Technology for Developing Countries

by Sir John Cockcroft

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Overseas Development Institute

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2 to direct studies of its own;

3 to be a forum where those directly concerned with development can meet others and discuss their problems and share ideas;

4 to spread the information collected as widely as possible amongst those working on development problems;

5 to keep the urgency of the problems before the public and the responsible authorities.

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Preface

There is something absurd about a technology which can hope to put a man on to the moon in 1970, but seems likely to fail to feed adequately many millions of men left behind on earth. How can science always active at the promotions of knowledge be turned in on itself so as to help solve the age-old problems of hunger, ignorance and disease? This is a problem that has long concerned us at the ODI, and our very first publications were concerned with the application of modern knowledge of such things as fertilisers and small power plants to the needs of less developed countries.

Early in 1965 Professor Austin Robinson on return from one of his frequent trips to India raised with Professor Blackett and myself the question of what could be done in Britain to adapt our sophisticated technology to the needs of the sub-continent. It was partly as a result of this, I believe, that Professor Blackett asked Sir John Cockcroft to examine what was being done in Britain to promote technology suitable for developing countries, and to report to the Ministry of Technology. That report is the basis on which this lecture was given to an audience invited by the ODI.

It is significant and hopeful that a man who had virtually created Britain's atomic energy establishment could turn his attention to the problems of hand operated threshing machines for countries at the very beginning of their industrial revolution. For it is only if the advance guard of science turns its attention to those struggling along at the back of the queue that we can hope for some measure of progress for all of mankind.

WILLIAM CLARK

Technology for Developing Countries

The Overseas Development Institute has invited me to give an account of what is being done in Britain to promote technology for developing countries. This follows a survey I have made of this field at the suggestion of Professor Blackett, acting for the Ministry of Technology.

I have no special expertise in this field. I have been concerned in the past with the promotion of radioisotope applications in the Middle East group of countries and the visits I have made have given me some acquaintance with their problems. I have been a member of a group of US and UK scientists which discussed problems of applied science with Nigerian scientists and economists. I was also a member of the United Nations Scientific Advisory Committee which proposed the convening of the UNCSAT Conference on problems of developing countries held at Geneva in 1963 and I have read many of the technological papers of that Conference and of the UN Advisory Committee on the Application of Science and Technology to Development (ADCSAT).

The developing countries have of course an enormously wide spectrum of characteristics – wide in population numbers, in natural resources, in environmental conditions and in their stage of development as measured by their *per capita* Gross National Product. So their problems are equally wide ranging though they have many common features.

For convenience of treatment I will divide my address into three broad categories. First, the more sophisticated technology of the present and future which is now being adopted in some developing countries and whose application will spread; second, the medium scale technology suitable for plants scaled down one or two orders of magnitude in output below the outputs which are considered to be optimum for advanced countries and third, the technological developments suitable for small scale agricultural holdings and small scale industries.

Modern Technologies

Some technologies developed in advanced countries are already in use in some of the larger developing countries. India has full scale steel plants: and is building nuclear power stations with outputs of 200mW increasing to 400mW and with the rapid growth of demand is likely to build nuclear power stations of much higher output and thus achieve competitive nuclear power on the coal-deficient side of the country. The Indian Atomic Energy Research Establishment in Trombay has successfully developed the sophisticated technology required. This is spreading into local electronic industry.

The mining and metallurgical industries such as the copper belt industry in Zambia have for long used the most advanced technology. Most of the developing countries are fully aware of the contribution that mineral resources can make to their economies. They provide a source of foreign currency, attract foreign capital and provide mineral raw material upon which to base indigenous industries.

Much of the work of the Mineral Science and Technology Division of the Warren Spring Laboratory of the Ministry of Technology is of immediate interest to these countries. The Division co-operates with the Overseas Geological Survey in providing technical assistance in the mineral field through the Ministry of Overseas Development. The Laboratory has undertaken mineral processing studies on the following problems referred to it in this way:

The extraction of kyanite used in porcelain manufacture for Malawi, the upgrading of alumino-silicates used in glass manufacture for Sierre Leone, the treatment of a niobium bearing soil for Kenya, recovery of thorium and strontium from carbonate rocks for Malawi, the examination of iron, nickel and aluminium containing rock from British Guiana and improvement of iron bearing ores from Swaziland.

In addition, officers from the Laboratory have been seconded on aid programmes or through the United Nations to Turkey, Bolivia and Kenya.

Hydro-electric stations such as Kariba and Volta, the Congo stations and their associated transmission systems use advanced technology. The Hydraulics Research Station has carried out a considerable amount of work to help such projects in underdeveloped countries. The Mangla Dam project is a good example: this project is scheduled to be completed in 1968 and is being carried out under the terms of the Indus Basin Water Treaty.

The aim is to conserve the waters of the River Jhelum in West Pakistan to provide irrigation and also 1000mW of electric power. There will be three dams, the main one being 11,000 feet long and 380 feet high at the maximum point. Projects of this kind cannot yet be designed entirely on the drawing board.

Techniques have been developed over the past years to simulate the behaviour of the full scale plant on models. In the case of the Mangla Dam a considerable number of tests on models had to be carried out and the majority were undertaken at Hydraulics Laboratories in Pakistan, but the more specialised work was undertaken in UK at the Hydraulics Research Station. This included work on the design of the protection of the slopes surrounding the reservoirs against wave attack, which is of considerable importance in such a large project. The station also carried out tests and gave advice on the design of the tunnels and walls to withstand pressure pulses that might be expected.

Advanced technologies in the field of communication are likely to leap-frog the older technologies in some developing countries. Microwave communication links such as those recently installed between Turkey, Iran and Pakistan may be more economical and less subject to interference than land lines. Developing countries may take part in satellite communication systems in the future.

A report of the UN Centre for Industrial Development (STD/3/1/Periodic-1/UN2, February, 1965) surveys the construction of medium scale petrochemical plants in developing countries. In 1964 there were 30 plastics plants, 7 synthetic rubber plants, 3 synthetic fibre plants and 45 miscellaneous petrochemical plants for products such as acetone, carbon black, sulphur, detergents, insecticides. Countries with sizeable markets such as Argentine, Brazil, Mexico, India have built plants using imported technology obtained either by licensing, joint ventures, or direct foreign investment. In all these cases the technology is available for transfer. Brazil and Argentine have already started the production of synthetic rubber and India and Mexico are planning plants. Latin American countries such as Argentine, Brazil, Colombia and Mexico have either started or are planning plants for synthetic fibres such as nylon, polyester fibres such as terylene and acrilic fibres (orlon). Britain exported, in the three years 1963, 1964, 1965, a total of thirty-two petrochemical plants to sixteen countries.

The future of some developing countries in Asia, Africa and the Middle East could be vitally affected by shortage of water suitable for drinking, industrial uses and agriculture. Israel is a contemporary example.

Desalination plants using fossil fuel as a heat source for flash distillation processes today produce potable water from sea water in countries such as Kuwait on the scale of 10 million gallons per day at a cost of about 50 pence per 1,000 imperial gallons.

The cost of drinking water from conventional water undertakings ranges from 15–40 pence per 1,000 gallons, depending on the distance from which the supplies have to be conveyed and the cost of reservoirs, etc. The estimated cost of water from a possible barrage scheme at Hong Kong is about 20 pence per 1,000 gallons.

Studies are proceeding in the UKAEA and British Industry on the combination of flash distillation plants with nuclear power stations. Two examples have been investigated in some detail.

In the first, a large Advanced Gas Cooled Reactor (which, without a desalination plant would produce 625 MWE) has been combined with 6 desalination units, to produce a total of 60 m (Imp.) gallons per day (72 MG (US) per day), together with 400mW of electricity (net). With an annual capital charge of 8% this combination could produce electricity at 0.45 pence per kWh and water at 3s. 6d. per 1,000 gallons.

This scheme suffers from the disadvantage that the amount of electricity produced with a given quantity of water is rather high and more than many countries could accept.

The second study considered a scheme where the power-to-water ratio was much smaller. For this purpose the Steam Generating Heavy Water Reactor was chosen, because for a given quantity of electricity, it produces a much larger quantity of low grade steam – required to drive the desalination plant. This is a feature of all water reactors, but SGHW has an additional attraction – it is a pressure tube reactor, rather than using a pressure vessel, and this should make it easier to construct overseas.

In one particular case studied, an SGHW was combined with 8 flash distillation units, producing 80 MG (Imp.) gallons per day, together with 200mW of electricity for sale.

The cost of water and electricity from this scheme is slightly higher than those for the AGR, but the power to water ratio is more in line with the requirements of certain countries.

These costs are tolerable for drinking water and water for industrial purposes in areas where water is scarce but are still far too large for agricultural purposes where typical prices of water for agricultural use are of the order of 4–7 pence per 1,000 gallons though under shortage conditions market gardeners will pay up to 30 pence.

Desalination of brackish water by electrodialysis is being studied by scientists in Israel and at Harwell to determine whether this could produce water for crops such as citrus at acceptable costs. Electrodialysis can only become competitive with flash distillation if the salt content is below 5,000 p.p.m.

Most of these advanced technologies require a substantial number of engineers, technicians and skilled operators and comparatively little unskilled labour. They therefore draw on the critically short supply of trained manpower in developing countries. On the other hand, experience in countries such as India and Pakistan and Zambia (the copper belt) has shown that technicians and process workers can be quickly trained if adequate training schools are present. This underlines the importance of establishing technical colleges for the training of technicians in parallel with the foundation of new universities in developing countries. A great effort will have to be made to overcome the strong preference amongst the educated population for white collar jobs.

Medium Scale Technology

Many developing countries have market demands for products such as iron and steel, cement, fertilisers, oils, petrochemicals which are of the order of one-tenth of the optimum economic output of plants in advanced countries. Examples of this reported at the UNCSAT Conference are:

(i)	Iron and Steel:	
	Nigeria	100,000 tons p.a.
(ii)	Cement:	
	Congo	60,000 ,, ,,
	Ivory Coast	200,000 ,, ,,
	Cameroons	80,000 ,, ,,
(iii)	Fertilisers:	
	Nigerian scale for	
	Nitrogenous fertilisers	50,000 ,, ,,
	Phosphatic fertilisers	30,000 ,, ,,

(UN Centre for Industrial Development Report (E/Conf/5/83))

(iv)	Aluminium:	
	Cameroons	50,000 tons p.a.

(When a plant is scaled down in output by a factor of S the cost per ton of product is usually increased by a factor of the order of $S^{0 \cdot 6}$ though the actual factor may deviate largely from this.)

Iron and Steel Plants

At the UNCSAT Conference G. B. R. Feilden, FRS and A. G. Raper presented a paper on *A Low Cost Integrated Steel Works for Emergent Countries* (E/Conf/39/D/158). Design and cost information were given for an integrated plant having an output of 100,000 tons per annum with provision for a progressive increase of output up to 200,000 tons per annum. The paper proposed a blast furnace for iron making followed by LD convertors for steel production followed by a bar mill. Mr. Feilden informs me that since this paper was presented an integrated steel plant of the type he recommended is being constructed at El Fouladh in Tunisia and one or two other enquiries have been received.

Mr. Feilden gives comparative product costs as £18 5s. 0d. per ton for 100,000 per year and £15 5s. 0d. per ton for a million ton per annum plant.

In the three years, 1963, 1964, 1965, twelve medium sized steel plants were exported from Britain. These cost between £100,000 and £2 million and went to India, Bulgaria, Spain, Colombia, China, Yugoslavia, Turkey, Venezuela and Saudi Arabia. The total value of these British exports was over £5 million sterling.

Fertilisers

A UN Report 'Adaptation of technology to scale of production in chemical processes for developing countries' states that 'it is now an economic proposition to produce ammonia in plants costing $3 million whose production capacity totals some 20,000 tons per year. . . .' A recently developed 'packaged plant' has a capacity of only 60 tons per day. The production cost of liquid anhydrous ammonia has been estimated at about $36 per short ton compared with $32 per short ton for a plant with five times the output. I.C.I. Agricultural Division, Billingham, informed me that compound fertiliser and ammonium nitrate plants can be installed at an economic cost with capacities of the order of 50,000 tons per annum.

In the three years 1963, 1964, 1965, a total of twenty-three large fertiliser plants were exported from Britain to sixteen countries.

Cement

Papers presented to UNCSAT showed that there is a requirement for medium scale plants with outputs of the order of 100,000 tons per annum. An UNCSAT paper by Gottlieb of Gippalind

Cement Company, Melbourne, Australia (E/Conf/39/D/137) on a 'New Vertical Kiln' process for cement manufacture described a plant producing about 100,000 tons per annum. This appeared to have major advantages in cost reduction for medium size plants. The cost of the plant was estimated at £1·2 million (Australian).

The UN Centre for Industrial Development have reported (ST/ECA/75) that there is a practically continuous range of capacity in the medium range field available on the international market. The cost per ton of output was reported to increase by 5% for a scale factor of 100.

Canada gave a 'Maple Leaf' plant to Pakistan to produce 250,000 tons per annum at Daudkhel. New Zealand has provided through the Colombo Plan a medium size cement plant for West Pakistan.

In the first eleven months of 1965, Britain exported cement plant worth nearly a million and a quarter pounds, and individual orders worth between £10,000 and £800,000 went to thirteen countries.

Medium Scale Power Units

Several of the developing countries have achieved a central power generation system. Examples are the Ghana Volta River project, the Kariba Dam, the High Dam in Egypt and the Shah Pahlevi Dam in Iran, besides the projects in Pakistan and India. But the size of most of these countries is such that transmission of electric power generated in a central scheme to a town maybe a thousand or more miles away is uneconomic and local generation schemes are necessary.

The problem of generating power in an isolated town is very comparable with the generating power on board ship. Reliability and easy maintenance of the machinery are of prime importance. It is perhaps significant that, except in military propulsion applications where high fuel consumption is acceptable and the high power-to-weight ratio afforded by gas turbines is of overriding importance, the preferred ship propulsion unit remains either the diesel engine or the steam turbines. Indeed, single diesel units of very large power (up to 30mW generating capacity) are being developed to propel the very large tankers and these would undoubtedly have the reliability to act as prime movers for the small regional power units required in areas of an under-developed country remote from a central generation scheme or indeed countries lacking any such low-cost central generation scheme.

Gas Turbines

The Nigerian Development Plan (1964) shows that a number of Gas Turbine Power Plants are being introduced with outputs of 5mW to 17·5mW each, fuelled by natural gas and oil or heavy fuel oil. This is an interesting development since the capital costs lie between £37 per kW and £32 per kW. Three of these stations were built by Brown Boveri and one by English Electric. There are likely to be other countries such as Pakistan with similar fuel availability.

The English Electric 6mW gas turbo-alternator is very compact being considerably smaller than steam or diesel generating plant of equivalent capacity. A simple steel framed, sheet clad housing is the only weather protection needed and the foundation consists of a flat concrete slab beneath the bedplate.

The gas turbine is of robust construction and requires little maintenance once in service. Turbines of this type are regularly operating for up to 16,000 hours (or 2 years) between inspections and even after this length of time only a few minor replacement parts are required. As a result, operating costs are low and, allowing for depreciation, amount to less than one-third of a penny per kilowatt hour excluding fuel. Where cheap natural gas is available as in Nigeria the overall cost of operation can be extremely attractive.

Diesel Generators

The total cost for a typical Indian village has been given as 70,000 rupees for a 50kW diesel generator station (£105 per kW). The additional costs of a distribution network suitable for an Indian village might be about £5,000 giving a total cost of the order of £10,000. (E. W. Golding, ODI Power Supplies.) The generating costs were estimated at 4·9d. per unit with a load factor of 75% and 7·5d. with a load factor of 30%. At present only about 5% of Indian villages have electricity supplies. The capital cost of equipping 550,000 Indian villages without any electrical supplies in this way would be prohibitive and more centralised generating systems will be necessary as electricity generation spreads.

Solar Heaters

The Japanese are reported to be producing over 100,000 solar water heaters per annum at a cost of $6 and upwards. They are suitable for domestic water heating in countries of adequate sunshine. The University of Arizona has made encouraging progress in producing drinking water from brackish sources by solar distillation. A recent report in *The Times* on a plant of this kind erected on Perdike, an Aegean Island, to produce 2,400 g.p.d. quoted the cost of the water as 17s. 6d. per 1,000 gallons. Dracone transportation will probably be cheaper.

Technology for Agriculture and Small Scale Industries

The importance of small scale industry in developing countries is shown by the contribution of small scale industries in India. In India about 16% of the labour force work in factories employing less than 300 workers and 50% of the labour force were classed as 'independent workers'.

Dr. Schumacher has introduced the term 'intermediate technology' for the class of technology suitable for small scale industry. He has quantified this by defining the 'cost per work place' as being of the order of £100 – one or two orders of magnitude below the cost per work place of advanced technologies such as steel works which is about £10,000 per work place, fertilisers about £3,000 per work place. The development of this class of technology is given high priority in India. A small scale Extension Training Institute (SIET) is established at Hyderabad with the support of the Ford Foundation. The Institute arranged a conference on 'Intermediate Technology' in January, 1964, and the proceedings have been published in *Appropriate Technologies for Indian Industry.*

Typical industries supply bicycles, electric light bulbs, nuts and bolts, shoes, clothing, sewing machines, optical parts and agricultural machinery.

An appreciable amount of work on this class of technology in aid of developing countries has in fact been carried out for a number of years in this country. It is now carried out in Institutes or Centres of the Ministry of Overseas Development (ODM), the Agricultural Research Council and other bodies. The development work is in many cases financed by the National Research and Development Corporation (NRDC). I will now describe the work of some of these Establishments.

Overseas Liaison Unit – The National Institute of Agricultural Engineering

The Overseas Liaison Unit which is situated at the National Institute of Agricultural Engineering, Silsoe, is supported by funds from the Ministry of Overseas Development and has already been responsible for the development of a number of low-cost agricultural machines suitable for developing countries. These include:

(a) A basic one-wheel drive tractor for developing countries. This provides a simple, robust, cheap means of power capable of replacing a pair of oxen. Experimental trials have taken place in parts of Africa, Asia and South America and have been very encouraging.

(b) A thresher for small scale paddy growers. This is also applicable to other crops. It is driven by a 150 cc 4-stroke petrol engine or electric motor. It is manufactured in this country and costs £71–£95. Although only a few hundred machines have been exported from this country, thousands of locally made machines are now in use in South-East Asia.

(c) An animal drawn toolbar supplied with about eight tools. This has been designed to be pulled by a pair of oxen and can be used as a cart or as a toolbar unit which could accommodate a plough, ridging body, cultivator or a groundnut lifting device. The latest models are fitted with a seat and a high clearance model is also available. This equipment is now being manufactured in the UK and over 300 have been supplied to the Gambia.

(d) *Hand Operated Rice Transplanter:* In areas where two crops of rice are grown every year, transplanting causes a considerable labour peak and simple machinery that could speed up this operation is badly needed. The transplanter that is still being developed by the Overseas Liaison Unit is pulled by hand and can plant four rows at a time.

Other projects which have been carried out:

(e) A spice drier – constructed in collaboration with the Tropical Products Institute for use as a research tool for assessing the drying requirements of various spices in Jamaica.

(f) Ground-nut harvester – the complete ground-nut harvester has been developed to the prototype stage.

(g) A simple, hand operated pump for pumping from wells and boreholes.

(h) *Ground-nut aflatoxin:* A member of the NIAE carried out investigations in Nigeria in conjunction with the Tropical Stored Products Centre into the effect of different methods on harvesting on the aflatoxin content of ground-nuts.

(*i*) *Tie-ridging:* Simple tie-ridging equipment has been developed at the NIAE. This equipment can be used behind a tractor to construct small cross ridges between existing ridges in order to conserve moisture and prevent erosion.

In general, labour-intensive agricultural machines are needed in developing countries like India, which have large, under-employed labour forces. An agricultural machine, costing initially £100, and requiring three men to operate it, would be preferred in India to one performing the same task, but costing £500, and needing only one man to run it.

The Tropical Products Institute

The object of the Tropical Products Institute is to help developing countries improve the production and utilisation of their renewable resources. The Institute has a staff of 165, of whom approximately half are scientists and economists. Much of the work of the Institute concerns the improvement of industrial processes and the raw materials on which they depend. It is working, for instance, on the following technological problems:

(*a*) New methods of processing of coconuts and coffee. The object of the coconut work is the provision of additional protein-rich food for human consumption, along with the normal oil production.

(*b*) New methods of shelling cashew nuts to replace the present hand cracking methods. A pilot plant has been built and TPI are in touch with India, Ceylon, Brazil, Tanzania and Mozambique on this work.

(*c*) New uses for tropical products and particularly for waste agricultural materials, including the fabrication of building board from ground-nut shells, coffee husks and wood products: utilisation of indigenous fibres in craft industries.

(*d*) Fabrication of light weight building blocks made from rice hulls and cement.

(*e*) They have issued a series of reports on small industries, e.g. for buttons, chocolates, matches, wire nails, fibre suitcases, sugar confectionery. This has already led to the establishment of industries in developing countries in some of these fields.

(*f*) The utilisation of solar energy: Earlier on, work was done in this field on the design of a solar still. More recently a design study on a solar rice drier has been completed and it is likely that practical work to study this facility will be undertaken shortly.

(g) The major project in TPI's pulp and paper section is one of studying the pulping characteristics of tropical woods with a view to setting up pulp and paper industries in tropical countries. In collaboration with FAO and the Commonwealth Forestry Institute in Oxford, its present investigations are directed particularly to selecting the fast growing species best suited for cultivation for this purpose.

(h) TPI was instrumental in setting up the pyrethrum industry in East Africa and continues to give advice not only to other territories wishing to establish this industry but also to the UN Centre for Industrial Development.

(i) TPI is currently working with an engineering firm on the development of small scale equipment for palm oil extraction. The aim is to provide apparatus of low capital cost suitable for village use, which would also yield a good quality oil.

(j) There are two other aspects of TPI's work which are very relevant to the needs of developing countries in the technological sphere. The first is the loan to developing countries of specialists. For example, a food technologist on the staff of TPI is currently on secondment to Pakistan to help with the build-up of food technological work in that country. Another member of staff has, during the last year or two, visited a number of territories (Aden, Brazil, the Seychelles and certain African territories) to give on-the-spot advice in fish technology and to carry out experiments and demonstrations on fish drying techniques.

The second aspect is training of overseas personnel in this country. TPI organises individual training courses within its range of activities.

The Tropical Stored Products Centre

There is an enormous wastage of cereals in developing countries at the present time due to imperfect drying and processing and to insect attack. The Food and Agriculture Organisation of the United Nations has estimated that a conservative figure for annual world losses is 5% but the Tropical Stored Products Centre and the Pest Infestation Laboratory have estimated that losses of 25% or more can be common in the tropics, on occasions losses of 70% or more may occur. An American firm of engineering consultants have estimated that the annual loss through deterioration of rice stocks in West Pakistan from insect damage and moisture is about £2·3 million per year.

The work of the Tropical Stored Products Centre is largely devoted to the reduction of such wastage. The work has grown rapidly since the grant of independence to many Colonial territories and now occupies some 28 professional staff, many of whom spend most of their time in overseas countries. This has led to the establishment in a number of these countries of Government Departments concerned with maintaining the quality of harvested produce. Their work includes projects in aid of village activities, trading activities and factories. The village projects include simple aids to sun drying and storage of crops. Simple plastic mats and covers have been devised for drying and fumigation of produce, initially for spices, particularly in the Caribbean. This equipment (the Allgate drier) is manufactured by two British firms. Improved methods of building small storage containers have been devised to keep out insects and prevent losses from insect attack and a new type of shelling machine capable of cracking ground-nuts (and some other types of nuts) to give either almost one hundred per cent whole nuts or half nuts.

To help traders, simple sieves have been designed to facilitate an assessment of quality by separating dust and insects from the produce; these are now being used in many countries by inspection staff. Thermocouple spears capable of detecting deterioration in large stacks of produce stored in bags are now available commercially.

A Thermal Conductivity Meter for assessing the effectiveness of fumigation systems has been developed by the Pest Infestation Laboratory and is available commercially. Also a portable fumigation chamber is now being manufactured in Britain particularly for overseas problems.

Improved methods for assessing the presence of undesirable levels of moisture in produce presented for storage have been and are being developed and the TSPC has a programme of work on the use of plastics for improved storage.

Plastic containers of various types are being investigated and amongst the interesting 'factory scale' projects are the 'air-warehouses' made from PVC coated nylon fibre illustrated in the next slide. They provide storage capacity for 500–5,000 tons of grain and cost about 40s. 0d. per ton of storage. Their development has not been without problems such as water tightness, condensation and the life of the plastic which is now estimated at about 8 years. With one of these designs for the storage of produce in bulk in which loading or unloading is by blowing or sucking air-tightness is a problem. Air-warehouses have been supplied to India, Kenya, Tanzania, Malawi, Zambia and Nigeria.

Other interesting projects are the Dracone invented by Professor W. Hawthorne of Cambridge University and developed in collaboration with NRDC and Dunlop Dracones. Two of these are being used for transport of fresh water from the mainland of Greece to the Aegean Islands in 550 ton loads. A 5,000 tonner may be the next step. Fresh water can be supplied in such a way at relatively low cost per 1,000 gallons. At the request (and with the collaboration) of the TSPC, the NRDC is carrying out trials to modify Dracones to make them suitable for transporting granular material.

The TSPC has been involved with the trials carried out by Unilever on the development of bulk containers for use in West Africa; with the Stored Products Research Institute of Nigeria and plastics firms in Britain on plastic containers and liners and with the FAO on package protection against insect attack. The Centre has been responsible for the preparation of an FAO Bulletin concerned with the Storage of Food Grains in Tropical Africa.

Fish Drying

People of many tropical countries have become accustomed to eating fish in dried form, and indeed certain of them prefer it to fresh fish; the total consumption of dried fish in Nigeria alone is 25,000 tons per year. Lake Chad could supply a further 50,000 tons per annum. Much of this is dried by primitive methods, over open fires or in the sun, and the inside, which is not dried sufficiently, may rapidly become infested with insects and spoilage or organisms.

Hereto, attempts to dry fish on a large scale have copied these traditional procedures by employing constant temperature ovens but these methods have not proved economic. An experimental process evolved by the Torry Research Station in cooperation with the engineering firm of Yarrow & Co. employs a new principle in that the temperature of the fish is progressively raised as it is dried, allowing dried fish to be produced in hours rather than days. The plant is being further developed with the assistance of NRDC.

Fish prepared by the new process has proved very acceptable in Nigeria and plans are being prepared for manufacture and marketing on a large scale both there and in other countries.

It is hoped that the process will contribute towards improving the protein balance of the diet of people in many of the developing territories. Nevertheless, proper market surveys must be conducted in each potential user country on the acceptability of dried fish.

Reinforcement of diet by proteins

Many developing countries are generally short of animal proteins and this leads to protein deficiency diseases such as kwashiorkor in children. A number of attacks on this problem are proceeding including the increase of dried fish supplies; the supplementation of diet by protein rich food, studied by the Medical Research Council Infantile Malnutrition Research Unit in Uganda. The *Société Française des Pétroles BP* have constructed a pilot plant at Lavera in France for the production of edible protein by the fermentation of petroleum (Champagnat: Scientific American, October 1965). 'These proteins differ in no essential respects from those made by any other natural process whether by beef cattle, poultry, fish, plants or yeasts growing on sugar. They are rich in Vitamin B and have a well balanced variety of amino acids'. Tests are now being carried out with animals to determine their nutritional value and a number of palatable versions of food containing these proteins are being prepared. British Petroleum are supporting both the Lavera plant and a Research and Development Centre at Grangemouth in Scotland.

'Do it yourself kit'

A study of simple village technology was made by the US Agency for International Development, Communication Resources Division, Washington, D.C. A handbook has been published with drawings of 'kits of parts' to construct tube wells, hand pumps, sanitary services, etc. This is in some respect similar to some of the very simple equipment being developed by the Overseas Liaison Unit at the NIAE.

Tropical Housing – Building and Planning

The Building Research Station has for many years had a Tropical Section of about 8 professional staff who are engaged in providing advice on housing and building materials and planning to developing countries. Staff members visit Africa, Asia, Central America and Pacific countries. They have been especially concerned with advising on educational and medical buildings.

Research work has been carried out on the parameters affecting thermal comfort in hot climatic conditions, on materials problems arising from the use of local materials for bricks and concrete, on paint deterioration under tropical conditions, on the design of roofing suitable for tropical conditions and on the effect of hurricanes and earthquakes on structures. The amount of technological work which can be carried out is however limited by the small number of professional staff available (8) and the great demands made on them for advisory services.

The Central Building Research Institute at Roorkee, India, carries out considerable research on cheap tropical roofing materials, especially on concrete roofing. A number of interesting designs have been produced and subjected to tests under tropical conditions on many sites in different parts of India.

Tropical Roads

The Tropical Section of the Road Research Laboratory provides an advisory service on problems of road design, construction and maintenance in developing countries. This involves visits of senior staff to gain first hand knowledge of local problems, to give advice and often to plan research in collaboration with local organisations.

The Section has worked on the design of roads and runways to suit tropical conditions. By the study of local moisture conditions in soils, it has been possible to reduce the design thickness of roads between 2 inches and 8 inches on different soils, thus saving between £1,000 and £4,000 per mile in construction cost.

The Section has helped in the planning of road locations and the identification of sources of road making materials by combining aerial photography with the geomorphology of the area. Thus a geologist seconded to the Northern Nigerian Government was able from aerial photographs to locate a suitable line for a road through areas of black clay south of Lake Chad after three weeks of study.

The Section has helped in the stabilisation of soils with cement, lime or bitumen. In one case the introduction of cement stabilisation reduced costs by about 30%. In other cases savings of cost between 5% and 15% were achieved.

The optimum planning of roads is an important factor in the economy of developing countries, since transport and communications absorb between 15% and 45% of public expenditure – the greater part on roads. The work of the Tropical Section helps to ensure that the roads are built in the right place and to the right standards.

I have not yet been able to obtain overall figures for the magnitude of the professional effort engaged in Britain on specific technologies for developing countries. The professional staff working on these problems in Government establishments such as NIAE, TPI and TSPC is over 100. In addition to this, ODM make available a substantial number of scientists and engineers for overseas work and I understand that they envisage in their new proposals a core of specialists – about 100 strong – for loan to developing countries. The Commonwealth Development Corporation is sponsoring or taking part in projects whose total cost was of the order of £125 million at the end of 1964. I have already referred to the contribution by British Industry.

I think that the efforts in Government establishments on small scale technology could with advantage be increased and their work would gain by the rebuilding and grouping which is under consideration.

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The Overseas Development Institute has started a series of studies which look at the problems of aid as seen by recipient countries. The first country chosen for such a study was Uganda.

Aid in Uganda is a three-part study of the impact of aid in that country and of the problems of an aid recipient as seen by Uganda itself.

The first two parts of the study are: Part I *Aid in Uganda – Programmes and Policies,* and Part II *Aid in Uganda – Education.*

Part I Aid in Uganda – Programmes and Policies by Ralph Clark

This first general study examines the background, development planning in the colonial period, the first Uganda Five Year Plan, and aid and the influence of political factors. After this general survey, the author looks in particular at British aid, American aid and problems of technical assistance.

In his conclusions, the author demonstrates the distorting effects of tied aid upon the economy of a developing country, and pleads that since politically tied aid is likely to continue anyway it should be at least applied whenever possible to projects. He also argues that the British High Commission should be given more technical staff to deal with matters of aid and links this with the need for greater consultation among donors responsible for aid programmes in Uganda.

Part II Aid in Uganda – Education by Peter Williams
This study examines the impact of external educational aid to Uganda. The difficult educational choices confronting developing countries are discussed in the specific context of Uganda's problems. Should, and can, education be planned to meet national objectives in the political, economic and social spheres? Or should a developing country aim to provide education for all who want it and are capable of profiting by it?

Educational aid has made a significant contribution in Uganda. Thus 80% of Uganda's secondary school teachers are from overseas under Teachers for East Africa Scheme, Peace Corps, etc., Makerere University College has been largely built up with outside funds, and many more Ugandans are engaged on higher studies in overseas institutions than in Uganda itself. Britain and the United States have been the most substantial contributors of help.

Yet it has been difficult to put some of the aid to optimum use. The terms of financial aid have not always been suitable to Uganda's situation. Lack of collaboration amongst donor agencies has resulted in many competing scholarship offers and in the collapse of the Teachers for East Africa Scheme as a co-operative venture. Prestige buildings have been erected which may prove to be beyond Uganda's capacities to maintain. Expatriate teachers normally serve for only two years at a time and tend to arrive and leave in the autumn just a few months before their pupils take their exams.

Aid in Uganda – Education, published by the Overseas Development Institute, price 20s., is the second volume in a three-part study of the impact of aid in that country. Part I *Aid in Uganda – Programmes and Policies* was published earlier in March 1966 and it is hoped that Part III, dealing with agriculture, will be published later in the year. Parts I and II are now obtainable from *ODI Publications*, 98 Kingston Road, Merton Park, London, S.W.19.