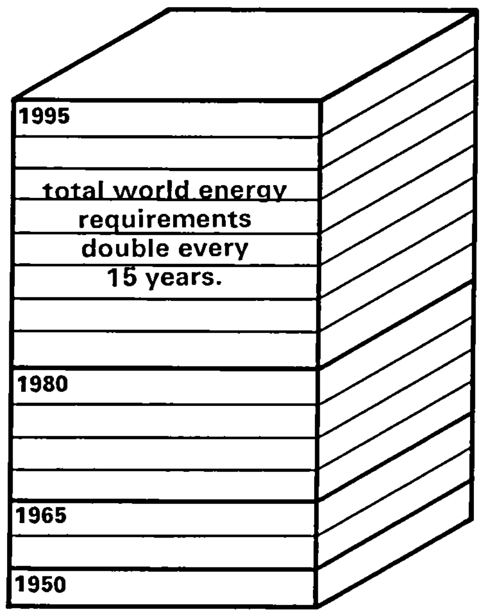


Photo Cartier-Bresson © Magnum, Paris

ENERGY RESOURCES *(Continued)*

Photo © Words and Pictures, Stockholm

by the year 2000. With these trends, by 2000 A.D. the gap between the U.S. and the developing countries will still be large and it could take 300 years to close that gap.

The problem in many developing areas is not only the very low and nearly static per capita energy consumption (the population growth largely negating the increased total production of energy) but also the "non-commercial" sources (mostly firewood) from which much of the energy is derived.

The use of wood as a fuel and the ensuing deforestation has already had the most deleterious consequences in India and in large areas of Africa. It is clear that there is little possibility of increasing the consumption of these non-commercial fuels in many parts of the world. The projected increases in energy consumption would (in the absence of new sources, such as solar energy) therefore have to come disproportionately from the commercial sector.

The world's consumption of energy for industrial purposes is already doubling each decade. If the rate of industrialization were to change fast enough to permit the developing countries to reach by the year 2000 the U.S. standard of living, the world-wide level of energy consumption would be roughly 100 times the present figure.

Our accumulated stocks of fossil fuels were almost entirely laid down during the Cambrian period, which began about 600 million years ago. The process is still continuing, but probably at about the same rate as in the past. Thus the natural accumulation during any part of the future that is of interest will be entirely insignificant; when we have used up what there is now, there will be no more.

The U.S. scientist, M. King Hubbert predicts that the world's resources of oil will be exhausted by 2100 and those of coal by 2500. It does not appear, however, that King Hubbert has taken into account any limitations other than those of discovery and extraction—such as a political decision by one country not to export its resources to another, or environmental restrictions on the use of a fuel.

Nor is there, on the other hand, any allowance made for an uncharacteristic flowering of collective human wisdom: should the peoples of the world decide, for instance, that oil and coal should be preserved and used for petrochemicals rather than burned for fuel, the supplies could last very much longer.

The peak in world oil production will be passed sometime between 1985 and 2000. By the year 2000, when the annual world-wide rate of energy consumption will be only three times the present rate, half or more of the total world reserve of oil will have been consumed. It is all but certain that gas and oil will cease being a major energy source for

Endless rows of pumps at work at an oil field (above) ; oil derrick (left).

humanity well before the middle of the 21st century.

The situation for coal is considerably better both with respect to the reliability of the estimates of reserves and the amount of these reserves. However, if the present rise in the rate of coal production is not checked in the near future, the peaking will occur before 2050 and the supply will be exhausted before 2100.

It should also be noted that coal mining has a particularly ugly effect on the environment and that the burning of coal produces serious pollution by the emission of sulphur and other products. Nevertheless, in the absence of non-fossil substitutes, coal will have to become the major source of energy for the indefinite future, and even with the most optimistic estimates as to the development of nuclear and solar energy, coal will be a substantial contributor to a growing energy consumption for at least the next 50 years.

Although the discussion of atomic energy is usually carried on in terms of the two alternatives, fission and fusion, a prediction of what the future holds in store really requires a subdivision of each of these methods into two categories.

If fission is likely to be the only available process—as appears likely for some time to come—the prospects for major and long time energy production from this source will depend very much on whether reliance will continue to have to be placed on the presently developed reactors, which use uranium 235, or whether breeder reactors, which start with uranium 238 or thorium 232 as a fuel will be put into production.

A report issued by the Organization for Economic Co-operation and development (OECD) Nuclear Energy Agency and the International Atomic Energy Agency projects requirements of 430,000 tons of uranium oxide for the world, exclusive of U.S.S.R., Eastern Europe and China, from 1970 to 1980. At the present time, uranium oxide which costs more than $10 a ton

Photo © A. Y. Chauvin, Paris

Coal miner with modern safety gear.

Photo Georg Gerster © Rapho, Paris

Hot water geyser being tapped for geothermal energy.

to mine is uncompetitive with fossil fuels. But even if we include the low grade ores as a source of supply, it is clear that the era of U 235 nuclear fission will be a short one probably terminating before the end of the century.

The situation will change drastically if and when the breeder reactor comes into use on an industrial scale. With breeding, a large part of the supply of natural uranium as well as of thorium would thus become available

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as fuel for fission reactors. This means not only that low grade ores could then be economically used, but that the energy output from each ton of ore would be very much greater. Under these conditions the existing uranium reserves could supply the world's energy needs for perhaps a thousand years to come.

There is every reason to expect that breeder reactors will be operational within perhaps 20 years. But that development will not completely solve the energy crisis and will, in fact, bring new problems in its wake.

For one thing, nuclear energy shares, with solar energy, the characteristic that it is capital intensive; the capital cost, per kilowatt of generating capacity, of a nuclear electric power plant is about twice that of a fossil fuel plant.

More important, the environmental consequences of large scale nuclear power production are serious. Here it is not primarily a problem of air pollution by effluent particles, as in the case of the burning of fossil fuels, but of the safe disposal of the radioactive fission products, the (small) risk of (highly disastrous) accidents in the operation of reactors and the thermal pollution caused by the massive cooling of the nuclear power plants.

Control of the thermonuclear fusion process—the process of the hydrogen bomb—so that it may be exploited as a source of useful energy involves a number of scientific phenomena that are not yet completely understood and of engineering advances that have hardly been seriously studied. The fusion process thus remains a possibility with a highly uncertain outcome.

It may therefore be premature to be concerned about the reserves of "raw material" required for the fusion process, but it is useful, nevertheless, since the successful realization of fusion, by way of the deuterium-tritium reaction might see us through about halfway into the 21st century, but no longer than that.

The picture would be changed dramatically if fusion could be accomplished with the deuterium-deuterium reaction. One cubic metre of water contains enough atoms of deuterium to provide a potential fusion energy equivalent to the heat of combustion of 300 tons of coal or 1,500 barrels of crude oil.

The total volume of the oceans is about 1,500 million cubic kilometres. If enough deuterium were withdrawn to reduce the initial concentration by 1 per cent, the energy made available by its fusion would amount to about 500,000 times the energy content of tho world's supply of fossil fuels. Many other disasters will befall the world before that supply would be exhausted.

There are three sources of continuously incoming energy: ● intercepted solar radiation; ● geothermal energy, which is conveyed to the surface of the earth from the interior by the conduction of heat and by convection in hot springs and volcanoes; and ● tidal energy derived from the kinetic and gravitational potential energy of the earth-moon-sun system.

It is a reasonably simple matter to estimate the approximate rate of input from each source, but the more difficult and important task is to determine how much of this can be tapped as useful heat or converted into work in the light of the prevailing technology, economic factors and environmental constraints.

The earth intercepts more than 1,500 quadrillion (1,500 followed by 15 zeroes) kilowatt hours of power each year, but not all of it reaches the earth's surface. About 30 per cent of the solar energy is immediately reflected back into space, another 47 per cent is absorbed by the atmosphere, the land surface and the oceans and converted into heat, and another 23 per cent is involved in the evaporation, convection, precipitation and surface runoff of water in the hydrological cycle. A small fraction, about 0.2 per cent, drives the atmospheric and oceanic convections and circulations

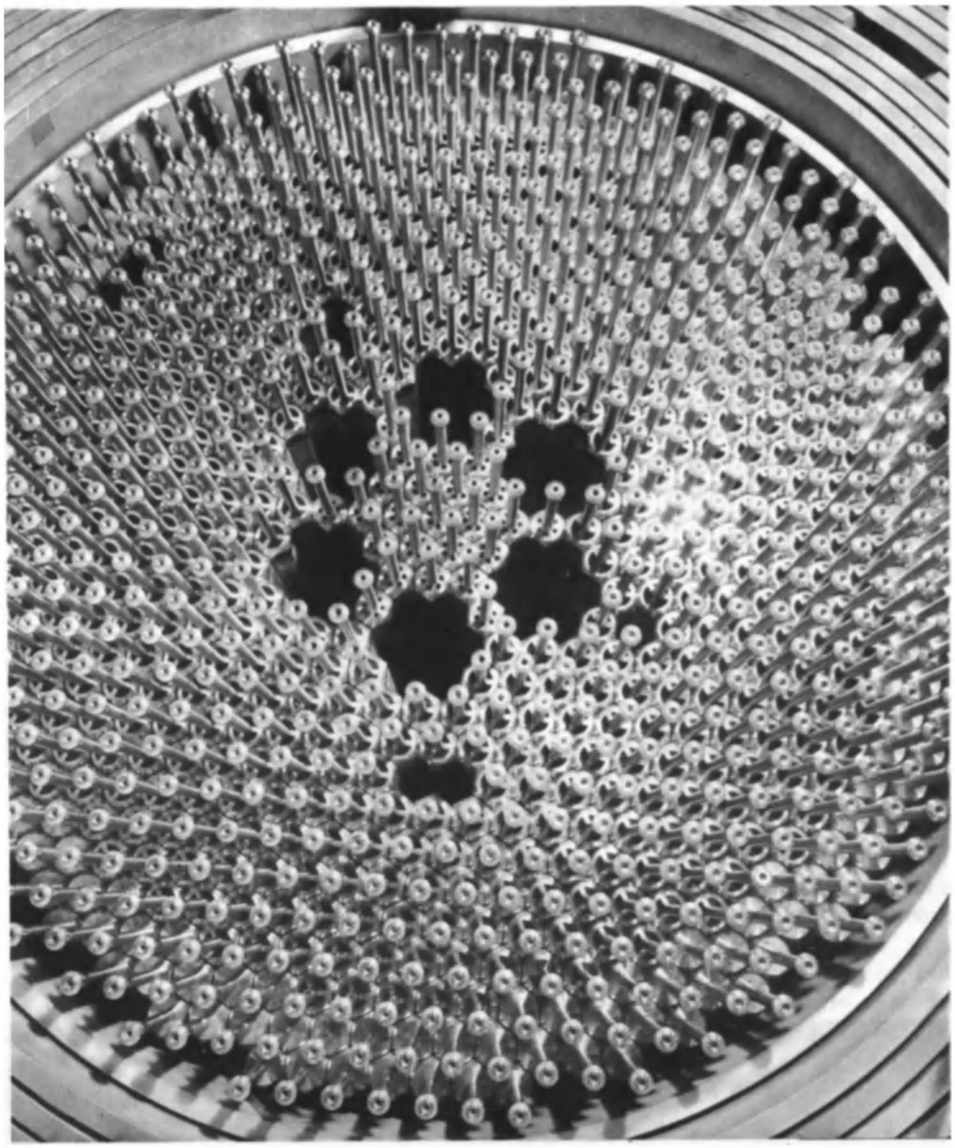


Photo © CEA, Paris

Many countries now carry out research on harnessing atomic energy for peaceful tasks. India, a pioneer in this field, decided as early as 1954 to set up the Bhabha Atomic Research Centre at Trombay, near Bombay (right). Above, the "heart" of France's "Rapsodie" reactor, in operation since 1967 at a nuclear research centre near Marseilles.

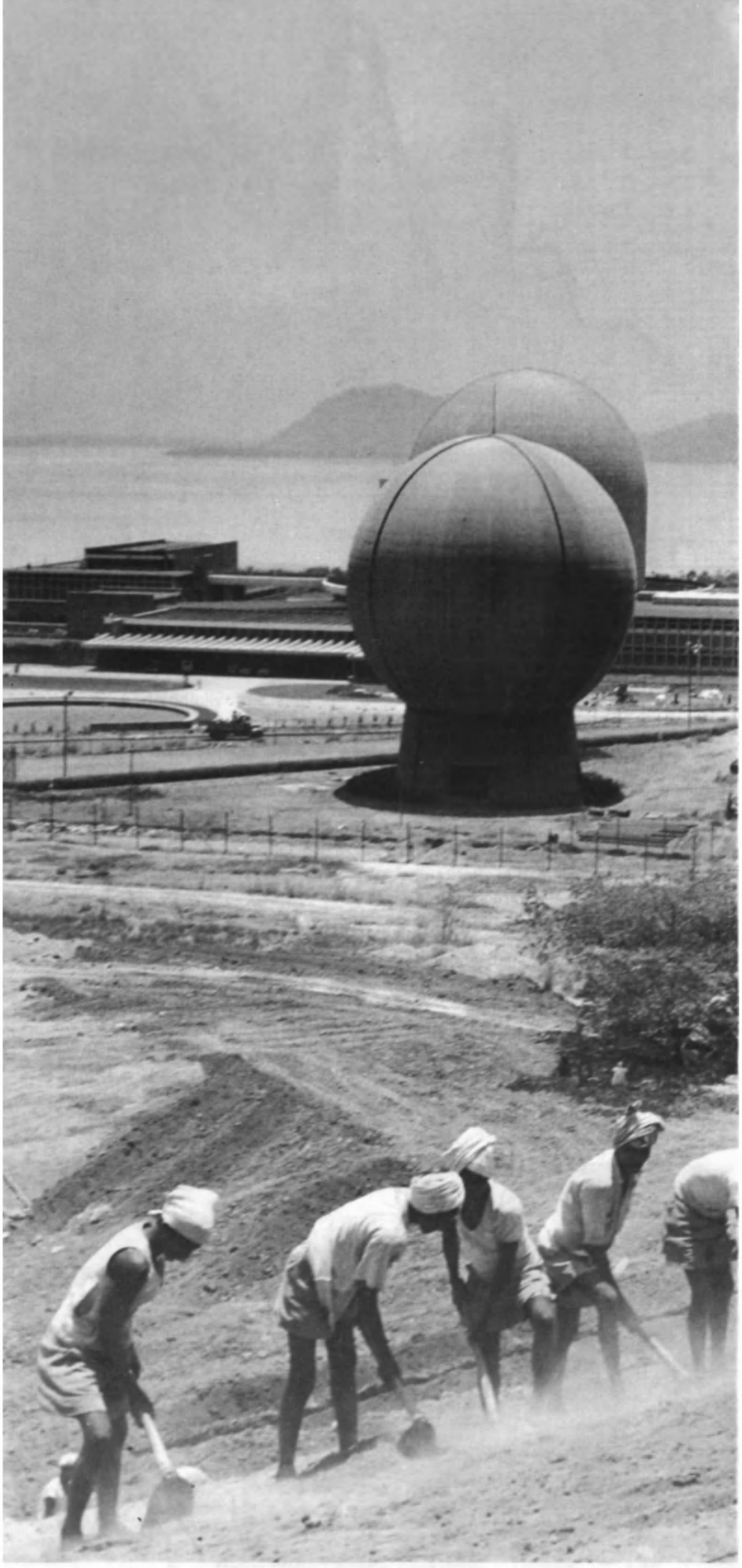


Photo H. Cartier-Bresson © Magnum, Paris

and the ocean waves. Finally, an even smaller fraction, about 0.02 per cent is captured by the chlorophyll of green plants and becomes, by photosynthesis, the essential source of energy for the growth of all living matter (as well as, in a minute fraction, the source of fossil fuels).

Tidal energy represents a potential source of power which, assuming it could be exploited continuously, could produce 567,000 million kilowatt hours of energy per year. This is less than 1 per cent of the world's energy consumption in 1970.

The presently existing or seriously researched ways of obtaining geothermal power all involve the extraction of heat from volcanoes or from the hot water filling the sands of deep sedimentary basins. A geothermal power operation has been under way in the Larderello area of Italy since 1904 and now has a capacity of 370 megawatts. The three other main areas of production are the geysers in northern California, Wairakei in New Zealand, and Iceland.

It has been estimated that the stored thermal energy in the world's major geothermal areas would, if exploited, provide energy equal to the amount consumed in the U.S. in the year 1970. Furthermore, this energy is depletable; if it were withdrawn over the next 50 years, the contribution to the world's annual power consumption, even during that limited time, would be less than that from tidal power.

We see therefore that the total power influx into the earth's surface environment is almost entirely (99.98 per cent) due to solar radiation; the sun's contribution to the earth's energy income is 5,000 times more than that of the other sources combined. This does not by itself *necessarily* mean that solar energy is therefore the only or even the major candidate for becoming a source of renewable energy but this conclusion does, in fact, appear to be correct.

It should be noted that all the solar components can, in principle, be tapped for power. The classic approach is to intercept a tiny fraction of the 47 per cent which would otherwise go to heat the land and water surface and the atmosphere, and to use it either directly as heat or to convert into mechanical or electrical energy.

With a collection and conversion efficiency of 10 per cent, something like 2 per cent of the land area of the U.S. would suffice to meet that country's total energy needs in the year 2000.

The potential water power of the world has been estimated at around 3,000 million kilowatts, about one third of the present world rate of energy consumption. However, only 8.5 per cent of this water power is developed (mainly by conventional hydroelectric systems) and the three regions with the greatest potential—Africa, South

CONTINUED NEXT PAGE

Photo Salt River Project

ENERGY RESOURCES *(Continued)*

America and south-east Asia—are the least advanced industrially.

Wind power is the sun's contribution by way of the atmospheric and oceanic convection mode. While windmills could be resurrected as a source of small power in certain locations, wind energy cannot be relied upon on a large or global scale. On the other hand, it may become feasible to exploit thermal depth and streamflow gradients in the oceans, especially in multipurpose operations involving also mariculture and fresh water production.

Turning to the last terrestrial solar energy absorption mechanism, recommendations have recently been made in several countries for increasing the solar energy harnessed through photosynthesis, by growing suitable trees and plants in special solar plantations and recovering the energy either through burning or the creation of synthetic fuels.

Finally there is a proposal for satellite collection of solar radiation and recovering the energy on a large scale outside the earth's atmosphere.

It is not yet clear which of the many schemes proposed for the harnessing of solar energy will prove to be the most efficient or how soon solar energy will be exploited on a large scale. But it is clear that among all the renewable sources of energy, the sun is the only serious contender for massive and long-term exploitation and that it is, in fact, the only real alternative or supplement to breeder reactors or fusion for dealing with the energy crisis.

In recent years the partisans of solar energy have shown a commendable realism in recognizing that the sun will not become a major direct source of power until the cost of its collection and conversion becomes at least comparable to that of conventional fuels.

Solar energy, when used directly as heat, in such applications as water and house heating and water distillation is, in some regions of the world, already competitive with fuel and electricity. There is little doubt that further

Hydroelectric dam (above) and aerial view of a major river delta with its complex of tributaries (below).

Photo © Aero Service, Philadelphia, U.S.A.

technological developments and mass production will lower the cost of solar energy utilization and even less doubt that there will be a sharp rise in the price of conventional fuels.

But it would be foolhardy to sit back and rely on this negative phenomenon because the cross-over point might then be reached at a time and at a price which would have disastrous consequences for the world's standard of living.

Humanity is willing to pay quite exorbitant prices for energy in special circumstances and for special uses, or when the sources employed have special characteristics.

Much high-priced energy is used in small quantities and for luxury uses such as electric watches or the space programme. However, the problem becomes serious when applied to underdeveloped or underpopulated areas of the world. There are places where there is at present no fossil fuel or nuclear energy available and where solar energy may be the best or the only hope for relief from suffering or a dreadfully low standard of living.

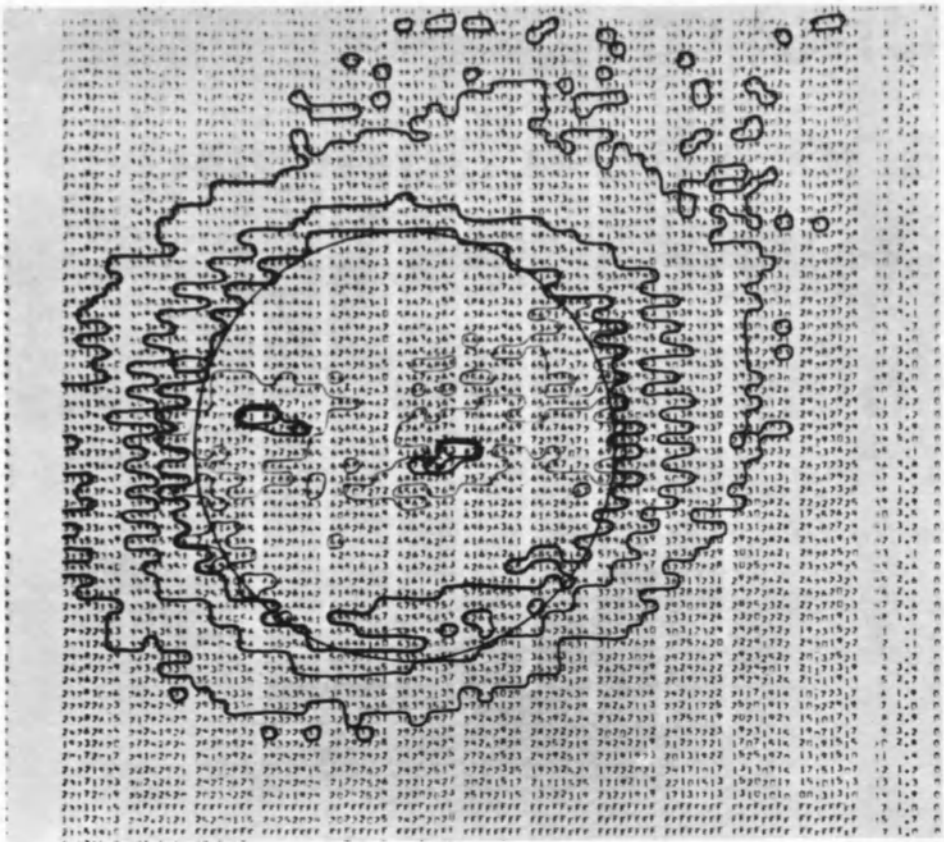
In the drought-stricken zone of west central Africa, for example, where millions of cattle have died and humans are starving to death for lack of water lying underground, fuel and maintenance-free solar pumps might just possibly be more effective and practical than diesel powered ones, for which the fuel has to be transported over miles of desert, and which may become useless at the first breakdown.

The energy supply crisis—discounting political and ecological considerations and a concern for improving the lot of the poor nations and people—is a crisis of the future, a crisis of anticipated growth.

The reason for the sense of crisis is, of course, that the world's consumption of energy is not constant, or even increasing linearly, but that it is rising exponentially.

It is clear that our present growth rates in energy production, in raw materials consumption, in population and in pollution cannot be sustained. This is a point which scientists and other throughtful men have appreciated for some time and which they are trying to get the world and its leaders to understand and to act upon.

In spite of the fact that the present impetus for solar energy development in the industrialized countries appears to be fed by concern with the exhaustion of the supply of other fuels, a halt to the increase in the consumption of energy will have to occur for other compelling reasons, long before some of these supplies are exhausted.



Photos © USIS, Paris

Below, eclipse of the sun showing solar corona (sun's outer atmosphere); the sun as depicted in a computer type picture transmitted by satellite (above).

Much will, of course, depend on when the equilibrium state is reached and at what level of consumption. If it occurs soon, before levels of consumption rise much more and before coal supplies are severely depleted, and, particularly, if breeder reactors are by that time in operation, the consumption of energy will not be seen as supply limited but as carrying capacity limited.

If that happens, it will not be the renewable aspect of solar energy but its non-polluting nature which will make it an essential source. For it is not only air and water pollution which may call a halt to exponential growth before anything else does, but it may very well be thermal pollution—the disposal of waste heat—which will limit the use of fossil fuels and nuclear energy. The solar energy which falls on the earth enters into the heat balance whether it is temporarily used by man for work or not. It is the only source of energy which does not contribute to thermal pollution. ■

Photos © USIS, Paris

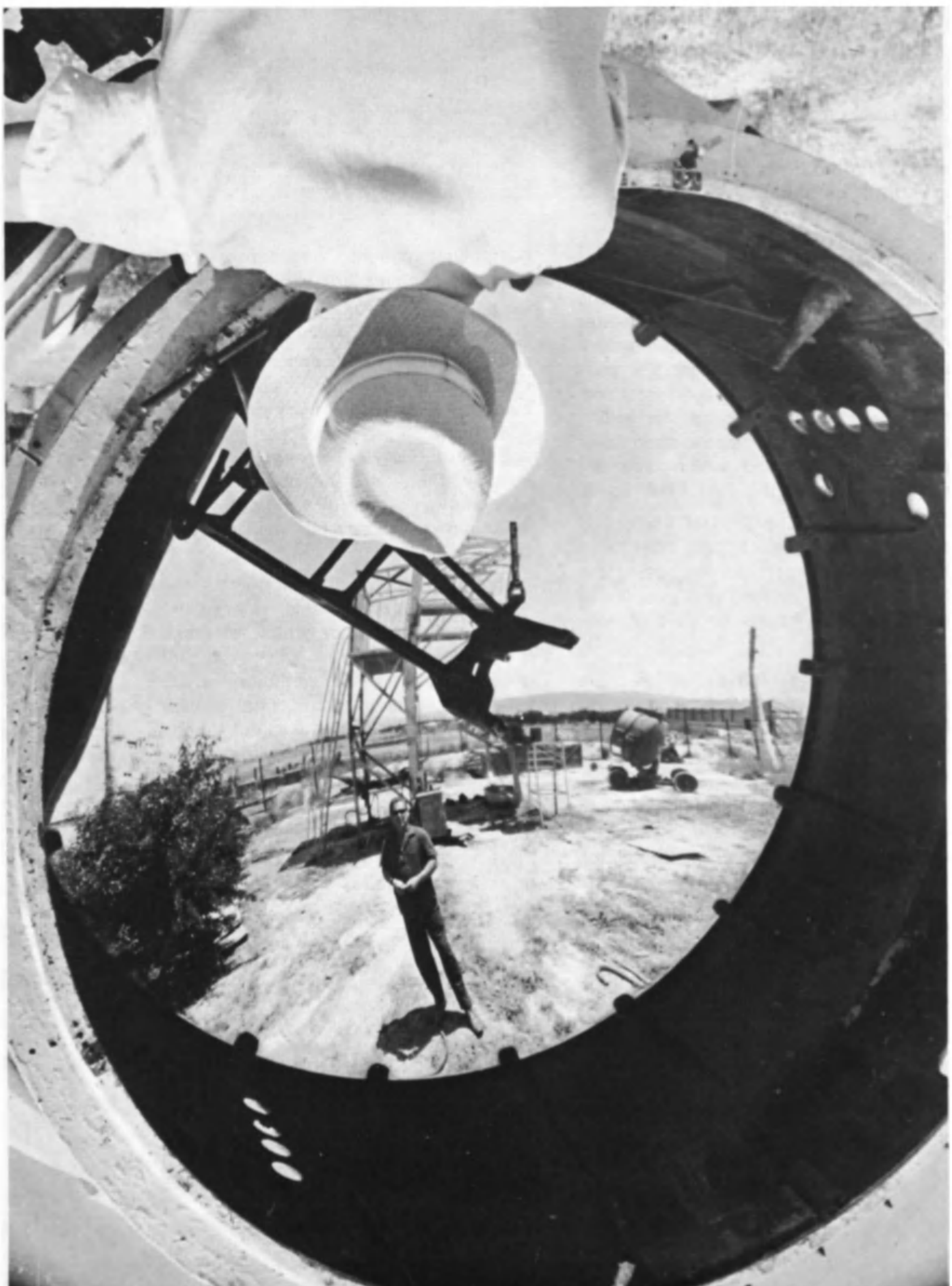
Unesco and the changing attitude toward solar energy

by Rolf E. Glitsch

SOME twenty years ago it was thought that solar energy might provide the ideal answer to man's energy needs but no breakthrough in the direct conversion of sunlight into energy application was made.

When the large-scale use of solar energy did not flourish largely due to economic reasons, many were disillusioned and others directed their attention exclusively to small-scale, low temperature applications for developing countries. Certain of these applications were successful, others failed to materialize mainly due to social and economic rather than technical reasons.

What has been operating here is a particularly pernicious case of the advanced-versus-developing nations dilemma. Those who could most benefit from the advance and utilization of



View of part of the solar still at the Bakharden State Farm in the Karakum desert of Turkmenia, U.S.S.R., reflected in a concave reflector (photo is purposely published upside down). For the past five years the still has supplied three metric tons of drinking water every 24 hours for the farm's livestock.

Photo © M. Koukhtarov, APN, Moscow

solar energy technology—the developing countries, most of them in the solar belt, with limited fuel resources, poor communications and isolated populations, and therefore much in need of small solar-powered appliances (such as pumps, refrigerators, heaters, dryers)—have lacked the scientific, managerial and financial resources for doing much about it.

And in the advanced industrial countries where there is plenty of capital and a surfeit of scientists and engineers, there has been little interest or incentive to invest human or monetary resources in either large or small scale use of new forms of energy.

Conventional fuel has, until recently, been cheap and plentiful. The planning and development of alternative sources has been almost entirely in the direction of nuclear power: "conventional" fission, breeder reactors and fusion. Small wonder that there has been an unwillingness by both public and private enterprise to finance the research and development of solar devices to make them competitive.

But over the last three years, at first slowly, but more recently, quite dramatically, attitudes have changed, and events have occurred which make it appear that the take-off point for solar energy development may now have been reached.

There is, at last, a widespread appreciation that the earth is a small planet with very limited energy resources; the costs to the industrial states—both monetary and political—of oil and natural gas are rising sharply; progress in breeder reactors and in controlled fusion has been slow; mounting concern with pollution and for the protection of the environment has not only cast a shadow over the use of fossil and nuclear fuels but also put a brake on the construction of oil pipelines and atomic plants and on the resumption of large-scale coal mining.

Finally, there have been a number of interesting technological developments—although not yet major breakthroughs—in solar energy collection and conversion. As a result solar energy development is now receiving wide (if not yet universal) respect and increased scientific and technological attention.

It is obvious that the time has come for new trends and new approaches to meet the energy needs of future generations. Discussions and action are therefore being initiated with a view to finding acceptable solutions not only on a national basis but also on an international scale.

ROLF E. GLITSCH, *geophysicist and mineral resources expert, has been a member of Unesco's Science Sector since 1968. From 1964 to 1968 he was Deputy Director of Unesco's Field Science Office for the Arab States in Cairo. He was previously engaged in applied research on the exploration of mineral resources.*

The situation today thus differs considerably from that of the early 1950s when Unesco became active in solar energy through its international programme for the world's arid zones. At that time Unesco and the Indian Government organized, in New Delhi in 1954, an international symposium on solar energy (and wind power). Its findings stressed the social and political implications as well as the technical possibilities of the use of solar energy, as did a number of technical studies commissioned by Unesco. But with the termination of the Arid Zone programme Unesco's interest and work in solar energy became dormant—an attitude caused by the world-wide stagnation in solar energy activities.

The United Nations too—through its Department of Economic and Social Affairs—had contributed to the development of solar energy by organizing, in August 1961 in Rome, a large symposium on practical ways of using energy from the sun (as well as from the wind and geothermal sources). This major international meeting on solar energy attracted about 500 scientists from over 50 countries. The proceedings were published in full and can be considered as a major contribution to the scientific literature in this field.

WHEN all the activities towards the promotion of solar energy application during the 1950s and 1960s are assessed, it appears that the public mainly judged solar energy applications as a possible *replacement* for other sources of energy. It is evident that the result of the judgement was not very favourable as there existed no satisfactory solution to the problem of solar energy storage.

Moreover, society underwent a certain change during this era. Centralized power production from coal, oil and natural gas or nuclear material and its distribution in the form of electrical energy with the advantage of continual coverage—sometimes even an international grid—became far more attractive. This form of power was considered more convenient than individual power units of small size which produced the required form of energy often without its transformation into electricity.

Solar energy applications could not fulfill the requirements which society, rightly or wrongly, expected of them—to be able to replace existing energy sources, to be continuously available (storage problem) and lastly to be not only as cheap as other sources of energy but preferably cheaper.

When society became seriously concerned about the existing energy resources solar energy came to be regarded as an *additional* source of energy, able to bridge the gap between the existing and the required amount of energy. Thus storage problems and to a certain extent commercial evalutions became less important.

Therefore, at the beginning of 1970, Unesco reviewed its interest in solar energy. A modest programme of education, information and promotion of international co-operation was launched. Research fellowships were awarded to scientists from developing countries, technical aid was given in Cuba and Mexico and a seminar on solar energy and its applications in Africa was organized (in Niamey, Niger, in 1972) for engineers and scientists from tropical Africa.

These activities culminated with Unesco's participation in the planning, organization and sponsorship of an international congress, "The Sun in the Service of Mankind" in July 1973 at Unesco's Paris headquarters (see article page 24).

Prior to the congress an international group of specialists met in Paris to advise Unesco on a possible future programme in solar energy. The group drew up a series of recommendations for projects that Unesco might consider for a broad international programme. Its proposals include:

■ Additional Unesco-supported solar energy training courses and an expansion of current fellowship awards to scientists, engineers and technicians in solar energy research institutes;

■ A clearing-house operation to provide information on educational, research and development aspects of solar energy to scientists, engineers. technicians, students and potential users in member states;

■ Aid to non-governmental organizations and to international solar energy seminars and workshops;

■ Missions to advise member states on possible development programmes in solar energy;

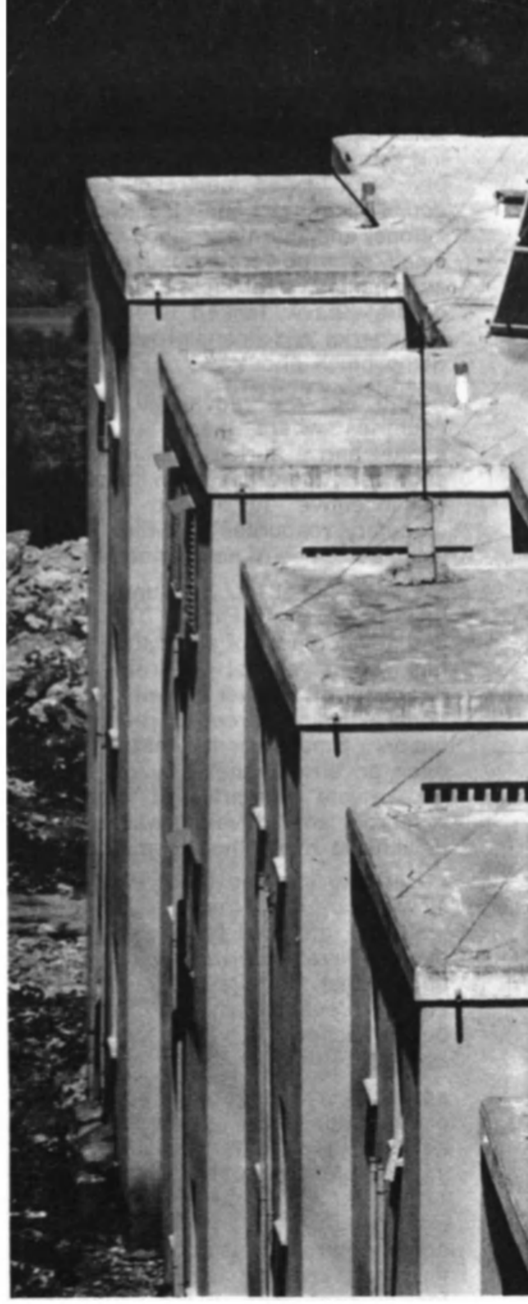
■ Co-operation with member states in drawing up and evaluating national, regional and global research and development projects for the exploitation of solar energy. Such projects might be designed to meet home, community, agricultural and industrial needs and embrace conventional solar energy devices as well as newer processes such as photovoltaic (solar) cells (see article page 16). Particular techniques and devices might include the solar pond, building design for natural heating and cooling, greenhouses, and other biological applications, solar furnaces for baking bricks, solar pumps and other small engines.

These proposals are now being studied by Unesco in the context of an eventual programme that would open up new possibilities for international co-operation in solar energy and its applications. ■

POWER FROM THE SUN

Solar energy, already being tapped in a multitude of ways, now offers great promise for tomorrow

by Peter E. Glaser



The solar energy falling on the roof of a house in a year far exceeds the energy used in the most highly industrialized countries to heat or cool a house. Here, energy from the sun is absorbed by batteries of collectors on a roof which are painted black to aid absorption. Hot water produced by solar energy is stored in cylinders behind the solar collectors. Experience shows that 100,000 solar water heaters of this type can save $1 million in fuel bills.

A riddle popular with French children concerns a farmer, a pond, and a water lily. It goes like this. The lily is doubling in size every day. In 30 days it will cover the entire pond, killing all the creatures living in it. The farmer does not want that to happen, but being busy with other chores, he decides to postpone cutting back the plant until it covers half the pond. The question is: on what day will the lily cover half the pond? The answer is, on the twenty-ninth day—leaving the farmer just one day to save his pond.

The realization that society will have to find the answer to this riddle has recently surfaced, and the issues of limits to growth are being debated. The "energy crisis" generated by the massive production and use of energy in the technologically advanced countries is one of the major topics before the public.

The question that needs to be answered is: has society reached the level of sophistication to apply solar energy for its overall long-term benefit consistent with the balance of nature? The answer is not yet obvious. However, efforts required to provide the answer are beginning to be made.

The amount of energy the earth receives continuously from the sun is enormous—some 167,000 times more energy than we now consume. One square metre of land exposed to direct sunlight receives the energy equivalent of about 1 horsepower, or about 1 kilowatt. Three hundred square metres of land receive enough energy when converted to meet the electrical power requirement of a typical one-family residence. If a piece of land in a desert 150 miles square could be covered with reasonably efficient energy conversion equipment, it could supply all the energy required by a country like the United States.

There are two obvious problems in efficiently harnessing solar energy. First, solar energy is not constantly available. Thus some sort of storage is needed to sustain a solar-powered system through the night and during periods when local weather conditions cut off the supply of solar energy.

Second, solar energy is diffuse. While the total amount of energy available is enormous, the amount available at any point is not large enough to be useful. Thus, solar energy must be collected and converted into useful forms.

Radiant energy from the sun is readily convertible to heat; one need only provide a surface on which the solar energy can be absorbed. If the surface is black, more than 95 per cent of the radiant energy is absorbed and converted to heat. If a fluid, such as air or water, is then brought in contact with the heated surface, the energy can be transferred into the fluid and subsequently utilized for practical purposes.

The two basic alternatives are focussing solar collectors and flat-plate collectors. Focussing collectors use parabolic reflectors to concentrate solar energy; the efficiency of such devices is good, but they must track the sun and this requirement makes them complicated and expensive. Flat-plate collectors are simpler and

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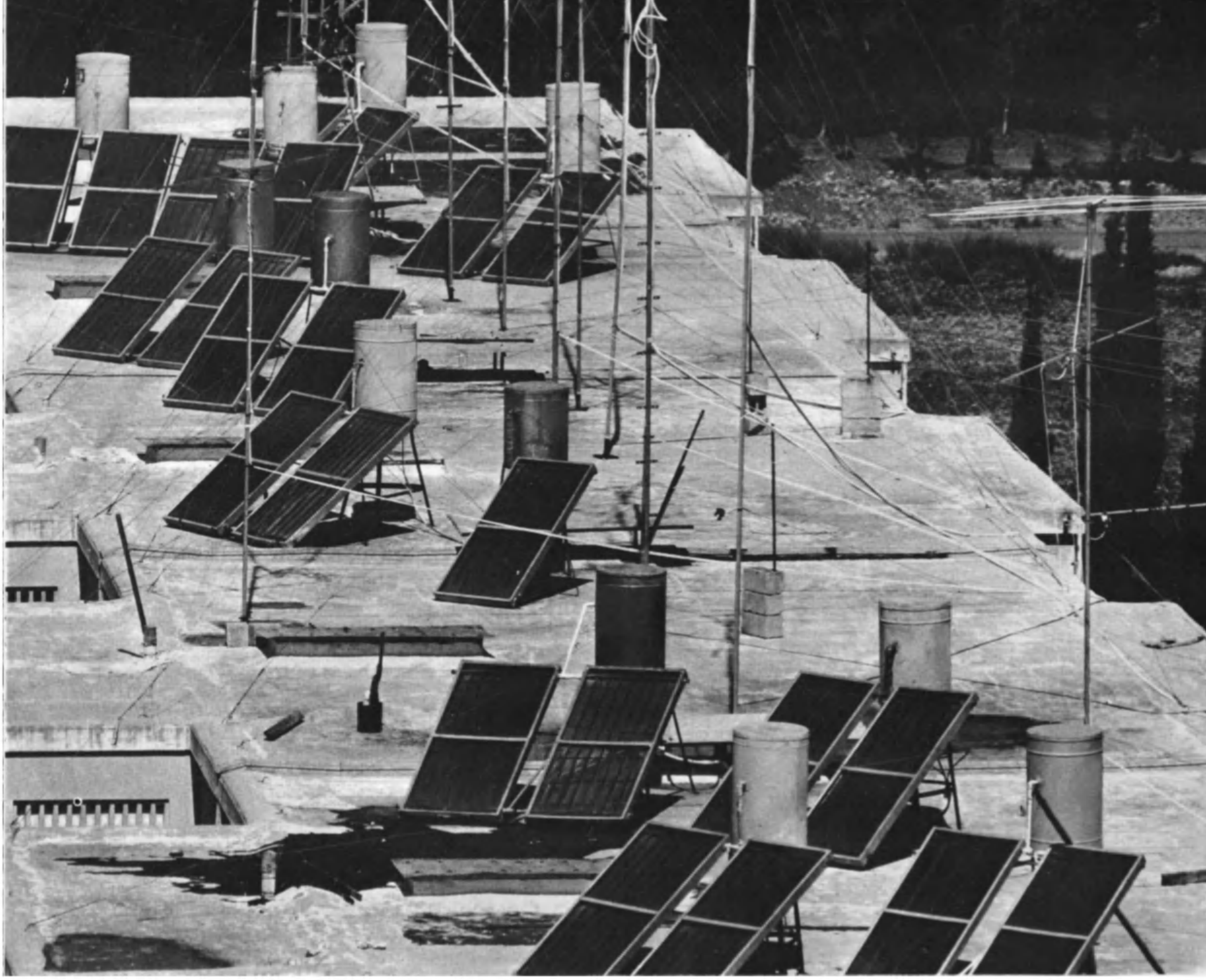

Photo Georg Gerster © Rapho, Paris

cheaper to build, but they do not reach high temperatures and have lower efficiency.

Glass-covered, flat-plate solar collectors can deliver heated air or water at typical temperatures of 100° to 200°F, useful in such applications as house heating, domestic water heating, crop drying, and the like.

Focussing solar collectors can deliver comparatively large amounts of energy to small receivers ; the receivers can be operated at high temperatures for such uses as steam generation, melting of metals, and heat treating of materials.

In more than a dozen countries throughout the world, domestic hot water supplies are heated by solar energy. Several million solar water heaters are in use, mainly in Japan, Australia, Israel, the United States, and U.S.S.R.

The system usually comprises a blackened sheet of metal in a shallow glass-covered box occupying 10 to 50 square feet of roof area. Water circulates through tubing fastened to the surface of the metal sheet, the warmed water being stored in an insulated tank generally at a level above the solar collector. In a sunny climate, the hot water supply of an average family can be provided by such a system. Auxiliary heat from an electric heating element or other heat source can be employed if desired.

A simpler design involves a transparent plastic envelope, similar to an air mattress, with a black bottom surface. The unit is filled with cold water in the morning; the solar energy absorbed during the day then provides a supply of warm water late in the afternoon. This type has been used extensively in Japan.

The principle employed in solar water heaters can be applied directly as well to the heating of houses with solar energy. A number of houses have already been built using solar heating systems. By enlarging the solar heating panels—or using more of them—on the roof of a dwelling, sufficient heat can be absorbed in the circulating water to provide most of the heating requirements of houses located in sunny climates.

A heat storage tank must also be supplied, practical considerations dictating sufficient capacity to carry most of the heating demand for one or two typical winter days. Conventional energy sources would be used to supply the balance of the hot water demand during unfavourable weather.

Air may also be used as the heat-transfer medium in house heating systems that employ solar energy. Air is circulated across or behind the blackened surfaces in glass-covered panels mounted on the roof, and hot air is delivered by fan and ducts to the rooms of the building.

In the past 25 years, more than

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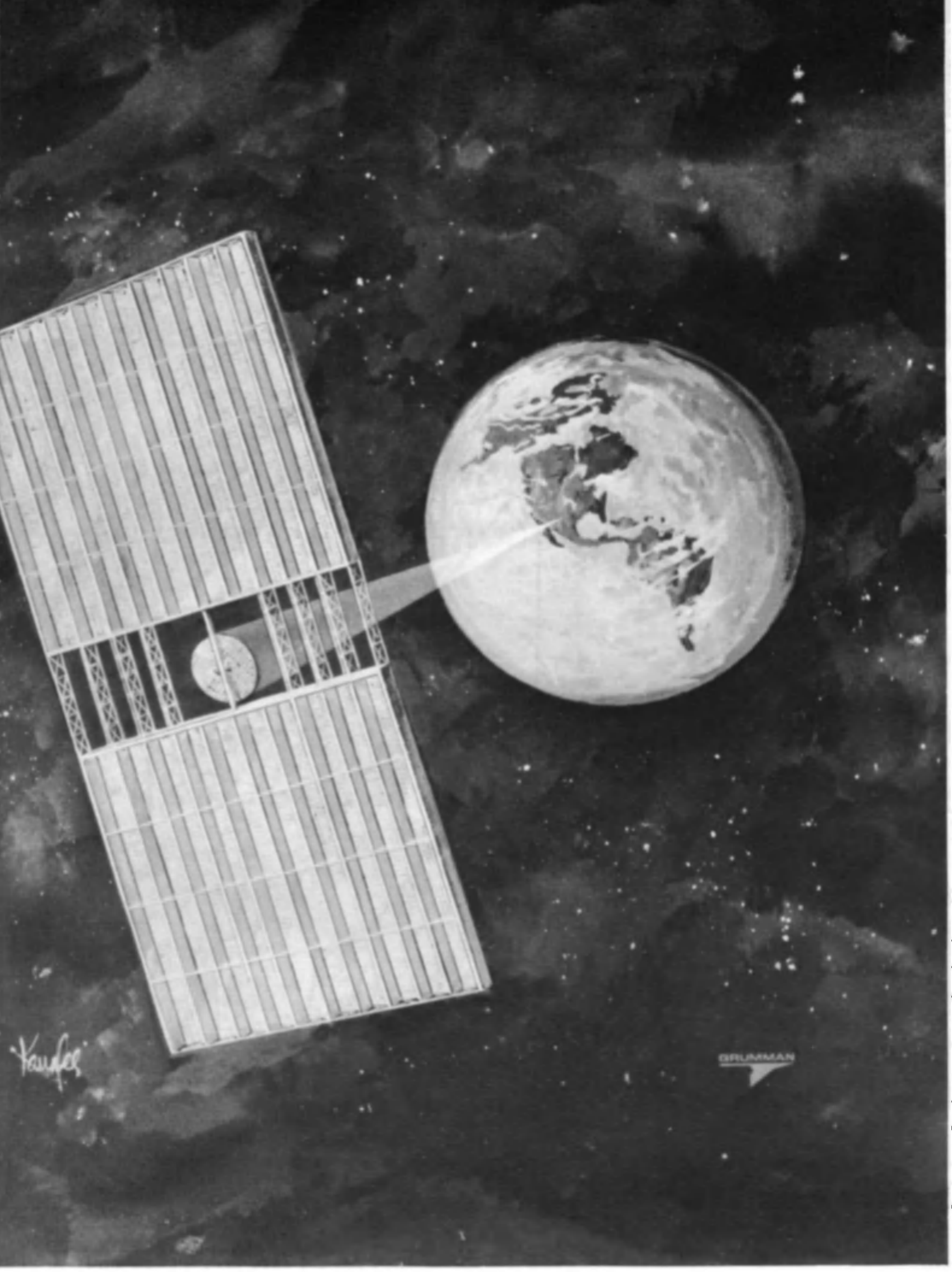

Photo © Arthur D. Little, Inc., Cambridge, Mass., USA

TODAY'S REALITY TOMORROW'S DREAM

Left, design concept for a satellite solar power station. This audacious project (to say the least) of an American firm in Cambridge, Massachusetts, would be in orbit at a height of 36,000 km. in space where solar energy is available virtually 24 hours a day. The station would have two banks of solar cells, each 25 square kilometres in size (5 × 5 km!). It would convert solar energy directly into electricity and feed it to microwave generators incorporated in a transmitting antenna (diameter 1 km.) at its centre. The antenna would direct a microwave beam to a receiving antenna (diameter 7 km.) on the earth where the microwave energy would be converted back to electricity. How such a gigantic device could be blasted into space is another problem, but if successful it would generate electric power ranging from 3,000 to 20,000 megawatts (a megawatt is 1 million watts). Right, Skylab I, the U.S. space station, photographed a few months ago from Skylab II Command Service Module. Its panels of solar cells (cross-shaped and rectangular) provide a power output of about 20 Kw. Inset, comparison of silicon-powered lamp and kerosene oil lamp in a Pakistan village. The lamp on the left is four times brighter than the oil lamp. Silicon solar cell kits are now available with batteries that store electricity during the day to light Pakistan village homes at night.

POWER FROM THE SUN *(Continued)*

20 houses and laboratory buildings have been heated, at least partially, with solar energy on an experimental basis. The United States, Australia, and Japan have been most active in this application. Most of the installations have been technically successful. Energy savings achieved through heating homes with solar energy can have a significant impact on energy consumption.

Residential cooling systems that rely on absorption-refrigeration cycles will require more technical development before they can use solar-heated water or air from a roof-mounted collector.

The inherent advantage of solar cooling is that the maximum requirement coincides roughly with the time when the maximum amount of energy is available to operate the system, that is, when the sun's radiation is most intense. In addition, the solar collector, which is the most expensive portion of the system, can be employed nearly year-round if cooling is combined with solar heating.

The development of the devices required to cool and heat houses with solar energy has reached the stage where these devices could be available in less than 10 years if a mass market is realized. In mass use, solar heating and cooling devices could reduce energy consumption. For example, the potential energy savings in the United States from the large-scale introduction of solar heating and cooling in buildings could exceed the flow of oil expected from the Alaska oil fields.

The primary advantage of converting solar energy to power is the inherent absence of virtually all of the undesirable environmental conditions ascribed to present and anticipated means of power generation with fossil or nuclear fuels.

Several imaginative concepts have been proposed for the large-scale utilization of solar energy on Earth. Which of the approaches will be the most feasible alternative to present power generation methods remains to be established. The important fact is that most of them are based on existing technology and well-known physical principles.

All large-scale terrestrial applications of solar energy will require a large land area because of the diffuse nature of solar radiation. This favours the development of energy conversion devices which can either convert solar energy directly into electricity, or, through efficient processes, produce high temperatures.

Very important to the success of any large-scale use of solar energy on Earth will be the capability of storing energy when the sun is not shining, the transmission of electric power over long distances, and the integration of the transmission line into a power grid system.

Solar energy can be converted directly to electricity by means of a cell constructed of a semiconductor

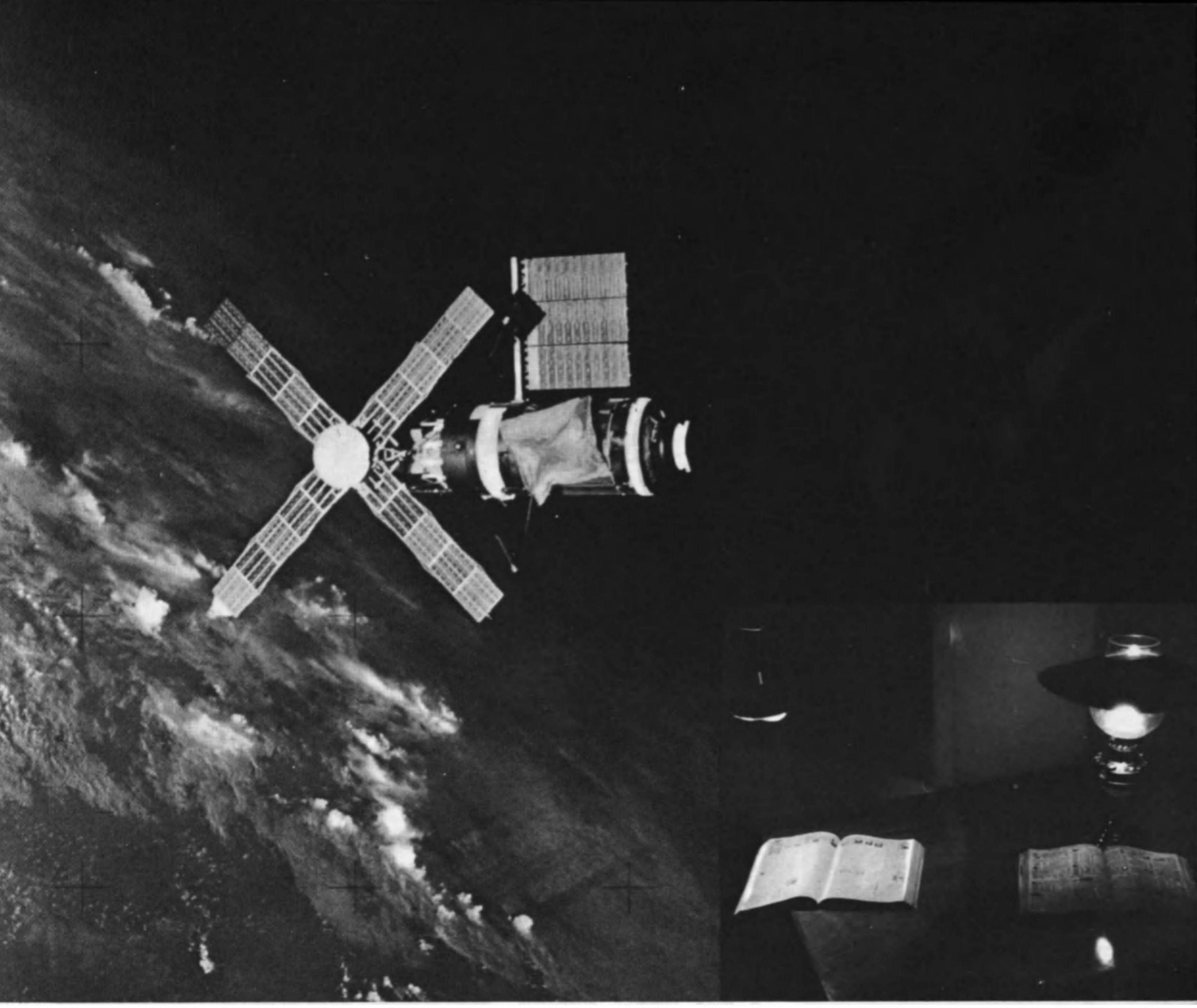

Photo NASA

Photo © Atomic Energy Centre, Lahore, Pakistan

crystal such as silicon. This process is called photovoltaic conversion.

In contrast to thermodynamic conversion, with photovoltaic conversion there are no moving parts, no circulating fluid, and no material is consumed. A solar cell can operate for long periods without maintenance.

The first successful solar cell was demonstrated in 1953. Today, similar cells are a necessary part of the power-supply system of most spacecraft. As a result of the space programme, there is now a substantial technological base for further developments. The two primary research goals are increased efficiency and lower costs. Efficiencies of 16 per cent have been obtained. The theoretical maximum for silicon solar cells is 23 per cent. Silicon solar cells can be purchased today for about $20 a watt.

New techniques in the production of single-crystal silicon and automated assembly of solar cells using mass production methods could bring prices as low as $1 per watt over the next 10 years. Once a major market has opened up, the cost of silicon solar cells could drop to only about 5 times the cost of plate glass. Beach sand, the material used to produce plate glass, is the basic raw material for silicon solar cells.

An alternative way of reducing costs is by partially concentrating solar radiation by means of mirror reflectors to minimize the number of solar cells. Large installations of reflecting mirrors and solar cells could lead to low-cost direct solar energy conversion systems.

For example, one square mile covered with such devices with an efficiency of only 10 per cent could generate 180,000 kilowatts when the sun shines. Since the sun does not shine all of the time, energy storage would be necessary with batteries or perhaps through the production of hydrogen by electrolysis.

The prospects of focussing the sun's energy to generate steam for a power plant have always been intriguing. A solar powered steam engine, using a large mirror to focus solar radiation on a boiler, was displayed at a Paris exhibition in 1878. Similar plants were built in California in 1901 and in Egypt in 1913.

Recently, large-scale terrestrial solar power plants have been proposed to work in conjunction with conventional power plants. Several approaches for the design of solar collectors and thermal storage devices are being investigated. Large areas of the desert would have to be covered with arrays of reflecting mirrors to focus the solar radiation on to absorber tubes. At least 100 square miles are needed to generate 1,000 megawatts.

These tubes, which are coated with selective radiation-absorbing coatings, are expected to heat a circulating fluid up to 1,000 °F. The fluid can then be arranged to transfer the heat to thermal

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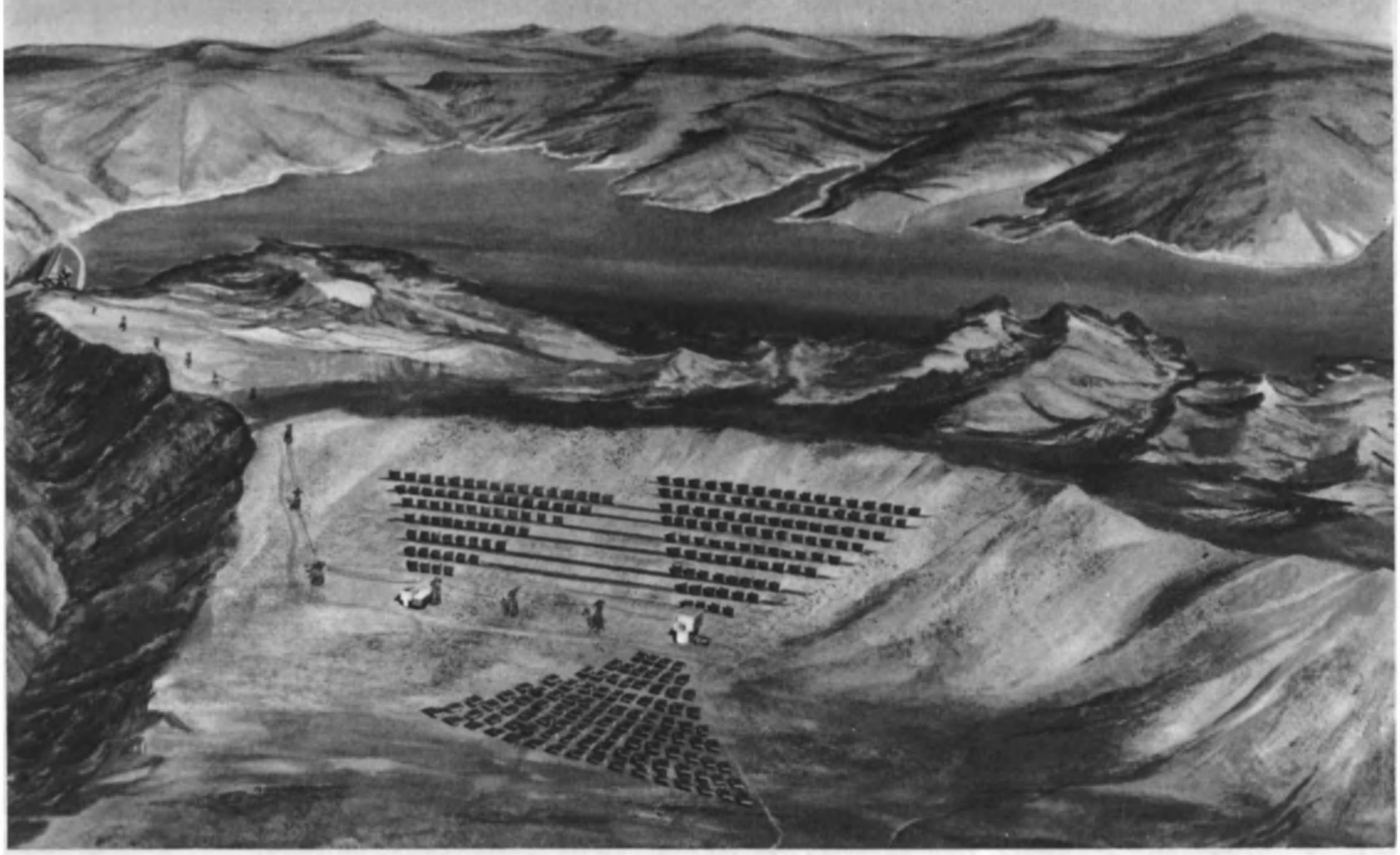


SOLAR BOOST FOR HYDROPOWER

Above, artist's concept of a combined solar - hydroelectric power installation envisioned for Horse Mesa dam in Arizona (U.S.A.). During periods of sunshine the solar conversion system would take over electricity production from the hydroelectric plant, thus effecting a considerable saving in the dam's water reserves. The installation shown here would comprise a small solar power pilot plant (left of photo) and a more powerful production module with twin batteries of reflecting mirrors. Right, close-up of the larger installation, with its power house (left of photo).

Photos © Martin Marietta Aerospace, Denver, USA

POWER FROM THE SUN *(Continued)*

storage to permit withdrawal of the heat during cloudy days and at night. Alternatively, heat pipes can be used to transfer the heat from the solar collector to the thermal storage. Heat is transferred from the thermal storage to the working fluid which drives turbine generators to produce electricity.

If this work proves to be successful, demonstration plants are expected to be built in several years, and large-scale power plants are expected to be possible in about 20 to 30 years. The primary location for such power plants would have to be sunlit desert areas receiving predictable and copious amounts of solar energy.

Solar energy sustains the winds. The power potential in the winds over the continental United States and its seashores exceeds by at least a factor of 10 the United States projected needs for electricity in the year 2000. Winds are remarkably repeatable and predictable. A wind power system could incorporate its own electricity storage which may include the electrolysis of water to produce hydrogen for transmission through pipelines as an alternate fuel.

In 1915, 100 megawatts of electricity was being generated by wind power in Denmark. In the 1940s, a 1.000 kilowatt machine was operated in Vermont, U.S.A., on an experimental basis. Substantial advances in the design of very light-weight aeroturbines indicate that small as well as large scale wind power generation may be feasible. Projections indicate that wind power could generate 20 per cent of the year 2000's annual electricity production. This projection is based on the use of wind turbines ranging in size from 100 kilowatts to 2 megawatts.

The temperature difference between the sun-heated upper layer and the deeper cold water of oceans can be used to power very large heat engines. Experimental power plants were built in 1929 off the coast of Cuba and in 1956 off the coast of Africa. These plants failed because of design limitations and damage by a hurricane. If successfully developed, this approach would make it possible to tap the tremendous heat energy stored, for example, in the Gulf Stream with the potential to generate 26 trillion kilowatt hours per year.

To extract this energy, specially designed ships (with a potential output of 500 megawatts) would be anchored in the Gulf Stream. The warm surface waters are passed through heat exchangers which boil a fluid such as propane to drive huge turbines coupled to generators. The cold water pumped from the ocean depth is circulated through heat exchangers to condense the working fluid (propane).

The process has to rely on heat engines operated over a temperature difference of about 40° F. A system efficiency of less than 5 per cent is projected. The major challenge is to develop the very effective heat exchangers and to design the large turbines to extract energy from the working fluid. In addition, materials have to be chosen to withstand the effects of seawater for prolonged periods.

Terrestrial conversion systems suffer from the fact that sunlight is not constantly available and is diffuse. This means terrestrial systems all need large collecting areas and storage capacity. This also means that conversion systems are economical in only a few favourable geographical locations.

These are earth-bound obstacles, and the way to overcome them is to place the conversion system in a satellite solar power station orbiting the earth where solar energy is available nearly 24 hours a day (during the equinoxes the satellite will pass through the earth's shadow for a maximum of 72 minutes each day).

The maximum utilization of solar energy can be made in an orbit around the sun. The first step towards the fullest use of solar energy is represented by a satellite in orbit around the Earth. This approach permits solar energy conversion to be carried out where it is most effective with only the final step arranged to take place on Earth.

Similar to already existing satellite world-wide communications networks, power from space has the potential to provide an economically viable and environmentally and socially acceptable means to meet future world energy requirements.

A satellite solar power station can be maintained in synchronous orbit 36,000 km. from Earth's equator. Two symmetrically-arranged solar collectors convert solar energy directly to electricity by the photovoltaic process. The electricity is fed to microwave generators incorporated in a transmitting antenna located between the two solar collectors. The antenna directs a microwave beam to a receiving antenna on Earth where the microwave energy is converted back to electricity.

Such a satellite can be designed to generate electrical power on Earth ranging from 3,000 to 20,000 megawatts. A system of satellites maintained in a desired orbital location could deliver power to most desired geographic locations with the receiving antenna placed either on land or on platforms over water near major load centres.

The use of the microwave beam allows all-weather transmission, so that full use can be made of the nearly 24 hours of solar radiation available in a synchronous orbit.

Only a limited expenditure of propellants for altitude control is required to overcome orbit-disturbing influences, such as the gravitational effects of the sun and moon, solar pressure and the eccentricity of the Earth.

The power generated by the Satellite Solar Power Station must be transmitted to a receiving antenna on the surface of the Earth and then rectified. The power must be in a form suitable for efficient transmission in large amounts across long distances with minimum losses and without affecting the ionosphere and atmosphere.

The power flux densities received on Earth must also be at levels which do not produce undesirable environmental or biological effects. Fortunately, man has considerable experience in high-power microwave generation, transmission and rectification, to achieve these design objectives.

A high-volume, two-stage transportation system will be required for a Satellite Solar Power Station. A low-cost stage capable of carrying a high volume of payloads to low-Earth orbit and a high-performance stage capable of delivering partially assembled elements to synchronous orbit for final assembly and deployment.

The challenge of a Satellite Solar Power Station capable of generating, for example, 5,000 megawatts of power on earth is to place into orbit a payload of about 25 million pounds and propellant supplies for station-keeping purposes of about 30,000 pounds per year. This challenge could be met by a space transportation system with the first phase represented by the space shuttle now under development in the United States.

Solar energy applications are still in an early stage of development. It is too early to tell which of the techniques now being studied will be useful in the long run. The prospect for developing these applications as alternatives to other energy production techniques appears to be very bright. But no quick solutions are in sight. However the successful development of even a few significant solar energy applications over the next few decades will permit society to look beyond the year 2000 with assurance that future energy requirements of all nations will be met without endangering the planet Earth. ■

DOWN ON THE SOLAR FARM

THE old way to run a steam turbine with solar energy is to do it with mirrors or optical lenses. They catch the sun, they focus it into a single hot spot to heat a boiler and raise steam. Then the turbine starts spinning to turn a dynamo and produce electricity.

It's a simple idea but it's not economic. Since the sun does not stay put, the mirrors or the lenses must be moved by a complicated tracking system to follow it through the sky. On cloudy days or even when the sun is obscured by a thin haze, they do not work very well. There's little heat, no steam and no electricity.

Several researchers have stopped looking into mirrors and, instead, they are turning to flat-plate collectors of which the simplest example is a black surface covered with a pane of glass. This is a "selective surface", it absorbs more heat than it radiates and the difference can be piped off and put to use. It catches heat even when the sun is not directly overhead so it need not be moved.

Since these surfaces do not concentrate sunlight nearly as much as mirrors do, a large area is needed to gather heat. Mirrors are measured in square metres, but selective surfaces are cheap and they could be spread over hectares. This has led to the concept of a solar power farm with land covered by sunshine collectors instead of crops.

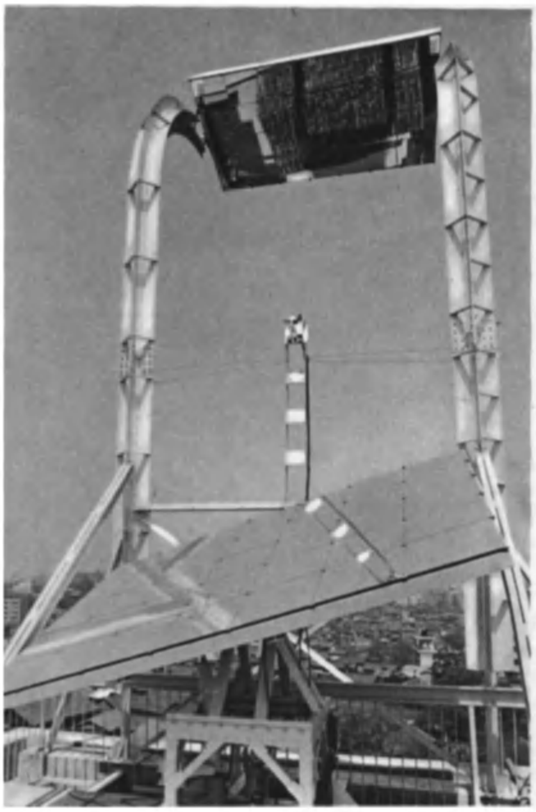
Dr. Aden P. Meinel, director of the Optical Sciences Center at the University of Arizona, and his wife, Marjorie Pettit Meinel, have calculated that a square measuring 118 kilometres on a side could collect enough sunshine in the southwestern United States to generate a million megawatts (a megawatt is a million watts).

They think that a plant could be set up in the Colorado River area where it would occupy some ten per cent of now uninhabited desert. Waste heat from the turbines could be used to desalinate enough water from the Pacific Ocean to meet the daily needs of 120 million people.

The Meinels have developed a "planar" collector that they use to heat their Arizona home and they have recommended that a 1-acre demonstration farm be set up with a three year budget of $4 million to test their system. In one model of a solar power farm, they propose four rectangular plots of solar collectors which would send heat to central storage tanks feeding turbines.

This would be a power plant with no tall smokestacks to smudge the air. The Meinels note that even motor cars would have to be banned from the area so that smog would not reduce power delivery from the sky. For once, more muck would mean less money. ■

YAMASHITA'S MIRRORS ON A HOT TOKYO ROOF



When the mushrooming, high-rise buildings of modern Tokyo shut out the sunlight from his old style, two-storey, wood-frame house, Japanese businessman Yasuichi Yamashita decided that something had to be done to get his sunshine back. He devised a system of three reflectors, one placed in his courtyard and two on the roof of a nearby building, with which to lighten his darkness. It's all done by mirrors, but the sunshine that now floods Mr. Yamashita's house is no illusion.

Equipped with an electronic sensor, the lower of these two mirrors (above), perched on a nearby rooftop, automatically tracks the sun. The upper mirror directs sunlight down into the Yamashitas' courtyard where a third mirror (being cleaned, below) bounces the sunlight inside the house (right). The Yamashitas say that they not only have their light and heat, but can also enjoy looking at the stars at night without going outside.

Photo © Paul Almasy, Paris

TOWER OF THE SUN, the striking 70 metre high landmark at the 1970 Universal Exposition in Osaka (Japan). Golden disc at its summit is in the shape of a solar energy mirror and symbolizes dependence of all life on earth on light, heat and energy from the sun.

SOLAR ENERGY CLAIMS A NEW PLACE IN THE SUN

On every continent, domestic heating and lighting units, water pumps, desalting stills, refrigerators are running on solar energy.

by Dan Behrman

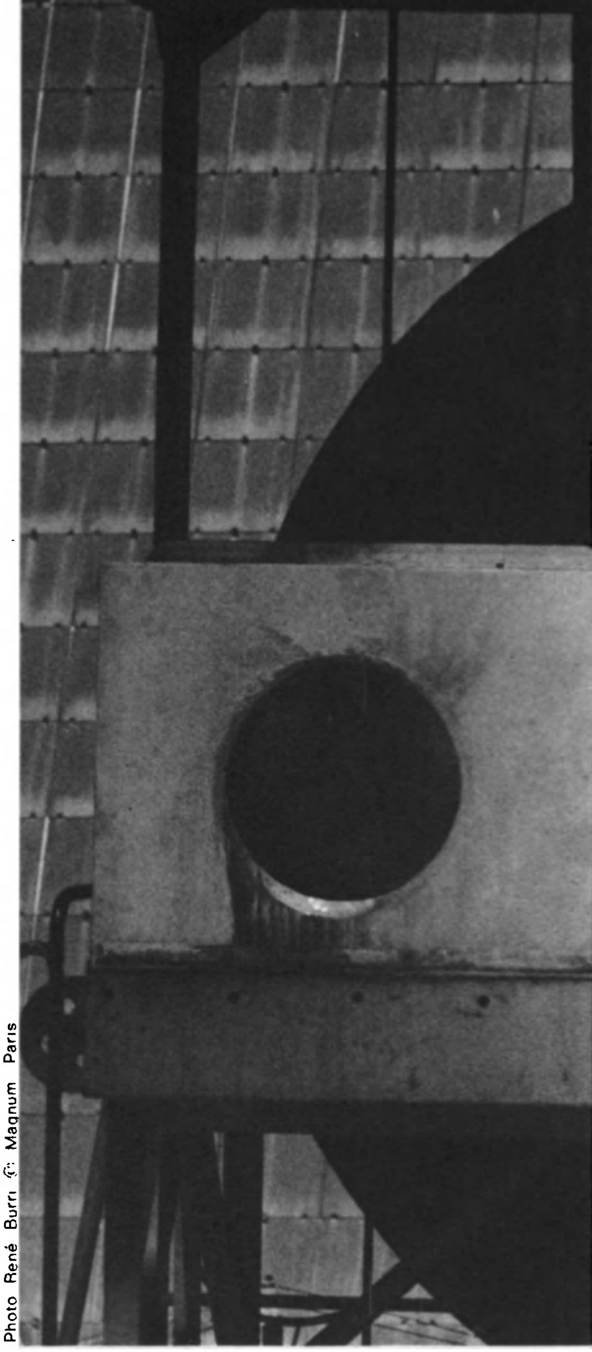


Photo René Burri © Magnum Paris

Solar furnaces are not only capable of converting solar energy into electrical energy and producing ultra-pure metals, they are also a priceless research tool for studying the properties of materials at high temperatures. Right, the solar furnace at Mont Louis in the French Pyrenees, built in 1952. The world's biggest solar furnace, completed in 1968 at nearby Odeillo, is much more powerful and can reach a temperature of 3,500 degrees C.

THE first rays of a world-wide co-operative effort to get more power from the sun have appeared on the international scientific horizon.

They could be discerned in the outcome of a meeting that brought thirteen experts from four continents to Paris, earlier this year to advise Unesco on how to set up a solar energy programme. This mini-conference was held just prior to the vast international congress on "The Sun in the Service of Mankind" that met under Unesco's sponsorship with its more than 800 participants from 59 countries.

Despite the discrepancy in size, the two meetings were complementary. The congress showed that techniques are available to apply solar energy at a time when the world faces a shortage of fossil fuels (particularly oil and gas) and a surplus of pollution; the experts' meeting sought ways to bring these techniques to developed and developing countries alike.

The experts suggested that scientists the world over consider the possibility of an International Solar Energy Decade, a "massive internationally-founded and directed research and development programme". This proposal was voiced emphatically at the closing session of the congress by its president, Prof. Pierre Auger, a leading French physicist and popularizer of science.

The experts also asked Unesco's Member States to think about "the possible creation of an International Solar Energy Commission to lead and co-ordinate a larger future international programme in solar energy".

The cautious optimism of the experts was more than justified by the congress itself. There scientists marshalled facts and figures to show that in such regions as the south-western United States or the eastern Pyrenees in France the sun is cheaper than electricity as a way to heat homes, and is getting within competitive reach of oil and gas, two fuels that can only rise in price.

A solar energy panel set up in the United States by the National Science Foundation and the National Aeronautics and Space Administration (NASA) has concluded that by the year 2020 the sun could provide 35 per cent of the nation's total building heating and cooling needs; 30 per cent of its gaseous fuel; 10 per cent of its liquid fuel and 20 per cent of its electric energy requirements.

But the panel did not think that Americans would have wait fifty years before starting to reap such benefits: "If solar development programmes are successful, building heating could reach public use within 5 years, building cooling in 6 to 10 years, synthetic fuels from organic materials in 5 to 8 years and electricity production in 10 to 15 years."

Solar power is a good way to heat houses because the sun delivers energy right to the rooftop without the long transmission lines required by electric power plants. On the other hand, solar-fired steam plants are very inefficient when it comes to generating electricity. It can be done—a battery-driven car has been run with electricity produced by a solar engine—but the cost per kilowatt is so high that it is just not realistic.

One way to get around this is to use

DAN BEHRMAN *is a Unesco science writer. He is the author of "The New World of the Oceans" (Little Brown and Co., Boston, U S A.) also published in a paperback edition, and "In Partnership with Nature: Unesco and the Environment", Unesco, Paris, 1972. His latest book, "The Man Who Loved Bicycles", was published last year by Harper's Magazine Press, New York.*

solar cells that convert sunshine directly into electricity without any boilers or turbines. Developed for use on artificial satellites in outer space, solar cells are extremely efficient but still wildly expensive. At one-hundredth of their present cost, they would be competitive and it is hoped that mass production will bring their price down.

One scientist at the congress, Prof. Sean Wellesley-Miller from Massachusetts Institute of Technology, has his own answer to the problem of cost.

"Just imagine that solar energy is everywhere in use, providing energy at a cost slightly above current prices. Imagine further that I was proposing the 'radical' idea of sending geological survey teams to the Middle Eastern deserts to search for oil and, having found it, to erect derricks, extract it and transport it either by pipeline or by especially constructed ships to the other side of the world where it would be refined and delivered to end-use points by truck.

"I am sure that, in these cases, there would be many people who would prove 'conclusively' that this would be economically infeasible."

He might have added that solar-powered generator plants would appear less uneconomic if they were stacked up against newly-invented diesel engines built the same way in small machines shops as one-of-a-kind prototypes.

In countries other than the United States, prospects for the sun are also looking brighter. In Australia, it has been estimated that 15 per cent of the country's energy needs could be met by solar power by the year 2000 and government scientists are now studying industrial applications that run from water-heating to timber-drying.

The world's most powerful solar furnace, the 1,000-kilowatt machine used to produce refractory materials of extreme purity at Odeillo in the Pyrenees of southern France, serves as the focal point for a major French effort directed by Prof. Félix Trombe. He began his work right after World War II, using reflectors from surplus anti-aircraft searchlights, and he is now one of the world's top solar energy authorities.

Prof Trombe is particularly proud of the contribution he has been able to make in Chile. In the clear, dry and transparent atmosphere of the Chilean coastal desert, loss of heat by radiation from the earth out into space at night is very high. Temperature differences of more than 40° C. have been obtained between an isolated "black body" and the air around it.

Developed by Prof. Trombe this process has been used by Chilean scientists to desalinate brackish water by freezing it. The fresh water, produced at the rate of 10 litres per square metre of basin per day, is used to grow tomatoes, radishes and cucumbers in greenhouses so that local miners, working in one of the world's driest deserts, can have a diet of fresh vegetables.

In the Soviet Union, solar power

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is under study and is already in use in various branches of the economy in Sunny central Asia and the Caucasus (see articles pages 32 and 38). As for Japan, it probably leads the world in the number of solar home water heaters in use.

Canada, though in a more northern latitude, is exporting expertise. At the congress, a paper by members of the Brace Research Institute of McGill University's Macdonald College in Quebec described how a large-scale solar steam cooker has been installed to feed 240 pupils at a school in Haiti.

The Institute's help had been requested by a religious community, Les Filles de la Sagesse, at Miragôane in Haiti. Charcoal, the traditional fuel, had become so scarce and expensive that the school was spending $60 a month just to heat the noonday meal for its pupils. Kerosene and similar fuels were not available because they, too, are costly in Haiti.

The Brace Institute's paper, written by R. Alward, T.A. Lawand and P. Hopley, described how a solar steam cooker was built for a total cost of $520 which means that it can pay for itself in fuel savings in less than nine months.

One should not forget that this is a special situation. In India, for example, a solar cooker as good as a 500-watt electric hot plate was tested but without success. Families did not always want to eat their big meals at noon—when a solar stove works best, of course, as in the case of the Haitian school—nor did women like to cook outside. When they did, they felt obliged to feed all the curious who came around to watch, and that drove up the price of solar energy. It would also drive up the price of barbecues if such a tradition of hospitality existed elsewhere.

SOLAR energy has proven economic first of all in the sort of absurd situations that affluence produces. Heating a swimming pool with the sun can mean a saving of several hundred dollars a month with no great hardship if one must miss a dip on an occasional cloudy day. In countries where fresh water is sold at a price that other countries pay for wine, a solar still can pay for itself very quickly.

As Dr Aden P. Meinel from the U.S., one of Unesco's group of experts, put it, solar energy is no longer a hobby for scientists and it is getting out "into the industrial world where money and men answer key questions".

Dr John Duffie, another expert and head of the solar energy laboratory at the University of Wisconsin in the U.S., remarked that money is not enough: "If you give me a dollar and I give you a dollar, we each have one dollar. If I give you an idea and you give me an idea, we each have two ideas."

This is the approach that the experts have urged on Unesco. Surveys are needed of existing information and a clearing-house should be set up to make it available where it is most needed.

The capacity to apply solar energy can be augmented in several ways, the experts believe. They recommend that Unesco should support such activities as the seminar it organized in October 1972 at Niamey (Niger) on solar energy in Africa or the training course it sponsored a year later in France at Perpignan, with Prof. Félix Trombe. They also asked that countries should be helped to start research and development work that could be financed internationally.

Such work is needed to develop greenhouses, solar pumps for irrigation, small furnaces to fire bricks, better buildings to take advantage of natural heating and cooling or techniques to store the energy of the sun overnight or longer.

That, perhaps, is the toughest problem of all in solar energy: what does one do when the sun doesn't shine? The experts could hardly recommend the solution suggested by Jonathan Swift, the author of Gulliver's *Travels:*

"He had been eight years upon a project for extracting sunbeams out of cucumbers which were to be put in phials, hermetically sealed, and let out to warm the air in raw inclement summers."

Luckily, the earth's supply of human ingenuity is not running out as fast as its reserves of fossil fuels. At the Paris congress, a number of unconventional solutions were advanced, nearly all based on the commonsense approach that the best way to collect and store the sun's energy is to use nature's way. One of them is photosynthesis, the process by which plants manufacture carbohydrates (sugars, starches, cellulose) from carbon dioxide and water.

It is the basis of the "energy plantation" described in a paper contributed to the congress by an American scientist, George C. Szego. He wants to use the sun to grow trees for fuel.

According to his calculations, 400 to 500 square miles of land could produce enough organic matter in the form of trees to feed a 1,000-megawatt power plant. Burning wood, he remarks, does not lead to much pollution and actually produces ash that could be used as a fertilizer to grow more trees.

He thinks that by farming trees to stoke an electric power station it should be possible to produce fuel at a cost close to $1 per million BTU's (British Thermal Units). In the U.S., he said, coal and oil-fired plants now operate at a cost of about $70 per million BTU's.

The panel set up by NASA and the

CONTINUED PAGE 40

HOME SWEET SOLAR HOME

THERE are some people who say we will be heating and cooling our homes with solar energy fifty years from now... and there are other people who have decided they don't want to wait that long.

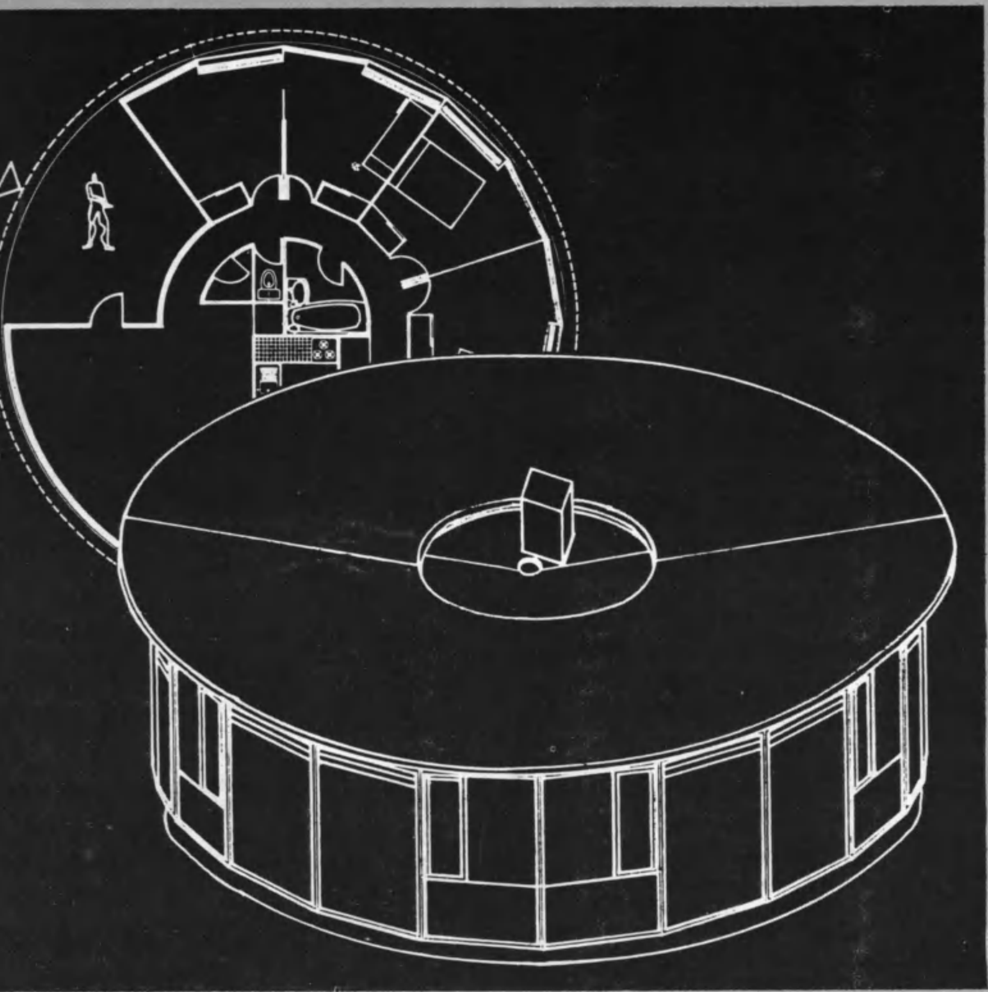
One of them is Harold R. Hay from Los Angeles who has invented a new word: solarchitecture. In a paper presented to Unesco's Paris congress on "The Sun in the Service of Mankind", Hay defines this as "the essential integration of interdisciplinary knowledge involving natural radiation forces, building design, materials of construction, and human comfort".

He first experimented with a house in Phoenix, Arizona, which he succeeded in heating and cooling with a roof pond 20 centimetres deep. Moveable panels let the pond warm up by day during the winter, then shield it at night to keep the heat in. In summer, the pond stays covered by day and, at night, the panels open to let the heat out.

Since then, Hay has constructed a solarchitecture house at Atascadero, California, on a test site that he calls "nearly ideal for demonstrating that heat storage produces superior comfort to the wasteful use of power for alternately heating during the cold nights and cooling during the hot daytime".

Cheap and easily available, water is Hay's preferred heat-storage medium. He uses it to fill plastic tubes which are inserted into walls of hollow concrete blocks. Hay remarks that such natural air conditioning is particularly appropriate to developing countries. Walls of earth, brick or stone can be built to support roof ponds even though they are priced out of the market in most industrialized countries. There is no need to buy motors and compressors with scarce foreign exchange. Natural air conditioning could be of special help to hospitals because it provides "gentle and uniform comfort with no noise, drafts or disease-spreading circulation of air".

This means a premium on low buildings because they have a much higher ratio of roof to total floor area and it is the roof that is needed to collect or get rid of heat. Such architecture runs counter to the universal trend of monumental high-rise buildings standing in lonely grandeur amidst a desert of parking lots.



Drawing © Jacques Michel, Neuilly, France

Left, circular farmhouse, built 10 years ago at Lissey in north-eastern France, is being adapted to capture energy from the sun using a system evolved by two Frenchmen, architect Jacques Michel and Professor Félix Trombe, head of the Solar Energy Laboratory of the Centre National de la Recherche Scientifique at Odeillo in the French Pyrenees. Vertical panels of polyglass are placed on the facade of the house a few centimetres away from sections of black-painted concrete wall. The "greenhouse" effect thus achieved causes heat from the sun to be absorbed and stored in the walls. Cool air from the rooms is drawn in through vents at the bottom of the wall, rises as it is heated between the polyglass and the heated wall and is then returned to the rooms. Below, model of a group of three houses, designed by Jacques Michel and using the same principles, now under construction at Odeillo. Two-thirds to three-quarters of the houses' heating requirements will be met by the sun.

SOLAR HOME *(Continued)*

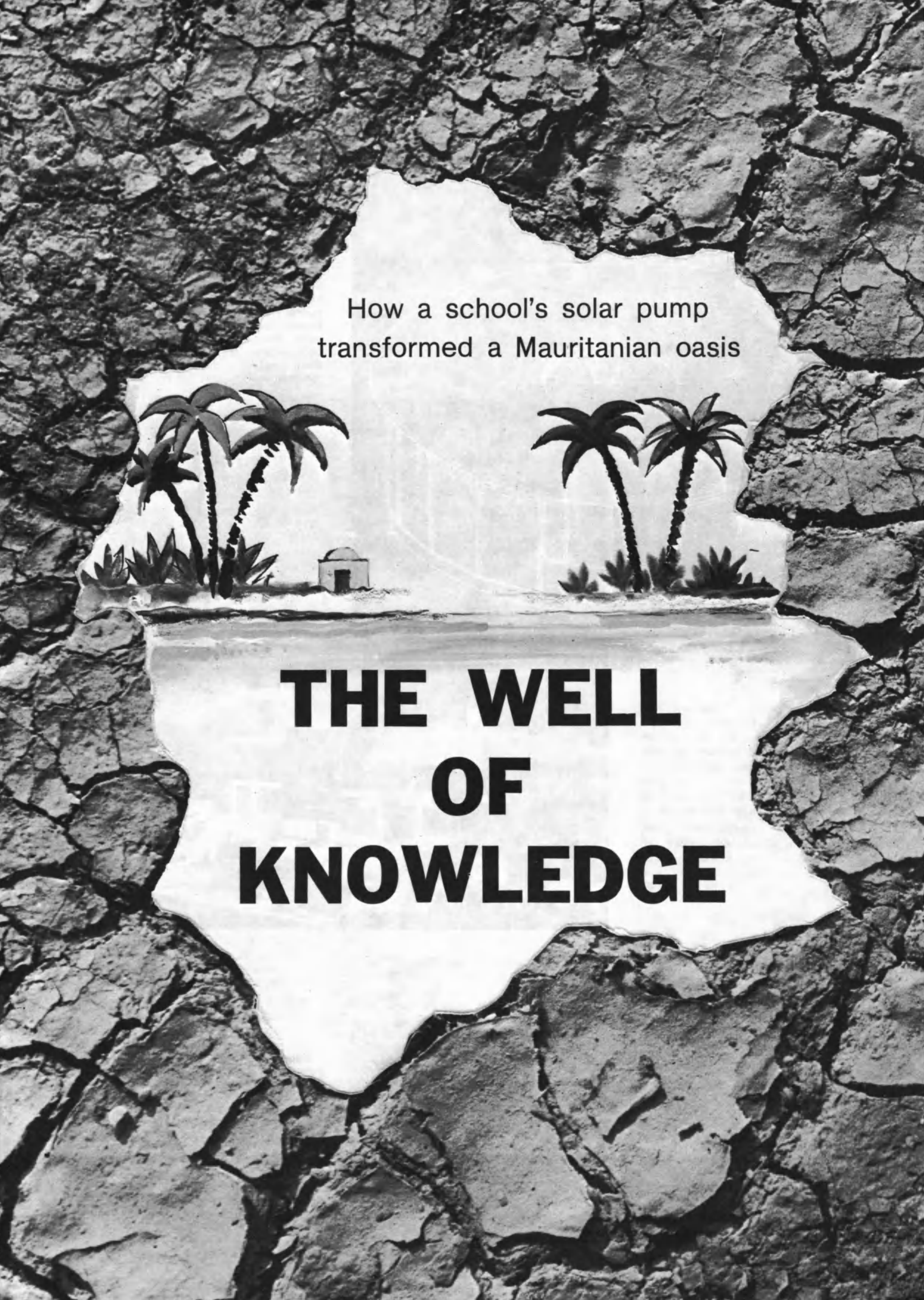
Hay wrote in his paper: "Land use and value are changing in ways that will affect, and will be affected by, on-site use of solar energy. Land prices may become higher wherever natural microclimates reduce the need for extra energy and property deeds might be required to indicate the energy value of building sites.

"To conserve virgin areas, new cities should be built on abandoned agricultural land and planned for lower power and fuel consumption through natural heating and cooling." ■

Photo © CNRS, Font-Romeu, France

Photo CSIRO, Victoria, Australia

Solar water heating for domestic purposes has been a small but flourishing industry in Australia for some 15 years, with a sizable export trade. Solar distillation is not yet established commercially, but a number of solar stills have been built and used successfully. Research programmes are being carried out by the Commonwealth Scientific and Industrial Research Organization and at a number of universities and work has begun on energy conversion using photovoltaic cells. Left, solar water heating system installed in a house at Mount Eliza, Victoria.



How a school's solar pump transformed a Mauritanian oasis

THE WELL OF KNOWLEDGE

by Howard Brabyn

WORN smooth and stained from constant handling, a length of rope, knotted at regular intervals, lies neatly coiled beside the mouth of the well. Untouched since the day nine months ago when it hauled up the last bucket of water drawn by hand by an inhabitant of Chinguetti, the rope mutely links sombre past with hopeful present.

For this is no ordinary well, and Chinguetti is no ordinary town. The seventh most holy place of Islam, the oasis of Chinguetti is a gruelling, 700 kilometre drive, along barely discernible desert tracks, due east from Nouakchott, capital of Mauritania.

Here deep in the Sahel, the semi-arid region fringing the southern limits of the Sahara and stretching across the heart of Africa from Mauritania to the Sudan, a crucial social and technological experiment is being put to the relentless test of practical application.

At the well, after centuries of service, knotted ropes and knotted muscles have given way to a classic, hydropump powered by sunlight absorbed and converted by collectors installed in the roof of Chinguetti's brand new schoolhouse.

Operating five to seven hours a day, every day, the pump can provide each of Chinguetti's 3,000 inhabitants with a daily 20 litres of water, just double the amount consumed before the pump was installed.

Before the pump came to Chinguetti, one member of a family would spend as much as half a day merely drawing water for the household. Often the task was delegated to children as young as six years old.

Drawing water was not a pleasant task, but the well was one of the natural centres of community life. For many Mauritanian children, the things they saw and the conversations they heard as they waited their turn at the well represented an important part of their general education.

In installing a solar pump was there not a danger of increasing the water supply but at the same time drying up the well of knowledge, of destroying one of the focal social points of community life?

The logical solution? Build a school with a roof that would act as a solar energy collector. The well of knowledge would be revived and community life invigorated.

Other problems arose. What form should the new building take? Should it be a functional building of ultra-modern design? Or should an attempt be made to make it harmonize with such beautiful existing buildings as Chinguetti's ancient mosque?

This question resolved itself in the happiest possible way. A tower was essential to house the pump and storage tanks and attached to this was the school building itself, the roof of which had to be of simple, rather flat gable type if it was to fulfil its role as an energy collector. The building was erected by local labour under the direction of an experienced foreman from Senegal, since the Senegalese are traditionally the expert masons of west Africa.

The resulting construction, with its courtyards, small windows and tower topped with the traditional protuberances, which guard the building and its occupants from danger, blends perfectly with the age-old buildings of Chinguetti. What is more, the design is such that the entire building could be constructed with local materials.

Some nine months after the completion of the pumphouse-school the pump is smoothly throbbing away bringing the benediction of water to 3,000 people. Its simple controls are handled by an unskilled local man. Only one technical inspection a year will be required and the designers hope that the pump will still be throbbing away in 15 or even 20 years time. School has begun and Chinguetti has resumed its traditional way of life relieved of one back-breaking, soul-destroying labour and with its water supply doubled.

The story of the Chinguetti pump began in the early 1960s when the late Professor Henri Masson, doyen of the University of Dakar and long-time resident in Africa, turned his attention to the problem of improving the water supply of this drought-prone region.

There were, he knew, adequate reserves of water just 10 to 20 metres below the surface and nothing, in theory, could be easier than to dig new wells or improve old ones and then instal classic pumps powered by the tried and trusty diesel engine. The necessary technology, it seemed, already existed and was only waiting to be applied.

But was it the right technology for this part of Africa? Who would instal and service machinery imported at

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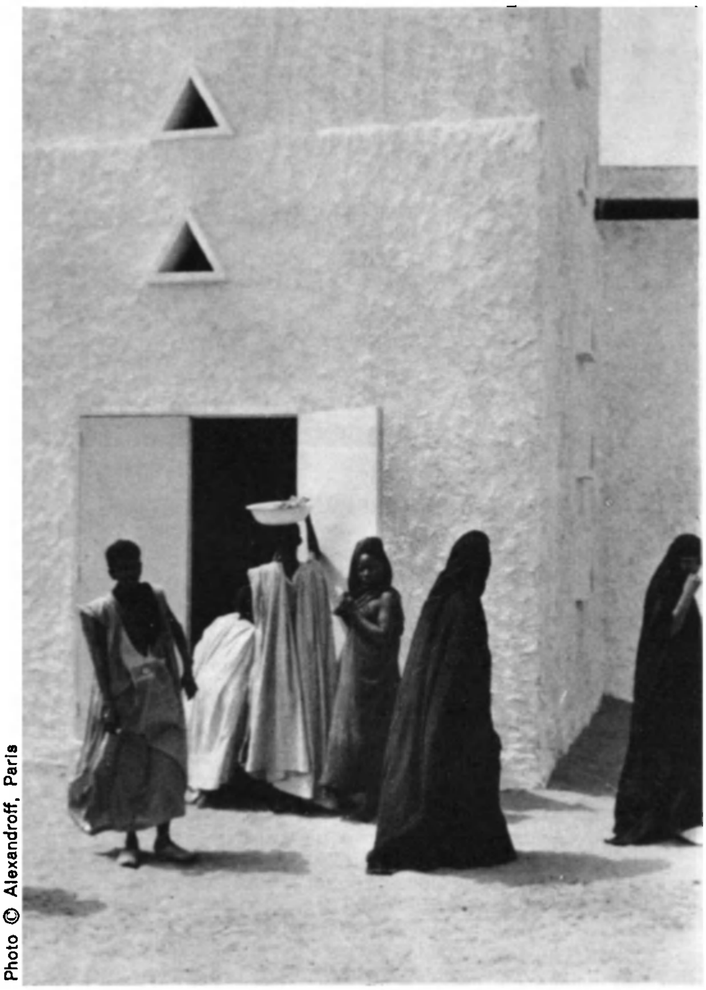
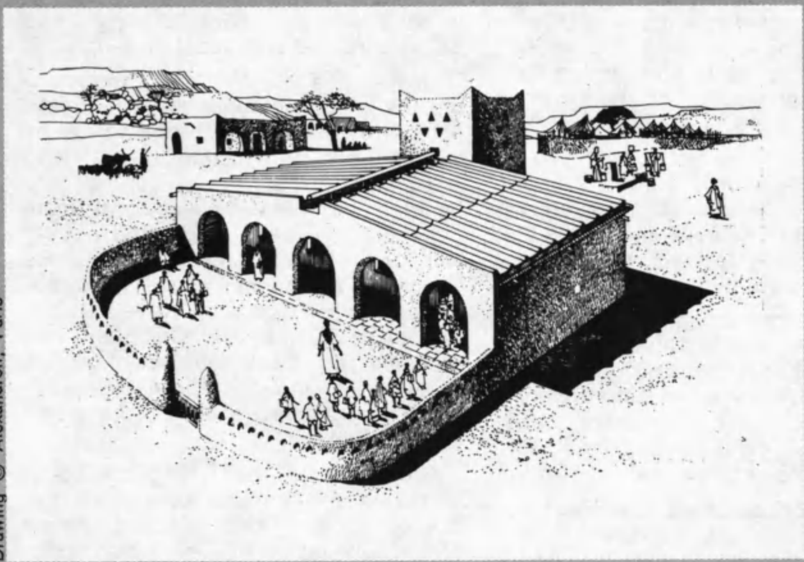


Photo © Alexandroff, Paris

The schoolhouse tower at Chinguetti housing the solar pump and water storage tanks.

HOWARD BRABYN, *English writer and journalist who has specialized in popularizing scientific and educational questions, is assistant editor of the English edition of the "Unesco Courier".*



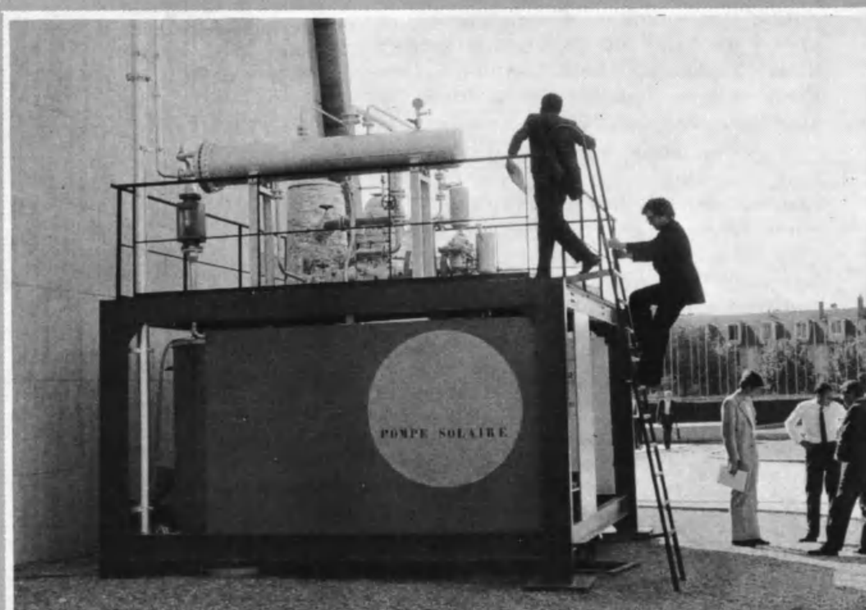
Drawing © Alexandroff, Paris

AFRICA PLUGS IN TO THE SUN

CHAD — Flat plate solar collectors of the type used at Chinguetti, Mauritania, can easily be fitted to the roofs of existing buildings. Left, sketch of the school at Ati, in Chad, showing the roof as it will look when fitted with "canaletas" or "solar gutters" to power a water pump.

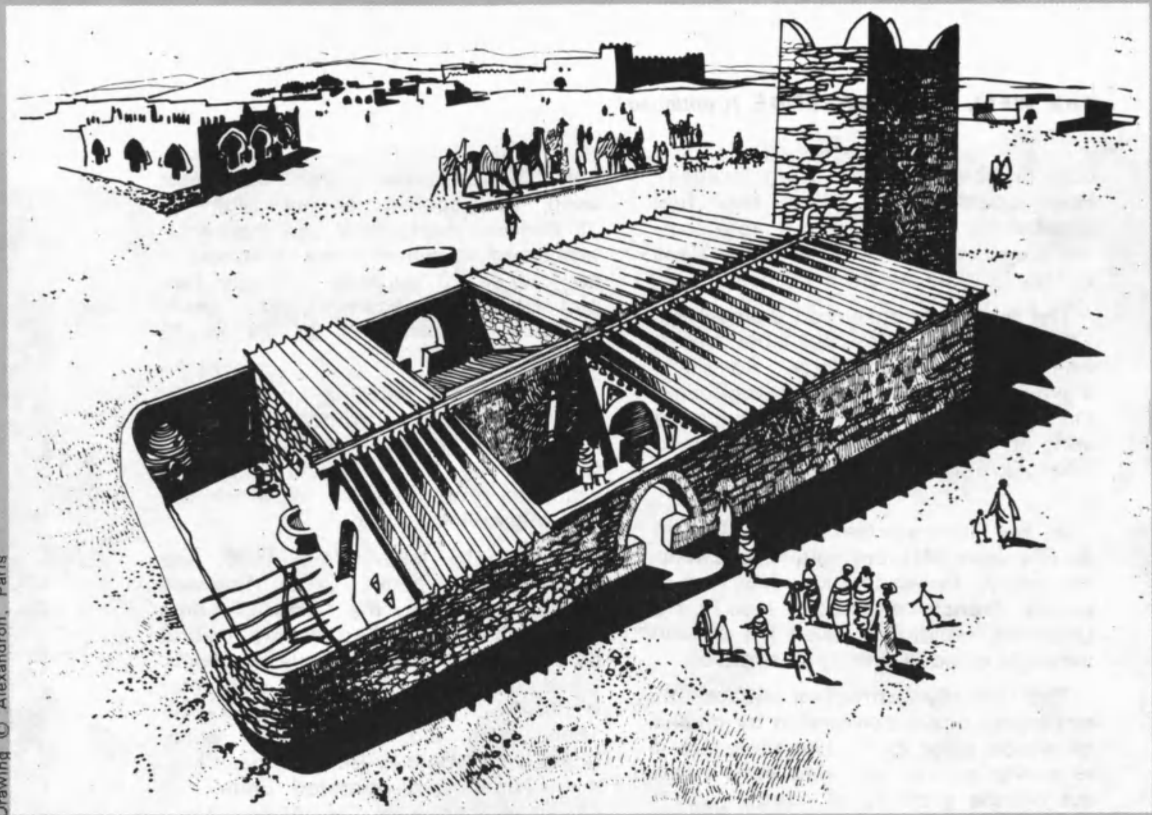
Photo Paul Almasy - Unesco, Paris

SENEGAL — For many years the University of Dakar has been one of the world's leading centres of solar energy research and it was there that the successful Masson-Girardier solar pump was developed. The Government of Senegal is encouraging the development of practical applications of solar energy. It has plans for the establishment of a number of bush dispensaries with water and electricity supplied by solar pumps. Above, a technician adjusts an absorption apparatus in the Solar Energy Laboratory of the University of Dakar.



Two displays in the Unesco piazza, Paris, during the international solar energy congress "The Sun in the Service of Mankind", held in July last year. Right, the Masson-Girardier solar pump (of the type installed at Chinguetti) and, opposite page, a simple, experimental steam engine, powered by sunlight concentrated by an array of reflectors.

MAURITANIA — Right, the school-pumphouse at Chinguetti, Mauritania. As well as providing power to pump water, the roof collectors cool the classrooms below. When the pump is working the temperature in the classrooms falls as much as five degrees centigrade.



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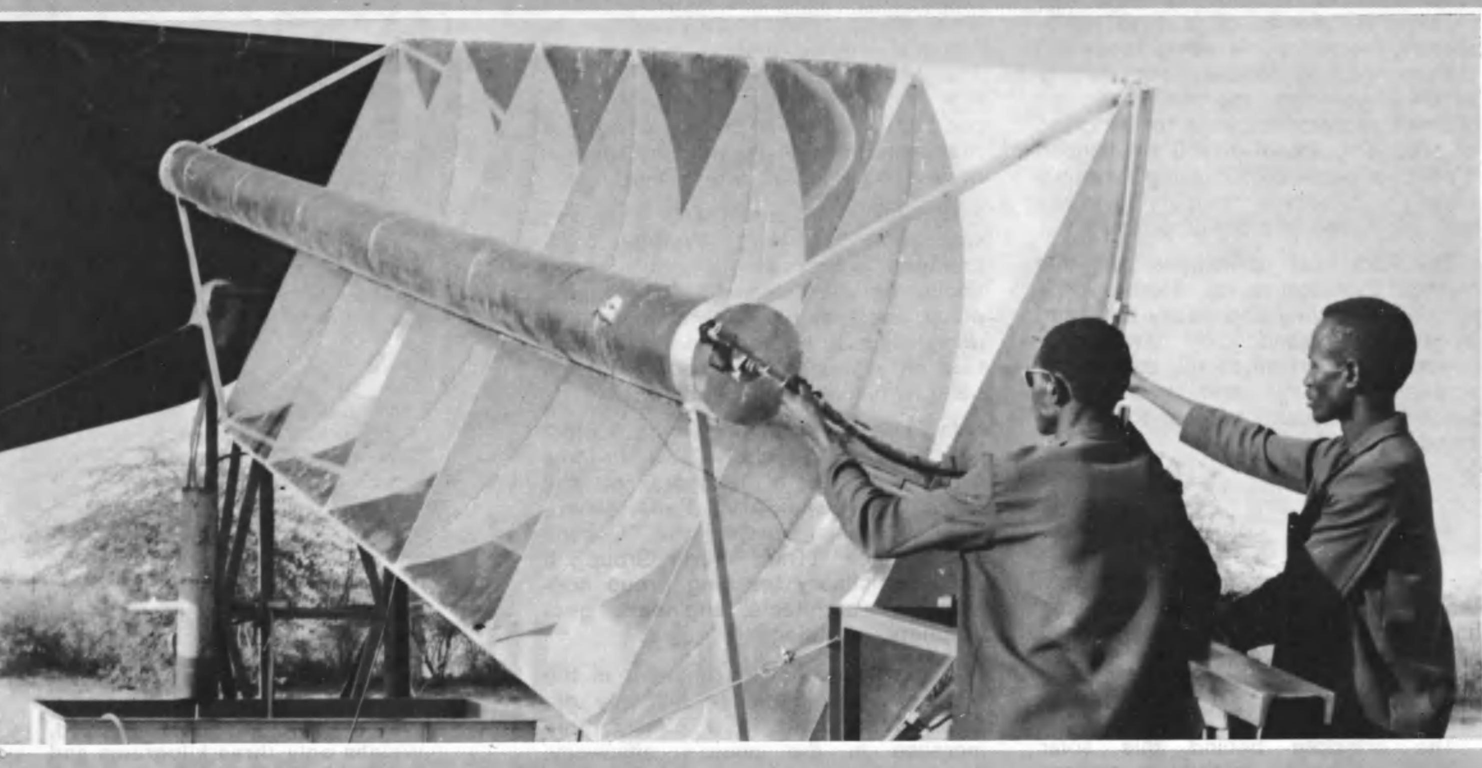

Photo © Michel Hetier, Paris

Photos Dominique Roger - Unesco, Paris

NIGER — The Niger Office of Solar Energy (ONERSOL), headed by one of Africa's leading authorities on solar energy, Dr. Abdou Moumouni, is carrying out a wide-ranging programme of research on solar energy applications. Above, this solar collector looks like a giant home electric heater, but instead of the central tube giving out heat to be reflected by the curved mirror, the mirror collects the sun's rays and concentrates them on the horizontal pipe, thus heating the water inside.

considerable expense from abroad? How could spare parts and fuel supplies be transported to remote communities across these trackless wastes? What would it all cost?

The questions answered themselves. The technology was available but it was the wrong technology. Somehow a way had to be found of producing long-life, maintenance-free equipment and of tapping the only abundant, locally-available energy source—the sun.

In the laboratories of the Institut de Physique Météorologique, at Dakar university, Professor Masson and a young French engineer, Jean-Pierre Girardier, rapidly reviewed the classic methods of solar energy conversion.

The initially attractive notion of employing direct conversion by means of silicon solar cells (like those used to power spacecraft) was soon ruled out on the grounds of cost.

Next to be considered was conversion by means of a high temperature thermal cycle using focussing collectors such as parabolic mirrors which concentrate the sun's rays on a small receiver capable for example of producing steam (if you set light to a piece of paper by focussing the sun's rays on it with a magnifying glass you are using the same principle).

The practical difficulties of this method soon led to its rejection. The mirrors are bulky and easily damaged by wind and sand; they have to be continually adjusted as the sun moves across the sky; and even small amounts of cloud reduce their efficiency considerably.

A simpler, more reliable method was needed to cope with the harsh conditions of Africa. The two men turned their attention to a form of conversion using fixed, flat-plate collectors.

The principle behind this solar energy conversion method is comparatively simple. Water circulating in a closed system of pipes running through flat-plate collectors is heated by the sun. The heat from this water causes a liquid gas, such as butane, to expand rapidly thus building up a pressure that drives a piston which in turn drives a pump. The gas then passes through a condenser where it is cooled and liquefied by the cold water pumped up from the well on its way to the storage tank, and the cycle is then ready to begin again.

The principle may indeed be simple, but in practice it calls for a faultlessly designed, high efficiency engine capable of operating with very small temperature differences. The pump at Chinguetti, for example will operate when the temperature of the well water used for cooling is as high as 35 degrees centigrade and the temperature of the water in the collectors is as low as 60 degrees. Simple flat-plat collectors, however, can easily produce temperatures of 70 to 75 degrees.

Experiments with a number of strictly laboratory prototypes with no possible practical application were followed by the production of four practical prototypes all of which are still in service.

First to be installed, in 1966, was the "NADJE" pump, to be followed two years later by the "SEGAL" pump (both initially installed at the Institut de Physique Météorologique de Dakar, Senegal, though "SEGAL" was later transferred to a site in the bush). Then came the "ONERSOL" pump (installed at Bossey-Bangou, near Niamey, Niger, and operated under the expert guidance of Dr. Abdou Moumouni, Director of the Niger Office of Solar Energy (ONERSOL) and one of Africa's leading authorities on solar energy). In 1971 followed the installation of the "OUAGA" pump, at Ouagadougou, Upper Volta, on which the first experiments in using the thermal cycle of commercial butane were made.

By this time Jean-Pierre Girardier was back in France. Working in a cramped corner of his firm's workshops, he perfected the "Chinguetti" pump, the first fully operational pump designed to fit into an integrated construction planned in co-operation with helio-technicians and architects.

In Paris Girardier had made contact with two architects, M. and Mme Alexandroff, both teachers at the Ecole des Beaux-Arts, Paris, where they were members of the "Groupe Tiers-Monde" (Third World Group), a multi-disciplinary teaching group consisting of architects, engineers, geographers, sociologists, etc.

This was a decisive moment in the pump's development. Not only did this contact lead to a considerable increase in the pump's efficiency, thanks to the development of improved collectors known as "Canaletas", or "Solar Gutters", but it also brought increased emphasis on the economic, cultural and sociological implications of introducing a revolutionary technology into a remote African community.

Perhaps for the first time ever, a piece of new technology was being planned as much round basic sociological considerations as on technical imperatives. Indeed, anyone who really cares about Third World development, who wants to make sure that the right technology is used at the right time, at the right place, in the right way, might be well advised to take a trip to Chinguetti to look at a length of coiled rope and to drink of the well of knowledge. ■

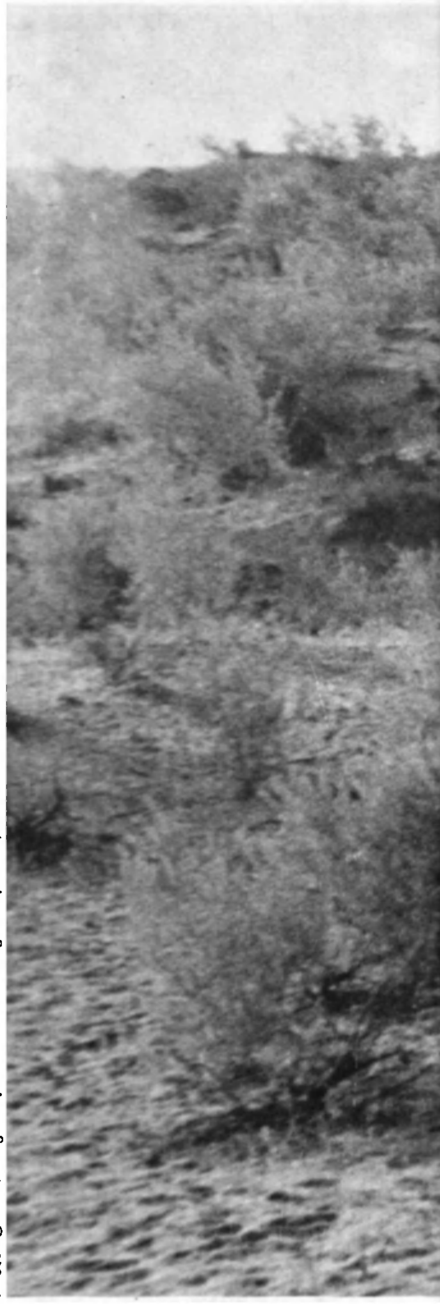

Photo © Yuri Yegorov, "Inventors" Magazine, APN, Moscow

Scientist O. Avezov of the Uzbekistan Academy of Sciences takes a compact solar still which he helped to invent for a practical test in the desert. The "portable well", as it has been dubbed, weighs only three kilograms and can hold two litres of salt water. Folding solar panels open out to capture the sun's energy and provide drinking water.

HUNTING THE SUN IN THE STEPPES OF CENTRAL ASIA

Drinking water in the desert now fifty times cheaper

VADIM ORLOV *is widely known in the U.S.S.R. for his work as a popularizer of science. He is a member of the editorial board of "Technology for Youth", one of the Soviet Union's most popular magazines with a circulation of two million.*

by Vadim Orlov

IN one of his essays, Maxim Gorky describes a curious incident involving Anton Chekhov: "One day I saw Chekhov, while sitting in his garden, try unsuccessfully to catch a sunbeam with his hat and put it on his head. The would-be sun-catcher became more and more irritated by his failure, and his face became more and more angry. Finally, after tapping his hat disconsolately on his knee, he abruptly rammed it onto his head."

The reason why I recall this vignette of Gorky's is that I am convinced that scientists, in the depths of their hearts, cherish the same dream of capturing the sun's rays, only they do not express it in quite such a direct way, having long been in the habit of speaking the

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Photo © "Inventors" Magazine, APN, Moscow

language of figures and formulas rather than the language of poets.

There was a wave of interest in solar devices in the eighteenth century. In 1741, Mikhail Lomonosov submitted a paper to the Russian Academy of Sciences, in which he suggested "exploring the electrical force in the focus of an instrument of combustion". There is an illustration of an imposing machine for concentrating the sun's rays in a treatise by Lavoisier.

Scientists in the second half of the twentieth century, with their more business-like approach to the future, have turned with fresh enthusiasm to this ancient problem of harnessing the sun's energy. In 1950, the French physicist Frédéric Joliot-Curie declared: "If we had the proper equipment and if we could use only 10 per cent of the solar radiation falling on a surface equivalent to the area of Egypt, we would obtain as much energy as the whole world produces today."

Certain enthusiasts of technological progress, accustomed to juggling with the astronomical figures of power output of modern industrial plants, continued to take the traditional view of solar devices as technically impracticable curiosities. The error is forgivable: Watt's steam engine, Diesel's motor, Laval's turbine and Tsiolkovsky's rockets were all regarded by their less far-sighted contemporaries as little more than fairground attractions.

Soviet scientists fully realize the potentialities of what many of them call the "noble fuel". The pros and cons of modern solar technology have also been carefully weighed from the economic point of view. As a result, an integrated plan for Soviet research in this field has been produced.

The research and development plan takes into account the guidelines which have been laid down for the economic development of the U.S.S.R. and which foresee the irrigation of millions of acres of natural pasture and the sinking of tens of thousands of boreholes. It would in many cases be advantageous if the pumps required for this purpose could be powered by solar energy. This would make it easier to keep herds on distant pastures and would mean a saving of millions of roubles.

Most of the uses of solar technology are connected with agriculture, but there is also a very wide range of possible domestic uses, and the integrated research plan provides for a number of laboratories to specialize in this aspect.

Scientists in Uzbekistan have concentrated their attention on the transformation of solar energy into electricity using semi-conductors, and are building domestic solar water-heaters, cookers, stills and refrigerators on this principle. Specialists in Turkmenia are working on air-conditioning devices for appartments as well as for devices to supply drinking water to cattle pastures.

The heating of buildings by solar means is being studied in Georgia, while in Armenia the possibility of constructing devices or plants for metal-smelting operations, where a high degree of purity is required, is being explored. A laboratory of the U.S.S.R. Academy of Sciences' Power Institute (Moscow) is seeking to improve the technical specifications of solar devices by studying the physical processes involved.

This concerted scientific programme is already beginning to bear fruit in some parts of Soviet central Asia and the Transcaucasus. A powerful solar still has been installed on the Shafirkan State Farm in Uzbekistan, where sheep are bred to produce astrakhan. It supplies about four metric tons of fresh water a day, at only 2 roubles a cubic metre. This is quite an achievement, when it is recalled that in some desert regions the same quantity of water costs a hundred roubles. The still can work perfectly well even in winter.

A group of research scientists under Corresponding Member of the Uzbeck Academy of Sciences Giyas Umarov has built and successfully tested prototypes of a compact solar cooker and a portable solar still. The heat source for the cooker is a folding parabolic collector with a diameter of 1.2 metres. In clear weather, it produces as much heat as an 800 watt electric cooker and a volume production model costs no more than 35 roubles.

The still, which its inventors have called a "portable well", weighs only 3 kg. when empty, and when full can hold 2 litres of saline water. A factory now being built in Bokhara will begin to turn out these devices in 1974, and when in full operation will produce 25,000 water-heaters, cookers and stills a year.

In the deserts of central Asia, where even in the shade the temperature sometimes reaches 50°C, the problem of keeping food is particularly difficult. The ordinary domestic refrigerator works by the evaporation of a liquid refrigerant and must therefore incorporate a pump, which complicates the design of the refrigerator and makes the apparatus less reliable.

A member of the physics Faculty of the Bokhara Institute of Education, Orif Shodiev, has built a refrigerator using a solid refrigerant, ammoniate, which evaporates directly when heated by solar energy, without passing through the liquid phase, and then re-crystallizes. This refrigerator requires no pump, is simple to use and reliable—and the hotter the weather the more ice it produces.

The Bakharden State Farm in the heart of Turkmenia's Karakum desert has been using a unique solar still for the last five years. It supplies three metric tons of drinking water for the farm's sheep every 24 hours. This fully automatic device uses solar power both to pump the saline solution out of the ground and to distill it.

The main components are a collector with a surface area of 20 square metres and a solar battery with an area of about 1 square metre. Its operating voltage is about 27 V and its power output is half a kilowatt. It is automatically equipped to follow the sun across the sky, to find it again after it has emerged from behind clouds and to swing back from west to east in the morning. An apparatus of this type becomes economically viable when alternative sources of fresh water are more than 35 to 40 kilometres away.

Tests carried out in the Central Asian republics with photo-electric generators which activate the sluices of automated irrigation systems show that it is cheaper to instal such a system than to bring in a low-voltage power line.

The heat of the sun is now harnessed to operate driers of various

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SOLAR-POWERED RAZORS AND SHEPHERDS' STOVES

Left: this device generates enough electricity to power a razor or a radio. Five photovaltaic solar cells in the bulb-like central unit convert sunlight reflected by the parabolic mirror into electricity.

Right: Uzbekistan shepherds gather for an open-air meal prepared on a solar cooker designed at the ultra-modern Institute of Applied Physics of the Uzbekistan Academy of Sciences, Tashkent.

Photo Yuri Yegorov © "Inventors" Magazine, APN, Moscow sorts for fruit, grain, sunflower seeds, meal, fish, timber, etc., and the temperature in greenhouses and driers can be raised by 9 or 10°C by using selective glass which lets through sunlight at the short-wave end of the spectrum and reflects long-wave radiation from its inner surface.

Until recently, no attention was paid to solar radiation in the design of insulation for buildings; only the external winter temperature was taken into account. In recent years, however, a new field of science, to which the name of "constructional actinometry" or "heliotechnics" has been given in the U.S.S.R., has come into being and has considerably influenced thinking in this area.

A device now being tested in Turkmenia is capable of "servicing" a four-storey block of flats using only solar energy. It provides air-conditioning, water heating (up to 300 litres per household per day), and central heating. Installation of this apparatus increases building costs by only 4 to 6 per cent and in any case pays for itself in two to three years from savings in electricity and fuel. Residential and industrial buildings using this system are to be constructed in many parts of the Soviet Union, particularly in places a long way away from grid supplies.

Some of the solar devices which have been built in the U.S.S.R. are by no means small-scale units. The huge solar furnace which is being built in Erevan, capital of Armenia, will be unique of its kind. The parabolic mirror will be 10 metres in diameter and the furnace will develop 50 kilowatts at a temperature of about 4,000°C. The Erevan furnace will be used both for research and for industrial applications.

Less powerful prototypes are already in operation. Only with the use of solar energy is it possible to reach the high degree of purity nowadays required in order to obtain heat-resistant materials, semi-conductors, luminophores and new chemical compounds.

Scientists are already saying that a "solar era" in power engineering is on the way—if not in the twentieth then in the twenty-first century. A preview of this era was offered by a recent exhibition of science-fiction paintings, "Tomorrow's World", held in Moscow. A picture by the Soviet astronaut Alexei Leonov and the painter Aleksander Sokolov showed a gigantic mirror orbiting in space. Lighting up vast regions of the earth at night, such a device could be immensely useful to places where ground and air traffic is particularly heavy after dark. ■

What ducks have taught us about 'biological clocks'

THE sun is essential to all forms of life, but it can have injurious as well as beneficial effects. These twin aspects of the effects of sunlight were highlighted in the "Sun and Life" section of the international congress, "The Sun in the Service of Mankind", held at Unesco headquarters in July 1973.

Ultra-violet rays, for example, play an important role in the development of the human bone structure, but can also have a harmful effect upon the skin (see back cover).

A number of studies described the effect of light on the nervous system, on muscular reaction time, etc.

Human beings and ducks enjoy and need the sun (see opposite page), and experiments with ducks have taught biologists a great deal about the physiological mechanism by which light affects various glands. Research carried out by Jacques Benoit, honorary professor at the Collège de France, Paris, has shown the effects of orange and red radiations in stimulating the gonads (sexual glands) and endocrine glands. Light stimulation occurs through the eye, but experiments have shown that it can act directly upon the hypothalamus (a sort of mini-brain within the brain proper) and cause rapid development of the gonads.

Other studies show that our organs and their activities are regulated by an internal, biological "clock" mechanism directly linked to the day/night solar rhythm. "Jet-lag", the feeling of malaise, loss of appetite, difficulty in sleeping, etc., experienced by an air passenger transported thousands of miles in a few hours, results from the sudden upsetting of biological rhythms.

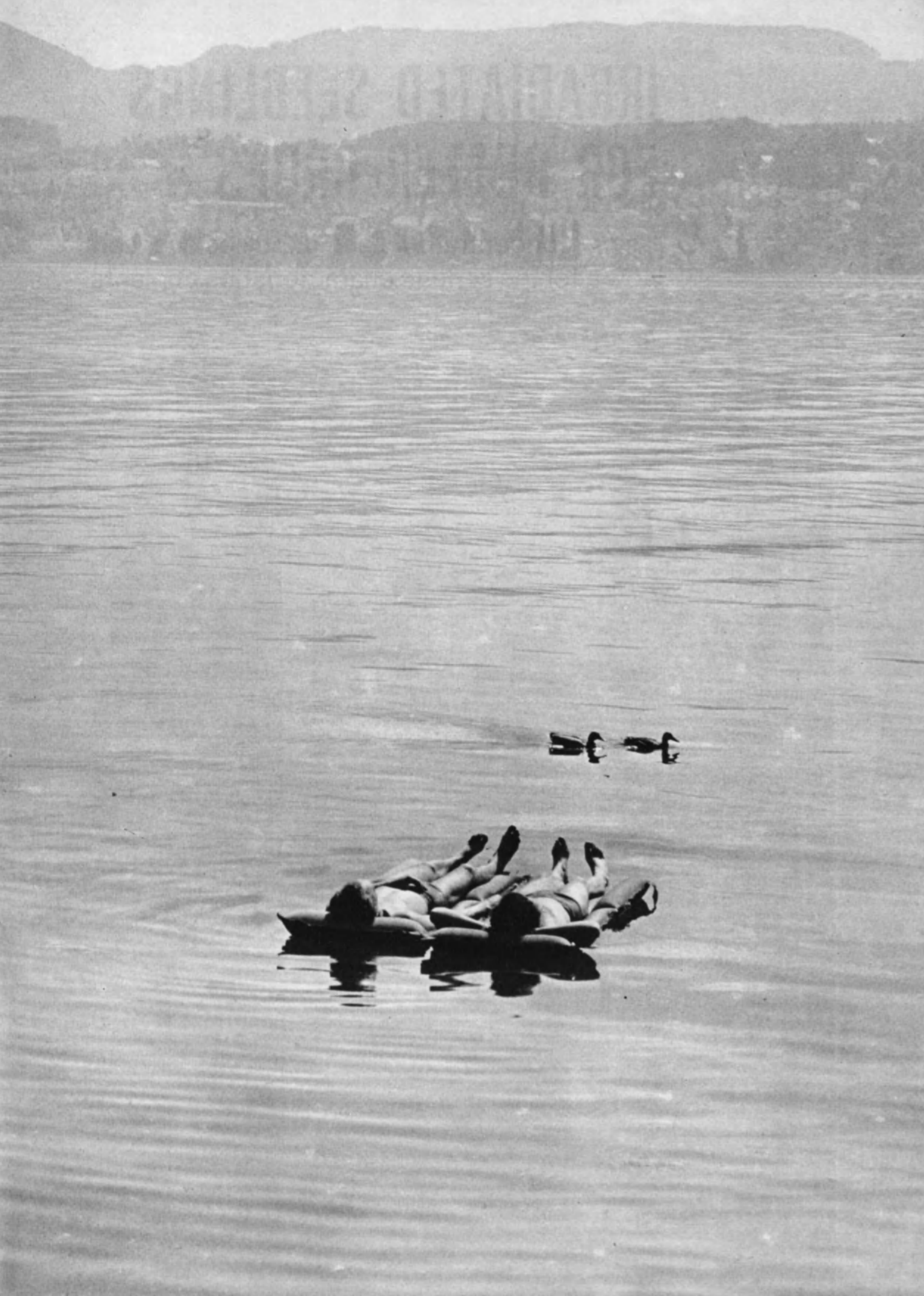
After a flight from New York to Paris, for example, it takes several days to re-establish the waking-sleeping rhythm, a week to re-establish the temperature rhythm, and several weeks for certain glandular activities to resume normal functioning. The precise cause and effect of this phenomenon have yet to be fully understood and explained.

Professor Benoit's experiments with ducks have helped to clarify the relationship between light and human biology. Drakes were confined either in total darkness or in uninterrupted light; in both cases they went through three or four sexual cycles during a year instead of the usual single cycle.

Such discoveries mark the birth of "chronobiology", a new discipline of great importance since it has shown that the human organism is affected by medicines or toxins to a greater or lesser degree according to the time of day. The mortality rate of rats injected with nicotine varied from 83 per cent at 1800 hours to only 8 per cent at 1300 hours. Similarly, reaction to penicillin varied as much as 41 per cent, the most favourable period being between 1900 hours and 0400 hours.

Other experiments described at the congress included those carried out by Professor Jean Dorst of the Muséum d'Histoire Naturelle, Paris, on the seasonal migration of birds and fish. These experiments show that birds are able to keep track of the sun's position throughout the day and when in flight to make the necessary corrections of course every hour to compensate for the apparent movement of the sun. This implies that birds also have a form of internal "clock" which "reminds" them to take this factor into account.

All this research is revealing hitherto unsuspected facts about the mechanism of these biological "clocks".



IRRADIATED SEEDLINGS FOR BETTER CROPS

Using concentrated light impulses we can now alter the genetic characteristics of plants

by Aleksander Shakhov

ALTHOUGH solar energy is the very basis of agriculture and forestry, paradoxically, little attention has been paid to the problem of increasing the efficiency with which plant life makes use of solar energy.

It is true that scientists have for years been studying the process of photosynthesis whereby plants, in the presence of sunlight, can assimilate carbon dioxide from the air and produce oxygen. The study of this process over the last 200 years has given us considerable insight into the mechanism which enables plants to use sunlight and into the biosynthesis of the products of chemical changes in living matter.

But the hopes which scientists entertained of bringing about a significant increase in the productivity of agricultural crops by improving the process of photosynthesis have been disappointed. In the course of many millions of years of evolution, plants would appear to have developed such a sophisticated apparatus for capturing and processing light in their leaves that it would be extremely difficult, if not impossible, to improve on it and make it even more productive.

Nature appears to have provided plants with the ability to assimilate light in limited quantities, so that the processes within the plant cells are not harmed by large doses. Even in countries with a humid tropical climate and favourable conditions of temperature, the rate of photosynthesis is not very high.

It has been calculated that plants in the process of photosynthesis assimilate only from half to one per cent of all the light energy absorbed by their leaves, and only in the most favourable circumstances does this figure rise to 4 or 5 per cent, which is the absolute limit.

ALEKSANDER SHAKHOV, *Soviet expert on plant physiology, is a pioneer of studies on techniques designed to increase crop yields by exposing plant seeds, pollen and tubers to concentrated sunlight. He heads a research team at the Timiryazev Institute of the Physiology of Plants of the U.S.S.R. Academy of Sciences in Moscow.*

Scientists have nevertheless persisted for many years in their desire to increase the amount of light which can be used by plants. Could plants use more solar energy if it could be introduced into those parts, such as seeds, pollen or tubers, which do not have the faculty of photosynthesis? Would it not be possible to improve yields of plants and thus improve crops by using intense sunlight in some way?

This was an idea which occured to my colleagues and myself in the late 1950's when we were doing research in the Kola peninsula in the Arctic on the effects of 24-hour sunlight. In these regions, where the sun is very low in the sky, the sunlight contains a relatively high proportion of red and infrared rays. Although infrared rays play no part in photosynthesis, they are more actively absorbed by plants in the Arctic than in the middle latitudes, as if to make up for the heat which the plants lack.

We set out this idea in a paper which we published in 1957 on "The photothermic hypothesis of the adaptation of plants in Arctic conditions". This theory stressed the possible significance of *non-photosynthetic* use of solar energy. This idea found further confirmation when we were able to observe the striking effect of concentrated sunlight on non-photosynthesizing seeds, pollen and tubers.

When, by subsequent research, we were able to prove that the biochemical processes in those components of the plant's cell known as mitochondria and peroxisomes and the cell nucleus changed under the influence of light, we advanced a theory of the "non-photosynthetic transformation of light energy by plants".

Many years of experiments over the length and breadth of the Soviet Union have shown that the transformation of light in the non-photosynthesizing organs of plants can produce appreciable effects and that this is therefore a new way of increasing plant yields. In our early research on this subject, we subjected plants and seeds to a brief but intense "shower" of light, using sunlight reflected and intensified by the mirror of a solar device. In order not to singe the plant, it is irradiated in short bursts —pulses of from 1 to 0.01 second's duration. The period between the pulses is a fraction of a second. During irradiation, the plant receives thousands of pulses or "light quanta".

By treating the seeds of various plants (e.g. potatoes) in this way, it is possible to accelerate and improve germination and the growth of shoots. Piercing the leaf or pollen grain thousands of times and penetrating deep into the cell itself, the light quanta act directly upon the fundamental cell processes. They stimulate the formation of a membranous system in those parts of the cell where the energy processes take place, increasing the activity of the enzymes which are the catalysts of biochemical reactions. More important still is the fact that irradiation with pulses of light affects the synthesis of proteins and nucleic acids and also affects the chromosomes and genes which govern heredity.

As a result of experiments it has been possible, for instance, to increase the early crop of tomatoes and cucumbers in Kazakhstan by 20 to 30 per cent. The overall yield on experimental fields with an area of between 10 and 20 hectares has been increased by 15 to 16 per cent.

PROMISING results have been obtained in some sugar-beet growing areas of the Soviet Union. Pulsed-light irradiation of sugar-beet seeds has produced not only a heavier yield but has also increased the sugar content by from 0.5 to 1.5 per cent and more—as against the 0.5 to 0.7 per cent increase which has been produced by selective breeding over a period of 25 years.

In Kazakhstan, by subjecting potatoes and melon, water-melon and soya bean seeds to 45 minutes of irradiation, yield of those crops have been increased by 15 to 20 per cent, and

Photo © V. Jacobson Pravda, APN, Moscow

cotton yields have similarly increased in Uzbekistan by 5 to 10 per cent.

Such is the effect of pulses of concentrated sunlight on the non-photosynthesizing organs of plants. This effect is even more pronounced when the light alters the hereditary characteristics of the plant, but this requires a longer period of irradiation.

If seedlings of spring-sown wheat are submitted to a daily dose of pulsed-light radiation of 30 minutes for between 10 and 20 days, the next year the descendants of these plants will have bigger ears with a larger number of grains and will ripen a week earlier. The yield of the new strains, known as photomutants—genetically stable over several generations—is 50 % higher than that of the original plants.

In Moldavia, irradiation of winter wheat at various stages of development has produced 5-6 per cent of photomutants. Some of these were strains with a shorter and stronger stalk and a larger protein content in the grain. These plants have annually produced genetically identical offspring for five or six generations.

After soya beans had been subjected to pulse-light radiation for half an hour a day throughout the vegetative stage, photomutants were obtained which ripen three to four weeks earlier than their predecessors. The fact that these plants remain genetically stable through six generations while continuing to produce the initial crop of 30 quintals per hectare shows that plant breeders have something new to work on here.

Poplar buds given radiation while growing produced a coarser type of pollen. Seedlings pollinated with this grow better in their first year or two of life, which could be very important for forestry in semi-arid regions. Lastly, Dr. C. V. Moraru, working in Moldavia, has managed, by irradiating winter wheat throughout the summer period during the hours when the sun is high in the sky and sunlight is at its most intense, to produce photomutants which are genetically stable for ten generations.

Such photomutants are now being carefully studied and are being tried out in the fields and in plant geneticists' laboratories, where they will be used for further selective breeding. Thousands of acres in Moldavia are being sown with a photomutant strain of wheat to obtain selected seeds. This high-grade wheat has already produced thousands of quintals of grain.

Thus, by using the concentrated rays of the sun, man is now able to alter and improve agricultural crops and to produce new, heavy-cropping varieties. At the same time, the overall problem of changing the genetic characteristics of agricultural plants by means of light is still a new and very difficult one.

All we have done is to make a successful start, to take the first steps to prove that solar energy can be used by man to transform plants by acting on their genetic characteristics. Since plant life depends on sunlight and is controlled by genes and since the sun and the genes together are the motive forces of agriculture, it is to be hoped that this new science of "photo-energetics" will be instrumental in improving the productivity of agriculture. ■

SOLAR ENERGY CLAIMS A NEW PLACE IN THE SUN *(Continued from page 26)*

National Science Foundation to study solar energy has looked at this proposal quite favourably. It could find no strong social objections although it did see a problem in land costs.

Then it cited a number of other ways to achieve a similar conversion of sunshine into a fuel that can be used at any time. In many cases, the end-product is hydrogen, a clean fuel that is easy to transport. It could be produced, for example, by using the photosynthetic apparatus of green plants or blue-green algae.

Another useful gas, methane, can be manufactured by letting bacteria go to work on solid wastes. There is nothing new here; many sewage treatment plants already meet their own power requirements with the gases they generate.

An even older process, charcoal-burning, appears in the NSF/NASA report under the much more alluring name of pyrolysis. This is destructive distillation carried out in an atmosphere void of oxygen. It breaks organic wastes down into liquid, solid or gaseous fuels and, so the panel thinks, the U.S. could meet one per cent of its oil requirements in this way alone.

WATER is a cheap way to gather solar energy with a cost per square metre infinitely lower than that of mirrors or the so-called selective surfaces that absorb more heat than they radiate. It is used in the so-called solar pond developed about fifteen years ago by Dr. Harry Tabor, head of the National Physical Laboratory of Israel.

The first pond was about 600 square metres in area. It measured a metre deep with a blackened base. When filled with layers of water in which salt has been dissolved, the denser bottom layers are heated without any convection occuring. So the heat stays down at the bottom where it can be drawn off and used to run a turbine while the sun pours more heat onto the surface. Interest in this principle is being awakened with the rising cost of fossil fuels.

Most tempting of all is the possibility of using the ocean as a gigantic collector of solar energy to be had for the asking. Some forty years ago, a French scientist, Georges Claude, suggested that the difference between the temperature of the ocean's surface and its depth—about 20°C in certain tropical areas—could be used to run a heat engine.

His idea was demonstrated on a bay in Cuba where 22 kilowatts of power were generated but then it was allowed to become dormant when the discoveries of new fields staved off an oil shortage that was a threat even forty years ago. Today, the NSF/NASA panel wants to wake up this idea.

Another way to use the sea was suggested at the congress by Dr. Ali Kettani of the College of Petroleum and Minerals in Saudi Arabia. He wants to harness solar evaporation to perform the apparently impossible feat of generating hydro-electric power in a country with neither rainfall or mountains.

How? Look at a map of Saudi Arabia. Its coastline is dented by the Dawhat Salwah, a small gulf 6,000 square kilometres in area. Quatar lies across the Dawhat from Dahran, and the island of Bahrain is in the middle, forming a stepping-stone for a proposed series of dams.

Once the Dawhat Salwah had been shut off from the open sea, it would receive no new water to replace what it loses by evaporation in one of the world's hottest climates. After three or four years, Dr. Kettani calculates, the level of the gulf would fall by thirteen metres. That would be enough of a head to run a "helio-hydro-electric" plant producing 300 million kilowatt-hours per year.

"Scientists should think big", he told the congress, "Theoretically, enough sun falls on 5 per cent of the area of the United States to generate all the electricity that the United States will need in the year 2000. But I'm sceptical about covering 40,000 square kilometres with solar cells. I try to avoid the problem of solar cells by using open areas of the sea to transform solar energy into electricity. This is a dam in a reverse and we are now investigating evaporation rates in Saudi Arabia to determine its feasibility."

He pointed out that other economic benefits could be expected from a Dawhat Salwah complex. Water on the lower side of the dam could be turned into a brine from which such highly-prized minerals as magnesium and bromine could be extracted.

Kettani estimates that it would cost $150,000,000 to carry out his project but it would bring in between fifty and sixty million dollars a year. And, not least of all in his view, it could conserve oil, the treasure of Saudi Arabia.

This would be a change from the present state of affairs but, if the omens at the congress are right, our whole world may be turned topsy-turvy. Homes that are cheap to build but costly to run because they eat great quantities of fuel could become obsolete, giving way to houses that hoard the sun's energy collected on their roofs.

Fred Dubin, a New York consulting engineer who spoke at the congress, is a long-time apostle of energy conservation. He estimates that about 40 per cent of the energy Americans consume goes for heating, cooling, ventilation, lighting and power systems in buildings. Proper design could cut energy consumption in new buildings by up to 50 per cent and in old ones by around 20 per cent.

"When the architect, for God knows what reasons, produced glass boxes with inoperable sashes and sheer wall surfaces without solar control, the engineers dutifully provided lots and lots of air-conditioning using lots and lots of power", Dubin has written.

Then Americans could save another 40 to 75 per cent of the power they now use in buildings if they turned to solar energy to heat and cool offices. This does not hold true just for sunny California but also in a chilly New England climate at Manchester, New Hampshire, where Dubin is planning an office building.

THE very shape of communities would change if energy came not only from mines, refineries or power plants but also from the sky. Solar energy could bring about the sort of revolution wrought by steam or electricity when they were introduced.

A hint of this came in a paper presented to the congress by Prof. J. K. Page of the University of Sheffield (United Kingdom). He also took a swipe at modern architects for introducing the worst features of European design into developing countries. Glass-walled buildings in hot climates demand air-conditioning that takes electric power away from industry. "It's a case of bad architecture slowing the industrialization of nations", he said.

Prof. Page sees the distinction being wiped out between town and country. Already, factory farming has created "animal cities" and even "animal slums" in the countryside. The next step is to bring the country into the city. He wants to use sunshine falling on buildings to grow plants on their roofs. Carbon dioxide and moisture generated by their inhabitants could be fed up to the gardens on the roof to speed plant growth.

And, during their lunch hours, office workers could relax in these gardens where city and country would be combined without the lemming-like rush of commuter migrations.

Dan Behrman

BOOKSHELF

Recent Unesco books

■ **Cultural Policy in Indonesia**

Prepared by the Ministry of Education and Culture of the Rep. of Indonesia. 1973, 46 pp. (6 F)

■ **Cultural Policy in the Philippines**

Prepared under the auspices of the Unesco National Commission of the Philippines. 1973, 40 pp. (6 F)

■ **Cultural Policy in Senegal**

By Mamadou Seyni M'Bengue. 1973, 61 pp. (6 F)

■ **Towards a Conceptual Model of Life-long education**

By George W. Parkyn. 1973, 54 pp. (6 F)

■ **The Unesco-IBE Education Thesaurus**

A faceted list of terms for indexing and retrieving documents and data in the field of education. 1st ed., 1973, 199 pp. (20 F)

■ **The Book Hunger**

Edited by Ronald Barker and Robert Escarpit. Co-edition Unesco-Harrap, Paris, London, 1973, 155 pp. (22 F)

■ **Practical Guide to Functional Literacy**

A method of training for development. 1973, 170 pp. (10 F)

■ **Records of the Conference for Revision of the Universal Copyright Convention**

1973, 295 pp. (48 F)

Other books

■ **Main Trends in Psychology**

By Jean Piaget. (Harper Torchbooks) Harper and Row, New York, 1973, 72 pp. ($1.95)

■ **Comenius and Hungary**

Essays edited by Eva Földes and Istvan Meszaros. Akademiai Kiado, publishing house of the Hungarian Academy of Sciences, Budapest, 1973, 175 pp., illus.

■ **Towards a Steady-State Economy**

Edited by Herman E. Daly. W.H. Freeman and Co., Reading, U.K., 1973, 332 pp. hardback (£4.30), paperback (£1.70)

■ **W.H. Auden**

By Dennis Davison. (Literature in Perspective) Evans Brothers Ltd., London, 1970 (£1.25)

UNESCO NEWSROOM

'One world for all' photo contest

An international photo competition in conjunction with World Population Year 1974 is being organized by the Cologne Photokina, a world photography festival, and the Fed. Rep. of Germany National Commission for Unesco. Its theme, "One World for All", is that chosen by the U.N. for World Population Year and aims to promote awareness of problems associated with the 100 million annual global population increase. Closing date for entries is April 2, 1974. Further details can be obtained from The Photokina Office, Kölner Messe, 5 Köln 21, Postfach 210760, Fed. Rep. of Germany.

U.S. aid for Philae rescue operation

The United States is to contribute the equivalent of $1 million in Egyptian pounds to Unesco's international campaign to save the temples of Philae on the Nile. The work of transferring the temples to a nearby island began in 1972 and should be completed by 1976. Unesco member states have thus far paid or pledged over $6,500,000 towards the estimated cost of $13,700,000.

Tanzania's health campaigns by radio

Nearly two million Tanzanians have been participating in health education campaigns based on radio programmes and study groups. The campaigns dealt with the country's major health problems, including malaria, hookworm, dysentery and tuberculosis, and their texts provided follow-up reading material for Tanzania's recent national literacy campaign.

'Books for all'

Unesco has invited its member states and 400 non-governmental organizations to join in a long-term programme for the promotion of books and reading. Suggested ways of overcoming current problems in the production, distribution and use of books are outlined in a special Unesco booklet, "Books for all". The global programme is a follow-up to Unesco's successful International Book Year observed throughout the world in 1972.

U.S. and U.K. science writers share Kalinga Prize

The annual Kalinga Prize for the popularization of science was recently awarded to Dr. Philip H. Abelson, editor of the U.S. weekly "Science" and to Nigel Calder, the British science writer. This is the first time since it was founded in 1951 that the Kalinga Prize, awarded by an international jury chosen by Unesco, has been shared by two winners. Nigel Calder is also the first son of a Kalinga Prize winner to follow in his father's footsteps. The prize for 1960 was awarded to Lord Ritchie Calder. Dr Abelson, editor of "Science" since 1962, is also president of the Carnegie Institute in Washington. Nigel Calder was editor of the British weekly "New Scientist" from 1962 to 1966 and is widely known for his books and TV programmes on science.

1974 is World Population Year

The United Nations has designated 1974 as World Population Year to mobilize world-wide public opinion and concern about population growth and bring a better understanding of the basic demographic problems facing our planet.

■ *Focal point of World Population Year will be the convening by the U.N. of the first global intergovernmental conference on population to be held in August, in Bucharest, Romania.*

■ *The world's population in mid-1973 was over 3,800 million. If growth continues at the present rate (2 % a year) the 8,000 million mark would be reached in less than four decades.*

■ *More than half the world's people, about 2,100 million, live in Asia. Europe (excluding the U.S.S.R.) has 466 million, Africa 354 million, N. America 327 million, S. America 195 million and Oceania 20 million.*

■ *The Fed. Rep. of Germany has the lowest birth rate in the world (12.8 per thousand) and Swaziland the highest (52.3 per thousand).*

■ *The world's five most populous countries are China (787 million), India (550 million), U.S.S.R. (245 million) U.S.A. (207 million) and Indonesia (125 million).*

■ *If the world does not slow down its rate of population growth, a child born today, living until his seventies, may know a world of 15,000 million. His grandson may share the planet with 60,000 million*

Human Rights anniversary stamp

To mark the 25th anniversary of the Universal Declaration of Human Rights on December 10, 1973, the French Post Office has issued a special commemorative stamp (above). The Declaration was proclaimed by the U.N. General Assembly, meeting in Paris, in December 1948. First day covers and cards with the stamp and souvenir sheets can be obtained from the Unesco Philatelic Service, Place de Fontenoy, 75700, Paris.

Letters to the Editor

MUSIC, MAESTRO, PLEASE

Sir,

Your issue "Music of the Centuries" (June 1973) was most Impressive. Why not devote more issues to music? We all need to learn more about this rich, mysterious, and ancient form of communication.

Those who want to study music seriously are often set apart by society. In Brazil especially, few families accept or encourage the idea of a musical vocation, considered by most as a "passport to starvation". Yet a positive counter current to this mistaken idea seems to be gaining impetus at the Ministry of Education and Culture, and among the authorities in some Brazilian states such as my own, Ceará. But the attitudes of many generations cannot be changed overnight.

I am happy to say that in Brazil the "Unesco Courier" is reaching an ever-wider public. As for future issues, why not publish one on "Pop" music or on Musicotherapy, or perhaps on Ethnomusicology?

Orlânia Monteiro
Fortaleza, Ceará, Brazil

SCHOOLROOM WEATHERMEN

Sir,

Your special issue on meteorology, "Unlocking the Secrets of Tomorrow's Weather" (August-September 1973), became the basis of a fascinating series of classroom activities for my pupils. These included the building of a mini weather station, the study of different types of clouds and the drawing up of a world map showing locations of climatic disasters.

Claude Duval
History and geography teacher
Epinal, France

POINT OF NO RETURN

Sir,

After reading "The Myth of Ecological Equilibrium", by Miguel A. Ozorio de Almeida, in your January 1973 issue, we wish to protest against the general tone of this "reassuring" article which tries to make the most eminent ecologists out to be prophets of doom and sensation-mongers. What disaster must strike us before we wake up to the peril facing us? How can serious and authoritative conclusions be dismissed as "a lamentably short-sighted interpretation of trends"?

The despoliation of nature stems from the prestige attaching to numbers and quantity (as opposed to quality). That such a childish outlook can still be used as a guideline should provide an object lesson in humility for our civilization. Whether we like it or not, natural resources are limited. The dangers that M. de Almeida treats so lightly increase a little every day.

While developed and developing countries engage in a fruitless exchange of mutual recriminations, phytoplankton is disappearing from the oceans, the seas are being transformed into sewers, coastline and forest are being buried under concrete and asphalt, animal species become extinct, parasites proliferate and men multiply. Error piled upon error, trifling, though they may be, are leading us towards suicide. Are we so afraid that we cannot face up to the truth? Either we must act immediately —we have ten to twenty years before we reach the point of no return—or we shall perish.

Alain Persay
Forestry technician
Neuvic, France
On behalf of a group of 120 students

FAMILY FAVOURITE

Sir,

I wait impatiently for the "Unesco Courier" to arrive at our house. We have been taking it for longer than I can remember because my parents and brothers are keen readers. It interests me more than ever perhaps because, now I am ten years old and in the last class of primary school, I can see that everything that teaches us about education, science and culture is important.

We children in Cuba think a lot about the future and how we can learn more and more so as to be of service to the world at large. But we are also interested in the past which makes up the world's history. So I want to tell you how much I enjoyed the special supplement "Copernicus as told to children" in your April 1973 issue. I hope you will give us many other supplements as simply presented and as interesting as this one.

My name is Rosa Maria Pérez Mirabent and I am a hardworking, serious schoolgirl. I belong to our school television club in which I act or compère programmes. Our club produces a children's TV programme called "Recreo Infantil" which presents a simple, instructive picture of different countries and their ways of life.

Rosa Maria Pérez Mirabent
School No 65
Santiago de Cuba

NICHOLAS ROERICH CENTENARY

Sir,

This year marks the centenary of the birth of Nicholas Roerich who devoted his life to the ideal of bringing peace between nations. Nicholas Roerich is not only known as a great artist, but as the originator and author of the "Pact and Banner of Peace" which bears his name. In 1935 the Pact was ratified by the U.S. and all the Latin American countries and later by other nations, among them the U.S.S.R. and India.

The Nicholas Roerich Museum, in New York, has a large permanent collection of his paintings which will be augmented in 1974 by special loan exhibitions, and throughout the year various cultural activities will be dedicated to celebrating the centenary.

Sina Fosdick
Executive Vice-President
Nicholas Roerich Museum
Board of Trustees, New York

CONSCIENTIOUS OBJECTORS

Sir,

Your October 1973 issue ("Military Service and Conscientious Objection" page 31) does not make it clear that France recognizes the status of conscientious objector, giving the objector the option of performing two years of civilian service quite apart from technical or other co-operation projects. The law of 1963 allows young people to refuse, on religious or philosophical grounds, both military service and assignment to the usual forms of co-operation projects. No such law applies yet in Italy, but the question is currently being debated in the Italian Senate.

Paul Fabre
Talence, France

BETTER LATE THAN NEVER

Sir,

You probably receive many letters praising the "Unesco Courier" and I wish to add one more. However, I have read some letters of complaints. It is true that all the articles do not interest everybody but that is not the fault of the magazine.

Personally I find the "Unesco Courier" an excellent magazine—articles written by experts and beautifully translated, first-rate illustrations and the whole excellently presented and printed. Combining the intellectual with the material, it is to my mind one of the finest cultural magazines published. I am only sorry I did not know about it years ago.

Oscar P. Nelson
Vina del Mar
Chile

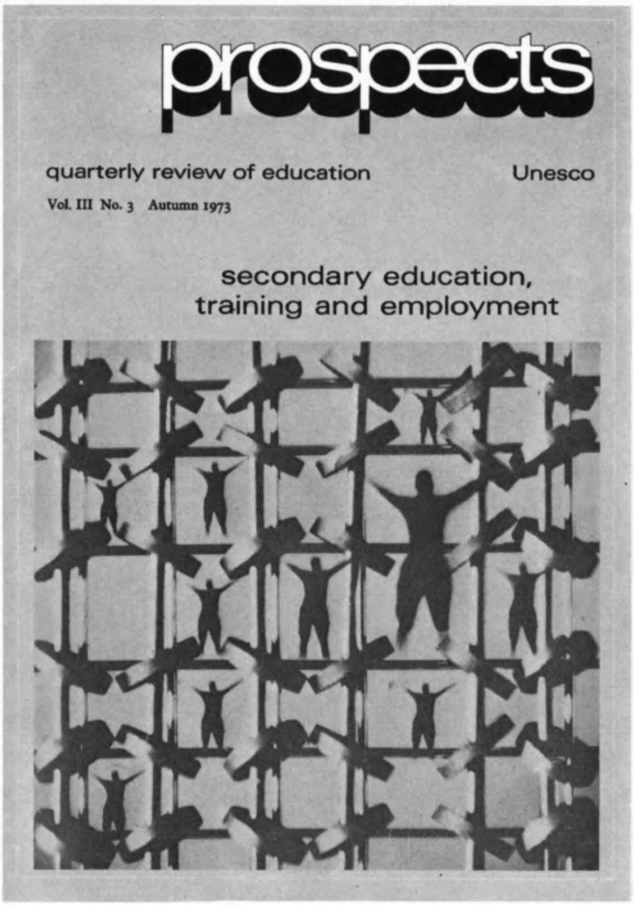
ONLY ONE RACE

Sir,

Your October 1973 issue on Human Rights was excellent. But why refer to different "races"? If I were asked to which race I belonged, I would say that I was a member of the human race. We all belong to the same race and are therefore all equal. God clearly had his reasons for giving us skin, hair and eyes of various colours, but not with the intention of giving some a feeling of superiority or inferiority towards others. So why continue to use the word race to indicate differences of colour between people when they all belong to "the human race"? If everyone would make an effort to understand this, the world would have fewer problems. If you developed this theme perhaps this notion would take root in the minds of millions and this would be a great step forward in the fight against racism.

C. Gillard
Reignier, France

Imp. GEORGES LANG, PARIS. — Dépôt légal C 1 — Décembre 1973 — IMPRIMÉ EN FRANCE (Printed in France)



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Perils of sunbathing

Posing as the "nose" of a solar-faced "sundial" drawn on a beach, this young woman basks in the warm rays of the sun. At a recent Unesco-sponsored congress on "The Sun in the Service of Mankind", many scientists warned against the dangers of overexposure to sunlight such as damaged eyesight, burns, skin pigmentation disorders and even certain forms of cancerous skin lesions. Certain substances used in the manufacture of some sun creams and lotions, cosmetics, deodorants, soaps and toilet preparations may dangerously increase the sensitivity of the skin to sunlight and particularly to ultra-violet rays from the sun (see page 36).