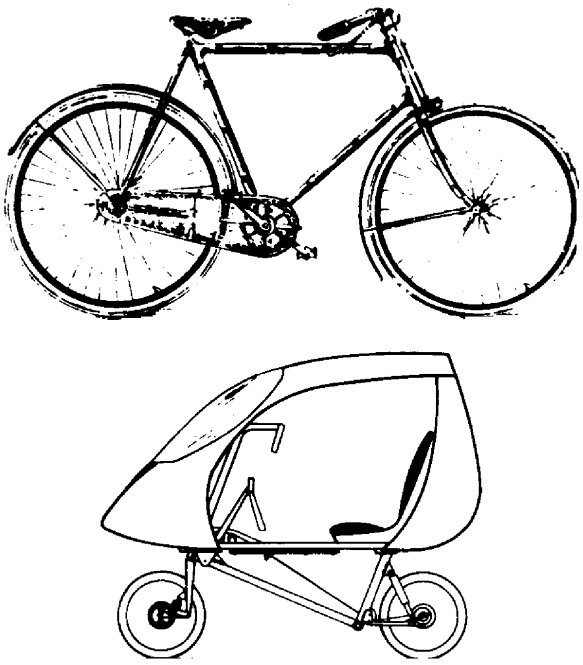

Transportation

Readers investigating transportation alternatives in the light of appropriate technology principles will find that this topic area reflects many of the fundamental problems and issues of technology choice and development goals. In the South, traditional transport technologies (e.g. backpacks, bicycle-loading baskets and frames, bike trailers, animal packs, carts, pedicabs, push carts, wheelbarrows, and small boats) have been almost completely neglected in engineering designs efforts.

Informed observers note that few modern vehicles fit the needs of the developing countries very well; in most cases, the designs or the machines themselves are imported. These vehicles—trucks, busses, cars—bring with them high foreign exchange requirements for purchase and fuel costs, probates of maintenance and spare parts, and low durability when operated over rough terrain. Although busses are usually an effective means of transporting people (especially in heavily populated areas and for long distance travel), trucks are often ill-matched to the basic transport needs of small farms. Trucks also require heavy investments in high-quality road construction, without which they have even higher maintenance costs. Furthermore, World Bank studies in Kenya give evidence that the concentration of ownership of trucks significantly limits prices received by farmers for their produce.

The technologies of transport include not only the vehicles themselves, but also the roadbed and surface materials, as well as design speeds and road routes. In road building, the technical choices reflect the goals of the programs themselves. Given the goals of most current road-building programs, once the route, design speed, and road surface and strength have been chosen, the most economical vehicle is likely to be the truck. Roads built with high-strength roadbeds and high

design speeds provide a hidden subsidy and competitive advantage for heavy-weight, high-speed trucks compared to other vehicles. The range, speed, and capacity of small motorized animal-drawn and pedal-powered vehicles would be served just as well by less expensive roads.

A peculiar characteristic of transportation systems is that the availability of higher speed transport technologies creates first a demand and then a dependence on long distance transport as settlement and industrial production patterns adjust. Increasing the speed of transportation increases the energy consumption at an even greater rate because both wind resistance and weight of the vehicle increase. Thus one observer of transport in urban and rural Southeast Asia notes: 'A shift in mobility from 2500 km to 5000 km in a 500 hour transport budget would increase energy requirements seven-fold through its greater emphasis on faster car-bus-rail-air modes at the expense of walk-cycle-subsidiary motor modes." (Peter Rimmer, in an article entitled "A Conceptual Framework for Examining Urban and Regional Transport Needs in Southeast Asia" *1978.) The writings of Leopold Kohr on scale and velocity also contain a number of interesting observations on urban transportation dynamics (see* **The Breakdown of Nations***).*

There are also other negative effects that come with smoother, faster transportation links. Road building is justified by arguments about the increased inputs that will be made available to small farmers, the increased market for farm surpluses that will be created, and the reduced running costs for the trucks that will operate over the better roads. Yet many observers have noted the classic pattern of destruction of crafts and cottage industries that also comes with the opening up of a road. Manufactured tools and household items trucked in from the towns and cities outsell the products of local potters and blacksmiths. The types of jobs available change, and the variety of income-producing activities in the community may be reduced. A whole chain of negative economic multiplier effects may be set in motion. The greater commercialization of agriculture is likely to also mean lower crop diversity and thus greater risks from pest attacks and global market fluctuations. Income in the community may shift significantly to land-owning farmers who sell their surpluses without being affected by higher rents.

There are reasons why national transport strategies dramatically affect the strength of local industry and decentralized development. In China, the development of the substantial rural small industry sector has brought with it a unique blossoming of managerial and technical skills among the rural population. One factor that seems to have greatly aided this process is the existence of protected markets that result from the commune system and the poor transportation infrastructure. (See, for example, the discussion of China's 2800 cement plants, in **Small Scale Cement Plants***.) It appears that there may be an optimum degree of transportation integration, beyond which damaging centralizing effects are felt.*

The Transport Panel of the Intermediate Technology Development Group has done some of the most consistently thoughtful reevaluation of the transport problem and possible avenues for appropriate technology solutions. Transport Panel members give high priority to improvements in intermediate motorized vehicles, traditional vehicles, animal packs, and bicycle-powered units; these represent a better match of available capital to the transport needs of small farming communities.

The farm family needs to move small quantities of inputs to the farm, harvested crops from field to home (often over rough terrain), and small surpluses to market. Small vehicles traveling at low speed over simple roads and tracks seem to best match this need. In fact, the animal-drawn cart in most developing countries

still dominates this activity. In India, it has been shown that the total national investment in bullock carts exceeds the investment in either the national railroads or the national road network, and the number of ton-miles of material moved is comparable. Recognizing that bullock carts are going to be part of the Indian transport network for many years to come, organizations such as the Indian Institute of Management have initiated work to improve cart designs through better bearings, lighter frames, and wheels less damaging to roadways. They are also developing harnesses that are not injurious to the draft animals (see **The Management of Animal Energy Resources and the Modernization of the Bullock Cart System***).*

The bicycle has often been cited as the most efficient machine for personal transport ever invented. It is also a major mover of goods in the South. Loads can be tied directly to bicycles or placed in special frames and baskets, and bike trailers and three-wheelers can be used to carry several hundred pounds of goods. **Bicycling Science** *offers the reader an excellent summary of the physics of bicycles and the human body as a power producer.* **Bicycles and Tricycles: An Elementary Treatise on Their Design and Construction** *provides an encyclopedic treatment of successful and unsuccessful design ideas.* **The Design of Cycle Trailers** *details the basic considerations in the design of two-wheeled trailers for hauling goods behind a bicycle, and includes design examples from around the world.*

Small engine-driven vehicles, including motorized bicycles, motorcycles, motorcycles with sidecars and other three-wheelers, and two-wheeled tractor-cart combinations have found a niche in many countries. These small vehicles with very low fuel requirements seem to have an almost unlimited number of possible applications. Discussion and examples can be found in many of the entries in this chapter (see, for example, ITDG's **Low Cost Vehicles***). Rough terrain vehicles produced in industrialized countries are cataloged in a World Bank report,* **Appropriate Technology in Rural Development: Vehicles for On and Off Farm Operations**. *These are primarily expensive, relatively high-speed vehicles with poor fuel economy, beyond the means of most farmers in developing countries.*

The kinds of roads needed by small vehicles can be built using labor-intensive road construction methods. Several of the books in this section discuss the requirements for labor-intensive programs that are economically competitive with those using heavy equipment in the construction of conventional roadways. The success of such labor-intensive road-building techniques has been demonstrated, but greater savings may be achieved if road standards are kept flexible and labor intensive programs are not required to always produce roads of equipment intensive standards. Where transport needs are defined as including roadways for lightweight small vehicles to travel at moderate speeds, labor-intensive road construction methods are more likely to be the first choice. In any labor-intensive road construction program, good quality hand tools and simple equipment are essential to high productivity (see **Better Tools for the Job** *and* **Guide to Tools and Equipment for Labour Based Road Construction***).*

Small boats can be very economical to build and operate, taking advantage of existing inland waterways and coastal routes for quiet movement of heavy loads. In some areas, inter-island communications and transport depend almost solely on small boats. Included are a variety of books on boat-building techniques that could in many cases be used to improve the safety, speed, and economic viability of traditional vessels.

A key consideration in vehicle choice and transportation strategy is, of course, fuel supply. Alcohol fuels, distilled from grains or crop residues, have been

generating great interest as alternatives to gasoline. Brazil has taken the lead in alcohol fuel production, based on cassava and sugar cane. Several books reviewed in the ENERGY: GENERAL chapter offer plans and instructions for small-scale alcohol fuel-producing units. However, the author of **Food or Fuel: New Competition for the World's Croplands** *concludes that large national alcohol fuel programs are likely to greatly increase world hunger by diverting vast areas of agricultural land into fuel production for the relatively wealthy few. And the basic futility of such programs is indicated by the fact that the entire U.S. grain crop, if converted to alcohol fuels, would replace only about 30% of the gasoline currently consumed in the United States. The dramatic 1970s increases in oil prices hit the citizens of poor countries hardest, forcing them off the busses and away from kerosene cooking fuel. Despite the public outcry over higher gasoline prices in the United States, consumption dropped little, and one out of every 8 barrels of world oil production is burned as gasoline in US. automobiles. As long as 6% of the world's population continues to consume about one third of the world's energy supply, the problems of conventional motorized transport in poor countries will intensify.*

Given the stiff buyer competition for scarce gasoline and the vast amounts of agricultural materials required for large-volume alcohol fuels production, it can be reasonably predicted that there will never be enough fuel for more than a tiny part of the world's population to be driving automobiles. Decades of settlement patterns based on the daily use of the automobile in the United States have locked this country into a high fuel demand pattern that will be broken only through a very difficult and expensive process of great change. In oil-importing developing countries, the decentralization of industrial production, along with increased emphasis on bicycles, improved carts, and small engine-driven vehicles appear to be important elements of a practical transport strategy for the future.

Rural Transport in Developing Countries, MF 26-683, book, 145 pages, by I. Barwell et. al., 1985, £7.95 from ITDG.

"Recent research has drawn attention to the fact that: 1) Few regular transport services operate away from all-weather road networks. However, many people live remote from such networks .... 2) In areas with all-weather road access, motor vehicles are beyond the financial means of the majority of people. Equally, many people cannot afford to use the transport services which do operate."

"There is unlikely to be a significant improvement in this situation for the foreseeable future given the limited resources available for expansion of road networks and motor vehicle fleets, and the problems of maintaining existing roads and operating conventional motor vehicles."

The nine case studies on the transport needs of rural people presented here provide some evidence that contradicts long-held notions about the nature of rural transport activities. Not only are footpaths and simple tracks the most used (though "invisible") part of the transport system, but rural people are more mobile than has been generally assumed.

This volume will aid in understanding the kinds of low-cost improvements in the transport system that would be most valuable to villagers.

Earth Roads: Their Construction and Maintenance, MF 26-675, book, 123 pages, by Jack Hindson, 1983, £7.95 from ITDG.

"In the early stages of development it is doubtful if modern high-cost roads are necessary: there is abundant evidence to show that the existence of a means of communication is more important than its quality .... (Most so-called 'low-cost' roads described in other books involve construction methods that) presume the knowledge and skills of a graduate civil engineer and the use of complex equipment. The result is a technology largely incomprehensible to the layman, and a road that is not low-cost."

Based on 20 years' experience in northern Zambia, here is a well-illustrated, practical book on the construction of genuinely low-cost, relatively long-lasting earth roads. The key feature of this system is the primary attention given to soil conservation techniques that divert rain water flows away from the road at all times and minimize erosion in drainage ditches. This manual was prepared for use by non-engineers for hand construction involving very little moving of materials; the author notes that even wheelbarrows will not be necessary for most of the work. Drainage techniques, road planning, construction and maintenance are all covered.

"The most important requirement on a village road, both in hilly and in flat country, is for slow, steady speeds in any weather and at any season of the year." The result is a slow-speed road that is well-suited to carts and bicycles, can handle up to 50 motorized vehicles/day, and that should remain passable.

The Rural Access Roads Programme, MF 26-682, book, 167 pages, by J.J. de Veen, 1980, ILO, out of print.

The Rural Access Roads Programme in Kenya is widely regarded as an important achievement in demonstrating that labor-intensive road construction methods can provide good quality roads at relatively low cost, if a well-organized management structure can be created. This program succeeded in constructing thousands of kilometers of low-volume rural access roads, connecting farming areas with the existing road network.

This book is about the organizational structure and management experience of the program. A short appendix describes and illustrates the construction activities. Whereas most of the work was done by hand, tractors and trailers were used for gravelling. The technology unit of this program carried out some interesting work on the improvement of hand tools and wheelbarrows; this work is not described here, but is covered by two other books (see reviews of **Better Tools for the Job** and **Guide to Tools and Equipment for Labour Based Road Construction**).

Rural communities were involved in road selection. "In areas with average terrain conditions, the original target of 45 km/unit/year can be achieved with a labour force of 270 workers." Average costs were US $5600 per kilometer, including all overhead costs. Maintenance contracts were signed with individual workers to be responsible for each section (about 1.5 km) of road, after it was completed.

Manual on the Planning of Labour-Intensive Road Construction, MF 26-664, book, 253 pages, by M. Allal, G. Edmonds and A. Bhalla of the International Labour Office, Geneva, 1977, out of print.

Not a how-to manual, this book is intended for use by planners who are responsible for national road programs, including people involved in evaluation

and design of road construction projects. “They may fully agree with the notion of appropriate technology, but they must first be presented with viable alternatives to the technology they are using. They also need to be given the means of evaluating, assessing and taking advantage of these alternatives. The present manual constitutes an attempt to meet that need.”

The authors note that an opening up of the spectrum of choice is required. Labor-intensive techniques should not be viewed as simply one way to achieve roads of equipment-intensive standards, but rather the design standards themselves should be flexible to allow for the most beneficial selection of technique, total road cost, user costs and maintenance costs.

There is a chapter (24 pages) on the range of labor-intensive techniques (mostly for hauling), including drawings, photos, and comments about relative costs and suitable applications. Included are headbaskets, stretchers, small trucks on rails, spades, pack animals, animal-drawn carts, animal-drawn scrapers, wheelbarrows, trailers, and small aerial ropeways.

"The planner of any labor-intensive scheme must bear in mind that the choice of the right sort of tool is as important as the choice of the right type of machinery in a capital-intensive project: given the right tools a worker's productivity can be enormously increased. A small research unit to consider the appropriate designs of small tools and equipment would be very useful."

"Earth roads are the most suitable for labor-intensive construction .... Also, earth roads are generally used to transport farm produce to market or to provide access to remote villages. Accordingly, they are of obvious and direct benefit to the local population."

Information is presented on the relationship between design speed and construction costs. Roads designed for vehicle speeds of 40 km/hour have substantially lower costs than those designed for vehicle speeds of 70 or 80 km/hour, because there is a larger acceptable range of curves and gradients.

The later chapters discuss cost-benefit analysis, problems of organization and management in labor-intensive works, and action to eliminate capital-intensive biases in policy and attitudes among engineers.

Roads and Resources: Appropriate Technology in Road Construction in Developing Countries, MF 26-668, book, 200 pages, edited by G. Edmonds and J. Howe, 1980, ITDG, out of print.

This study, prepared for the International Labor Organization, is about road construction programs. The authors note that "the use of more labor-intensive techniques can be technically and economically efficient." Part I, "Institutions and Issues of Implementation," is concerned with how to best organize labor-intensive programs and choose intermediate technologies. The special planning and administrative requirements of labor-intensive programs, and other institutional biases favoring equipment-intensive approaches are discussed. One chapter identifies a range of simple tools and equipment that, if given proper design attention, could multiply labor productivity by a factor of 3-6. These include Chinese wheelbarrows and animal-drawn carts on portable light rail systems.

Noting that road systems in many former colonies have been designed to move goods for export, one author urges that the emphasis should be "on providing inputs into the rural areas which will stimulate growth rather than access to ensure the maximum level of exportation."

Case studies in the second half of the book examine labor-intensive and

construction programs in Mexico, Afghanistan, India and Iran.

"The use of labor-based methods would seem ... to meet all the criteria upon which development planning is based. They serve the mass of the population, their implementation can involve popular participation in the decision-making process, they are an instrument of self-reliance, they can enhance the potential for rural development and they can, by providing income, serve to improve the standard of living of the mass of the population." Despite these claims, the authors have limited themselves to looking at how labor and good small tools and equipment can compete economically with heavy equipment. The goal of this strategy is twofold: income distribution and skill development on a broader scale.

There are a number of crucial questions that are beyond the scope of this book, such as: Who decides where a road will go? Who benefits from the road? Who loses? Who decides the road's design speed and strength (and hence costs and which vehicle owners will benefit)? What road-vehicle combinations go well together? Readers interested in these kinds of issues will find relevant material in other entries in this chapter.

Rural Roads Manual (Simple English Edition): Self-Help and Rural Improvement Roads, MF 26-687, book, 128 pages, by the Papua New Guinea Dept. of Works and Supply, 1977, K3.50 from Dept. of Works.

Papua New Guinea's Dept. of Public Works, recognizing the importance of well-constructed and maintained roads, has published this manual in an attempt to promote self-help road construction all over PNG. Written purposely in very simple English (the national language), it is a complete guide to road design, construction and maintenance using low-cost local materials and tools, and local skills. Covers subjects such as surveying, laying out a road, drainage, building in swampy areas, maintenance and upgrading, plus information on building bridges, culverts and low-level crossings.

Illustrated with drawings on almost every page, this manual is intended for fieldworkers and local government councils in PNG, so that road building and maintenance can become a decentralized process. While specific to conditions in PNG, this manual is valuable as an example for adaptation to other areas.

Better Tools for the Job: Specifications for Hand Tools and Equipment, MF 26-652, booklet, 43 pages, by William Armstrong, 1980, £3.95 from ITDG.

Labor-intensive road construction projects need large quantities of good quality hand tools and carrying devices like wheelbarrows. Available tools are often of poor quality, due to the practice of seeking the lowest quoted price without specifying quality standards. A Kenyan technology unit has developed a set of specifications which have been successfully applied to tools for road projects in that country. By including these specifications with price requests, the tools may initially cost 30% more, but are likely to have a 500% longer working life.

Materials, strength and hardness, and construction specifications are provided along with detailed drawings for each tool and piece of equipment (shovel, hoe, wheelbarrow, forked hoe, crowbar, machete, mattock, axe, pickax, spreader, and rammer).

"A very large proportion of the problems encountered with hand tools in the field (on road, irrigation and construction projects, for example) arises from the use of handles made from cheap unseasoned softwood .... The cost increase for a

specified handle (of seasoned hardwood) as compared to a cheap handle is modest, and no other single step can return such high dividends in terms of cost effectiveness and productivity."

Steel strength and hardness depend on chemical composition and heat treatment. The author notes that by pressing a diamond or hardened steel ball into a small number of samples of the equipment, the buyer can perform a low-cost reliable test of hardness to insure that tools have been made to specification.

Guide to Tools and Equipment for Labour-Based Road Construction, MF 26-677, approximately 30 pages, by International Labour Office, 1981, $42.00 from ILO; also available from TOOL.

"So far as road construction is concerned studies by the International Labour Office and the World Bank have shown that it is feasible to use labour rather than machinery for many activities with a consequent increase in local employment possibilities. For labour-based road construction to be both technically and economically acceptable, it is necessary, among other things, to improve the tools and equipment available."

This guide contains manufacturing specifications for a wide variety of hand tools and animal-drawn equipment useful in road construction. The intention is to provide details on efficient, durable, safe, effective tools. Advice is given on testing and maintenance. Operations include surveying, excavation, rock crushing, hauling, spreading, and compaction.

Low-Cost Vehicles: Options for Moving People and Goods, MF 26-680, book, 106 pages, by G. Hathway, 1985, paperback £8.95, hardback £14.95, from ITDG; also available from TOOL.

Here is the only book that covers the full range of low-cost transport devices from around the world, from headstraps and backpacks to motorized three-wheelers and micro-trucks. This volume should prove valuable as a source of ideas for new vehicles to fit special transport needs. Many photos.

"The small farm transport vehicle (sftv) is a new type of wheelbarrow which has been designed and developed by IT Transport and ITDG. It is specifically intended to carry loads up to 150 kg for distances of up to 10 km, which are typical of the transport requirements of small farmers"

Low Cost Transportation, MF 26-679, book, 63 pages, by Gert Thoma, 1979 available from German Appropriate Technology Exchange, GTZ, Dag-Hammarskjold-Weg 1, D-6236 Eschborn 1, Federal Republic of Germany.

Here is a nice collection of designs from around the world for carts, tricycles, wheelbarrows and handcarts, and their associated wheels, bearings, brakes, steering mechanisms and other details. Many of the advantages and disadvantages of each are noted. Some good hints on the fabrication of strong joints are provided.

"The choice of appropriate wheels for carts influences their overall efficiency. For example, the rolling resistance of hard wheels is about 50% higher than that of pneumatic tires. On rough terrain the difference is less or zero. It is recommended to continue the use of hard wheels for transport on unprepared terrain with low speeds while giving priority to big diameters."

The Design and Manufacture of Animal-Drawn Carts, MF 26-691, book, 122 pages, by Ian Barwell and Gordon Hathway of I .T. Transport for ILO / Habitat, 1986, £8.95 from ITDG.

Animal-drawn carts can play an essential agricultural role in moving large amounts of farm produce and materials. They can be low-cost, locally made, and able to travel across difficult terrain, without requiring foreign exchange for fuel or parts.

This is an overview of carts, wheels, harnesses, and how to make them all. Two- and four-wheeled carts, harnesses for different animals, and special carts for different purposes are covered. The principles of good design are explained in each case.

The Management of Animal Energy Resources and the Modernization of the Bullock Cart System, MF 26-686, book, 137 pages, by N.S. Ramaswamy, 1979, Indian Institute of Management, 33 Langford Road, Bangalore 560 027, India; out of print.

"For short hauls, small loads, versatile movement over any available surface and low freight charges, the cart has no peer either in the rural areas, or, for that matter, in the towns and cities. It is still cheap, readily available, and safe."

The author presents statistics to convincingly demonstrate the importance of animal power and carts in the Indian economy. Discussing deficiencies in design that need to be overcome, he offers evidence that the improvement of harnessing devices, agricultural implements, and carts should be given a high priority by the Indian government. To accomplish these objectives, he proposes the establishment of an Animal Energy Development Corporation, and outlines a program of activities. He also argues for less cruelty to the animals both in general use and through promotion of improved slaughterhouse facilities.

Animal power inputs on the Indian farm are even greater than in the transport sector. Two-thirds of all farm energy is provided by animals, while human energy provides 23% and electricity / fossil fuels only 10%.

Carts are used in moving 15-18 billion ton-km of freight per year in India. But "the traditional cart is defective in design. The draught power of the animal is wasted due to friction resulting from rough bearings and crude and inefficient harnessing, etc. The wobbling rim cuts into the road surface and damages it. . Weights run high. Traditional carts can be easily improved by: smooth bearings, lower weight, the introduction of a log-brake, better harnessing, the use of pneumatic tires on paved roads" and the use of hard rubber tires in rural areas.

As this is a compilation of papers, much of the text is repetitive. Photos of old and new cart designs are included.

Bicycling Science, MF 26-657, book, 243 pages, by Frank R. Whitt and David G. Wilson, second edition 1982, $12.50 plus postage from MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142, USA.

This very readable book describes the physics of bicycles and other human-powered machines, and the characteristics of the human body as a power generator. Topics include the power needed for movement on land, maximum performance of cyclists optimum pedaling rates, comparison of human power with internal combustion machines and electric motors, bicycle design for rough roads, braking of bicycles, construction materials (including bamboo frames and plastic frames), water

cycles, railway cycles, and possible future designing pedal-powered equipment or bicycle modifications for low-cost transport.

The authors note that tests of human energy production indicate that for prolonged periods (e.g., one hour) an ordinary college student would produce about 0.05 hp (37 watts). Other tests show highest power production for 1 minute of .54 hp (403 watts), and for 60 to 270 minutes, 0.28 to 0.19 hp (208 to 142 watts). Hand-cranking is not as efficient as pedaling. There is some evidence that screw-pedaled boats are more efficient than oar-driven boats. A gasoline engine added to a bicycle to give it the equivalent power of an extra human being would weigh 20 pounds. The same power using an electric motor would require adding the weight of one person, in the form of batteries and electric motor.

Some designs might be of particular interest in poor countries. Bamboo-framed bicycles were marketed prior to 1900. For rough roads, "some form of sprung wheel or sprung frame can greatly reduce the kinetic energy of momentum losses by reducing the unsprung mass and ensuring that the wheel more nearly maintains contact with the surface." (In developing countries, large diameter wide tires ensure an acceptably comfortable ride without a sprung frame.) Cycles with steel wheels developed for running on steel rails have less friction to overcome than the best bicycles on excellent roads.

The standard bicycle has seen few changes in design since 1890. The authors claim that this is partly because at about that time the automobile began monopolizing the attention of the inventive mechanics and mechanical engineers. There is certainly potential for new concepts and designs.

Bicycles and Tricycles: An Elementary Treatise on Their Design and Construction, MF 26-655, book, 536 pages, by Archibald Sharp, 1896 (reprinted 1979), $14.95 plus postage from MIT Press, 55 Hayward Street, Cambridge, Massachusetts 02142, USA.

This is a fascinating book on what is perhaps the most efficient machine ever created. A valuable reference for designers of bicycles, tricycles for hauling goods and people, bicycle trailers, and stationary pedal-power and treadle-power machines.

The first 140 pages contain an introduction to the physics and mechanical engineering of bicycles, essential to the design of successful machines. This would make a good text for design classes.

Part II reviews the history of the development of the bicycle, with the various improvements, when they were made, which ideas were dead ends and which ideas led to further refinements. The basic bicycle design we use today evolved by 1886.

The section on tricycle design may prove useful to those investigating design changes to make the pedicab more efficient and easier to operate. For example the effects of different tricycle configurations on steering capability are explored. Several special gears for driving tricycle wheels at different speeds when rounding corners are discussed in detail (clutch gear and differential). The author notes that great accuracy is not needed in the production of the bevel gears for a differential; these gears only move slowly even when a tricycle turns a corner at 20 mph.

In the remaining chapters (300 pages) the author discusses motion over uneven surfaces, frames, stresses on frames, different kinds of spoked wheels, hubs, bearings, chains, chain gearing, toothed wheel gearing, lever and crank gearing, tires, pedals, cranks, bottom brackets, seats and brakes.

This is truly a classic and monumental work on bicycle design.

The Design of Bicycle Trailers, MF 26-659, report, 44 pages, by Ian Barwell, Intermediate Technology Transport, 1977; 1986 edition 74 pages, by M. Ayre, £6.50 from ITDG; also available from TOOL.

"The intention of this report is to provide basic design information for those people in developing countries who wish to build bicycle trailers." Detailed recommendations about the critical aspects of trailer design are made to aid the reader in designing a trailer most suited to local circumstances. These design aspects include size of cargo space, center of gravity of the load, length of tow bar, hitch design, ground clearance, type and mounting of wheels, and chassis design. 15 bicycle trailers are described, along with photos and drawings of each.

"The trailer is a convenient way of extending the usefulness of bicycles .... It is cheap to produce, suitable for small-scale manufacture by local industries and can, if designed for that purpose, also function as a hand cart. For these reasons, the development of trailer designs which meet particular local requirements is to be encouraged."

A bicycle with a trailer can carry an amount of cargo almost as great as a tricycle (100 kg vs. 150 kg), yet the trailer can be quickly disconnected to allow use of the bicycle for personal transport. It should be possible to produce the trailers for not much more than l/2 the cost of a bicycle.

An easy to read, valuable report.

The Bicycle Builder's Bible, MF 26-653, book, 376 pages, by Jack Wiley, 1980, out of print in 1985.

This is mainly a buying guide and maintenance manual for bicycles. Variations such as unicycles, tandems, and motocross bikes are also discussed. The author shows how to convert a regular bicycle to a folding bicycle, and how to make some of the other unusual variations from bicycle parts.

Three commercially sold adult tricycles (Schwinn Town and Country, AMF Courier, and Gobby), all with three speeds and rear wheel differentials, are pictured and briefly described. Also shown is an industrial tricycle, The Mover (manufactured by Industrial Cycles, Dayton, Ohio).

There are a few useful ideas included for rigging up pedal-powered equipment. Many of these seem to be taken from **Pedal Power in Work, Leisure and Transportation**, or from the work of S. Wilson in England.

Bicycles: A Case Study of Indian Experience, MF 26-656, book, 87 pages, by United Nations Industrial Development Organization, ID/SER. K.1, Sales No. E.69.II.B.30, out of print.

For anyone interested in the idea of making bicycles on a national or regional level, this is a fascinating book. Much of it is technical; for example, it lists the specifications of each of the different parts for the chosen model (a single-speed, heavy-duty design). The book certainly does not provide all the information needed to begin bicycle manufacture, but it does give a good idea of what might be required.

There is a comparison of manufacturing requirements and costs in small and large-scale production units in India. Describes tests made for each of the major components. Lists conventional equipment required and costs. Describes the manufacturing and assembly operations, including those for a small-scale plant producing 15,000 bicycles yearly. Discusses manufacturing of specialized components

by small subcontractors.

The conclusions and recommendations include the following: a) A bicycle industry can be started with the manufacture of only a few simple parts and components and the rest imported. b) Complete bicycles can be manufactured by units making only a few parts themselves and obtaining the rest from cooperating small-scale units. c) Gradually imports can be reduced with a view to reaching self-sufficiency. Under a 3-phase program, the imports would be: Phase 1—free-wheels, BB shells hubs, rims, chains, spokes, nipples, tires and tubes, and steel balls; Phase 2—only free-wheels, BB shells, hubs, tires and tubes, and steel balls would be imported; Phase 3—only BB shells, tires and tubes, and steel balls would be imported. After this, all components would be produced within the country.

If the reader were to combine what is provided here with S. Wilson's "Oxtrike" idea (making use of sheet steel and angle iron instead of tube steel for the frames) a much smaller-scale and lower-cost method of production might be possible.

Bicycle Resource Guide, MF 26-654, a series of bibliographies averaging 100 pages, over 1000 entries, only two books still in print, $5.00 each from D.J. Luebbers Editor, 725 Kearney, Denver, Colorado 80220, USA.

This is a series of seven bibliographies. The 1976 bibliography, for example, has 106 pages, 1102 entries, an index, and costs $5.00 in the U.S. and $5.50 overseas. Entries include bikeway studies (both on existing roads and new separate pathways), accident studies, guides for local tours, bike laws, bike repair manuals, conference proceedings, 100 mail order catalogs, 290 newspaper articles, and 300 journal articles on medical, transportation, historical, legal, and industrial topics related to bicycles.

Of special interest to our readers in the 1976 bibliography are: repair and service manuals, case studies of bicycle/bus combinations as low-cost solutions to urban transport needs, articles describing new power packs for potential use with mopeds or bicycles, studies of "low-cost" bikeway pavement materials and design, publications presenting methods for using the bicycle in teaching certain principles of physics, and a document on transport planning incorporating bicycles in the city of Nairobi.

Maintaining Motorcycles: A Field worker's Manual, MF 26-663, booklet, 26 pages, by Russell Henning, 1982, $3.00 (add $1.15-$4.75 for airmail) from World Neighbors, 5116 North Portland Avenue, Oklahoma City, Oklahoma 73112, USA.

Basic considerations in preventative maintenance and selected "roadside" repair tips are combined in a common sense guide for keeping the small, simple beast of burden roadworthy. Includes rudimentary advice on commonly encountered maintenance problems such as battery and sparkplug malfunction; tire, chain, and air cleaner service; wheel alignment; and a service check schedule.

Automotive Operation and Maintenance, MF 26-688, large paperback manual, 200 pages, by E. Christopher Cone, 1973, revised 1992 edition $14.95 from VITA.

The author's experiences in Liberia, West Africa, of "experiment and occasional disaster" provided most of the material for this book.

"The intent is to offer suggestions to the driver or mechanic who operates in an area where service facilities and technical assistance are not readily available. In

such areas he must be his own advisor on every problem which may arise."

The first section concerns operation of a car in an area served by pioneer roads. The section is intended to assist the driver with temporary repairs to his vehicle so that he can get home in the event of mechanical trouble.

"The second major portion of the book is devoted to maintenance suggestions. These are intended for use in a frontier shop or repair center, no matter how ill-equipped this may be. This book should be used as a supplement to the vehicle's shop manual, and as a source of guidance. The shop manual will tell how to reline the brakes, for example, but this book is intended to indicate when relining is needed."

Chapter topics are: mechanical emergencies while driving, operating on pioneer roads, avoiding road hazards, extricating the vehicle, procedures when stranded, winches and towing, field expedients (on the spot temporary repair suggestions), check lists (for problem-locating and solving), tests and testing equipment, shop techniques, body repairs, a shop building, diesel engines, tools and equipment (for the car and shop), vehicle modification, parts and supplies, storage facilities, preventive maintenance, selecting a vehicle (a look at four-wheel-drive vehicles available), miscellaneous formulas, definitions, and an index.

The manual includes many large, simple drawings and diagrams that provide ingenious solutions (along with the text) to difficult problems; e.g., freeing a car stuck between logs on a bridge; extricating a vehicle stuck in mud or snow; temporary repair of broken brake or fuel lines. There are diagrams for homemade hoists and tire removers as well as general shop hints and a very handy index. The language is not difficult; closer to standard English than almost any automobile shop manual. An excellent book.

The Backyard Mechanic, Volume One, MF 26-670, 57 pages; Volume Two, MF 26-671, 77 pages; Volume Three: MF 26-672, 92 pages; 1981, publication 104N, Consumer Information Center, P.O. Box 100, Pueblo, Colorado 81002, USA, out of print.

Good illustrations and photos with clear instructions tell you how to do most car maintenance and repair activities. Brakes, cooling system, battery care, tuneup, body repair and painting and more topics are covered. The safe, permanent repair of tubeless tires is explained. Relevant to most automobiles.

Gasoline Engine Tune-Up, MF 26-676, booklet, 18 pages, 1983, publication 105N Consumer Information Center, Pueblo, Colorado, out of print.

Many photos and clear instructions in this booklet provide a good introduction to the steps necessary in tuning up gasoline automobile engines. It is much better than typical workshop manuals, which usually provide needed specifications but little guidance for the inexperienced. Even the reader who has been tuning up his/her own cars for years will learn a few things from this booklet.

Notes on Simple Transport in Some Developing Countries, Information Paper No. 2, MF 26-666, ITDG Transport Panel, report, 26 pages, out of print in 1985.

"The report discusses intermediate transport in Papua New Guinea, the Philippines, China and India, and describes the simple vehicles, human-powered, animal-powered and motorized, which are used in those countries." 22 photos of simple vehicles are included.

In Manila, among the unusual vehicles is "a bicycle and sidecar with a 50cc two-stroke engine mounted in the cycle frame. This drives the rear wheel through an additional chain drive, the original pedal chain drive being retained so that the rider can augment the power of the engine when necessary."

In China "many of the minor roads and tracks in the rural areas are narrow and unsealed but are quite satisfactory for the types of vehicle which travel on them" (bicycles, handcarts, wheelbarrows, and two-wheeled tractors).

The Chinese have shown considerable innovation in the design of tricycles for proper gearing and effective braking, while the Indians have not. (This suggests that the subservient role of the tricycle driver in India may have led to neglect from designers.)

A 1974 commission in Papua New Guinea recommended that 1) private cars were inappropriate to PNG conditions, 2) use of bicycles and pedal drive car vehicles should be promoted, 3) a bicycle path system should be built in Port Moresby, 4) the feasibility of using electric vehicles powered by PNG's substantial hydro resources should be investigated and 5) aerial ropeway systems for mountainous areas should be investigated.

"Simple vehicles can play an important role in the transport systems of all developing countries, yet their use is largely confined to the urban areas of Asia and their design is often based on imported technology rather than on local requirements."

Proceedings of ITDG Seminar "Simple Vehicles for Developing Countries"
Information Paper No. 3, MF 26-667, ITDG Transport Panel, report, 66 pages, 1977, out of print in 1985.

The papers included in this report cover "vehicles presently in use and prototypes currently being developed; the role of transport in agriculture; the use of simple vehicles in labor-intensive construction; manufacturing strategies for local production; and the transport needs and economic constraints in the rural areas of developing countries." The need for improved wheels and tires for rural dirt roads is noted as an important research priority. Thirty-six photos are included.

One of the more interesting motorized vehicles discussed is the TRANTOR, a multi-purpose vehicle able to serve as a truck, tractor, and passenger vehicle. The TRANTOR has been designed to be economically produced in developing countries in very low quantities (1000 units a year). Simple machine tools and jigs are used in production, and components are grouped into similar categories to allow the benefits of a large batch production to be achieved without requiring the production of a large number of completed vehicles.

This report provides additional evidence that an appropriate technology approach to rural transport would be considerably different from the prevailing approaches. "It is a technical fact that the design of roads in developing countries is dictated by the characteristics of the private car and the lorry (truck). The 'desired' speed that it is assumed car drivers want dictates the overall horizontal and vertical alignment of the road, whilst the frequency and load carrying capacity of the lorries that will use it decide the strength of the road's structure. It has never been shown that either or both of these vehicles is in any sense necessary, much less optimum, for development to take place. The possibility that other, simpler and probably cheaper vehicles might be more appropriate to needs does not appear to have been given serious consideration .... The simpler and thus most probably lighter the vehicle, the cheaper the cost of having an adequate road."

Contributing to the above problem is the fact that in developed countries "there appears to be a misunderstanding about the nature of movement demands (in the developing countries). For passenger transport the existing buses and various forms of share taxis probably meet demands very well. But for goods transport the available evidence suggests that the fundamental demand is for the movement of small consignments over relatively short distances. Smallholder agriculture, almost by definition, gives rise to limited crop surpluses and farm inputs."

The Design and Manufacture of Low-Cost Motorized Vehicles, MF 26-690, book, 190 pages, by Ian Barwell and Alan Smith of I.T. Transport for ILO / Habitat, 1988, £13.50 from ITDG.

An overview of a wide range of low-cost vehicles, showing how they are made, and proposing certain widely relevant improvements. In most cases "manufacture" of these vehicles really amounts to local metal fabrication of body extensions, truck beds, and so forth, while industrially produced motorcycles and motor vehicle engines are used as the power source. Suspension systems, braking systems, and hitches are among the subtopics covered. Lots of production details are provided.

It is clear that small vehicles could play a much larger role in the transport of people and goods in developing countries. Anyone fabricating such vehicles will find some useful new ideas in this collection.

Appropriate Industrial Technology for Low-Cost Transport for Rural Areas, MF 26-650, booklet, 54 pages, UNIDO, 1979, Document No. ID / 232 / 2, available free of charge from Documents Unit, UNIDO F-355, P.O. Box 300, A-1400 Vienna, Austria.

A 24-page background paper entitled "Appropriate Transport Facilities for the Rural Sector in Developing Countries" by I.J. Barwell and J.D. Howe of the IT Transport Panel is the most valuable part of this booklet. It provides an insightful and thorough examination of the elements of appropriate rural transport technology (both equipment and roads), and what actions policymakers and R&D groups can take in support of such technology.

The authors note that crucial on-farm transport technology has been almost totally neglected, along with virtually all of the low-cost technologies of the traditional sector: backpacks, bicycles, hand-carts, wheelbarrows, animal packs, and animal carts. The road networks do not effectively serve the majority of the population, but in fact subsidize the privately-owned imported motor vehicles and can bring real disadvantages to the rural poor (e.g., by destroying local crafts through transport of manufactured goods into the area). "Few vehicles have ever been designed specifically to meet the needs of developing countries. Their use in developing countries indicates not that they best meet transport needs but rather that they are better than anything else currently available." The authors note a variety of existing basic traditional vehicles which should be improved and more widely used.

Three Wheeled Vehicles in Crete, MF 26-669, paper, 10 pages, by Alan Meier, Pub. No. UCID-3968, free from the author, Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720, USA.

A three-wheeled vehicle has evolved in Crete, Greece, and reached widespread use in the rural areas in just 10 years. There are now 20 local factories producing these vehicles. Most have an 8-12 hp rope-started diesel engine. For many of these vehicles the engine can be converted in l/2 hour to a rototiller for agricultural use.

"The vehicle appears to have been in part responsible for the economic revival of agriculture in Crete. The three-wheelers borrowed much of their early technology from two-wheeled rototillers but quickly evolved into a unique vehicle." The rapid development and widespread use of these vehicles suggests they fill an important need for rural transport in less developed countries.

Appropriate Technology in Rural Development: Vehicles Designed for On and Off Farm Operations, MF 26-651, catalog, 150 pages, 1978, free to development organizations from Regional Development Unit, Transportation Dept., World Bank Publications, Box 7247-8619, Philadelphia, Pennsylvania 19170-8619, USA.

A catalog with brief descriptions of vehicles that are produced and sold commercially around the world, that could be used in rural areas of developing countries. The information comes from the manufacturers and has not been verified independently. There are more than 100 photos included.

Good as a summary of the range of rough terrain motorized vehicles designed in the industrialized countries: motorized tricycles and 3-wheeled vehicles, all-terrain vehicles, small tractors, small trucks, and hand tractors. Though a few animal-drawn carts and tricycles are shown, there is unfortunately little information included on the range of transport options affordable to the poor majority in developing countries.

The Manufacture of Low-Cost Vehicles in Developing Countries, MF 26-665, booklet, 31 pages, United Nations Industrial Development Organization, 1978, Document No. ID/193 (Sales No. 78.II.B.8), UNIDO, P.O. Box 300, A-1400 Vienna, Austria, out of print.

This is a report of a meeting that discussed the obstacles to wider use of low-cost vehicles. An interesting variety of motorized vehicles are described, many of them from India and the Philippines. These include motorized bicycles, mopeds, motorcycles (often with a sidecar), three-wheelers (150 to 1200 cc engine) and small trucks (600 to 1600 cc engine).

Particularly for the 3 and 4-wheeled vehicles, the pattern has been first to import, then assemble, then partially produce vehicles locally. This has prevented radical innovation in design that might have led to vehicles more suitable to developing country circumstances.

A number of points are made in the report which suggest that perhaps the widespread use of small motors on existing non-motorized vehicles could provide additional power and speed where needed, while avoiding the need for enormous investment in high-speed, heavy vehicle roads. This might allow improved traditional vehicles to recapture some of the activity now monopolized by the imported high-speed cars and trucks. Transportation activities would thus remain

in the hands of a broad section of the society.

In India there have "been moves to motorize cycle rickshaws, and at least two companies manufacture small two-stroke engines and conversion kits for fitting to rickshaws. One of these ... uses a 35-cc, two-stroke general purpose engine developed for agricultural and other use. It is used to provide chain drive to only one of the back wheels, which makes a differential unnecessary." Power packs for bicycles are also manufactured in India.

In the Philippines "about 90 percent of the motorcycle population is fitted with side-cars." In the countryside, these vehicles perform quite well on rough roads and paths.

"In terms of capital, space and economic volume, the requirements for making simple two-stroke engines are all only a fraction of those for manufacturing conventional four-cylinder engines. The technical requirements, although still exacting, are also much lower."

"In a world where high-performance vehicles did not exist, the required road structure and system of traffic regulations would be considerably different from that of either an industrial or pre-industrial economy .... Rigorous traffic separation reinforces the advantages of the more powerful vehicles."

Much of this report indicates that the traditional non-motorized transport vehicles have survived because they are better suited to existing needs for many tasks. Imported vehicles (and imported designs) suffer from high cost, difficulty of repair, lack of smooth supply of spare parts, high fuel consumption, and poor durability when operated over rough terrain. Thus there would appear to be an opportunity for low-cost motorized vehicles to replace many of the functions of the more expensive machines. Rather than argue for this, however, the expert group discusses ways to eliminate indigenous non-motorized vehicles: "The possibility of designing a motorized competitor for the rural bullock cart was discussed .... Indeed, it is the extent that low-cost vehicles replace the more primitive means of transport that will effectively measure their success." The failure to consider vehicles in the light of who makes and owns them is a serious shortcoming here.

A different, more socially appropriate approach would defend the role of existing vehicles such as bullock carts, and try to improve them rather than eliminate them. If hidden subsidies (in the form of more costly road construction required for high-speed heavy vehicles) were removed, low-cost vehicles might favorably compete with larger vehicles in many activities.

Electric Vehicles: Design and Build Your Own, MF 26-660, book, 210 pages, by Michael Hackleman, 1977, Peace Press, out of print.

This book does not give very many specific construction details, but it does describe the basic principles of the design of small electric vehicles. You will need to know basic electrical theory to use this book.

Electric vehicles are not effective off of hard surfaced roads, and may require frequent battery recharging during a full day of use. The vehicles presented in this book can carry a couple of people but not heavy loads. Unless there are major future technological advances in battery efficiency, battery weight reduction, and solar generation of electricity, it seems clear that electric vehicles will remain too expensive and inefficient for transporting people or things (especially away from surfaced roads).

A better alternative for low-cost motorized vehicles and power packs for small vehicles and bicycles appears to be small internal combustion engines perhaps

using fuels from biological processes (such as alcohol). But if you are interested in designing electric vehicles you should find this book useful. Many illustrations.

Boatbuilding Manual, MF 26-673, book, 240 pages, by Robert M. Steward 1980, 1987 (third) edition $29.95 (order no. 60160) from International Marine Publishing Company/Tab Books, P.O. Box 40, Blue Ridge Summit, Pennsylvania 17294, USA.

In this book, traditional wooden boat-building is explained in a systematic, textbook style that employs abundant illustrations, tables and photographs. Boat construction is a field with a large number of unfamiliar technical terms, a fact that makes many books very difficult for the novice to use. Happily, this manual makes the entire subject, from choice of materials through detailed construction procedure, accessible to the careful reader without oversimplifying.

“Instead of using a protractor to measure a bevel each time you take one off, make yourself a simple bevel board as shown in Figure 8-9(a). Use a piece of plywood about 3.5 inches wide and mark off angles from zero to about 30 degrees. Slide the adjustable bevel along the left edge of the bevel board until it lines up with one of the angles and read it off.”

"When a bevel is marked on a piece of stock to be sawn, it must be designated as either 'under' or 'standing', marking the piece UB or SB. This is most important, and after you have ruined a few pieces, you will understand the principle."

There are not plans for a specific boat, but valuable information for completing a boat of virtually any design are provided. Alternative materials for hulls are covered briefly in the text and a list of recommended books on these and other aspects of boatbuilding is included.

New Working Watercraft, Special Report from the National Conference on Applications of Sail-Assisted Power Technology, MF 26-681, book, 94 pages, by James W. Brown, 1981, out of print. (For general information on the techniques described below, write to Kamberwood International Services Inc., P.O. Box 550, North, Virginia 23128, USA.)

This book presents the case for the role of low-cost, lightweight, sail-assisted boats in maintaining or revitalizing small-scale fishing. Based on personal experience and consultancies in Africa, the Pacific and the Philippines, the author has adapted multi-hull design and cold-molding construction to create unique and ingenious craft. Many years of experimentation with new designs and alternative materials for high-performance sailing multi-hulls are apparent in the evolution of the designs presented. Most impressive is the resourcefulness and cultural insight shown in matching these designs to conditions in fisheries in the South.

Costs are kept low through maximizing the use of currently available local materials and reducing dependence on "alien" technology and petroleum. A patented system (termed "constant camber") is described for creating molded panels which can be sewn and glued together to create seaworthy hulls. This system alone, which circumvents exacting and tedious boatbuilding procedures, is high recommendation for the approach. Other features that distinguish the design(s):

a) human power can be used;
b) the working platforms are inherently stable;
c) small, non-marine, air-cooled motors can be used;
d) training time for local production is minimal;

e) prices can be competitive with existing indigenous craft.

This book does not include everything required to produce boats and is currently out of print. However, a packet of materials termed the "Constant-Camber InfoPak" is available for people interested in applying the technology in development projects or private enterprise. The contents are periodically updated, and the US $25.00 purchase price includes a minimal patent royalty for licensing an introductory boatbuilding project.

Worthwhile reading.

Fishing Boat Designs: 1: Flat Bottom Boats, MF 26-661, book, 46 pages, by Arne Fredrik Haug, 1974, $7.50 from UNIPUB.

"The paper contains a selection of designs of flat bottom boats suitable for fishing and transport work in lakes, rivers and protected coastal waters. The paper and the designs were prepared to provide detailed technical information to boatbuilders and fishery officers ...."

The designs are intended to be built by people having basic carpentry skills and either some boatbuilding experience or a few weeks of training. Building procedures and timber selections are covered.

"The boat designs presented here are suitable where low cost, or ease of construction, are all-important factors and where a somewhat reduced sea-worthiness ... can be accepted, or where extreme shallow draft requirements are an over-riding consideration."

Materials needed for construction are wood, galvanized nails and screws, caulking compound, wood preservative and sealer, and caulking cotton. The boats could be built with only hand carpentry tools, but a table-saw and hand-held electric drill would be useful. The boats are powered by pole, oar or motor; some of the boats could be modified for sail power with the addition of side-mounted keel boards.

Handbook of Artisanal Boatbuilding, MF 26-692, book, 131 pages, text in both English and French, by R. Lefebre, 1979, FAO, $9.50 from UNIPUB.

This handbook sets down in a straightforward way the main points of establishing a small-scale boatbuilding industry where none formerly existed. Identifying and training capable local carpenters, establishing open-air workshops, and organizing for the production of very small rudimentary plank-built boats are among the topics covered. The text, presented in both English and French, is clear and systematic and closely matched to explanatory illustrations and photos.

The contents are based on an FAO project in Africa where fishing had previously been conducted in dug-out canoes. Though the circumstances of this project were unique, and such a simple approach will not always have as great an impact, there are valuable insights here for readers interested in establishing a cottage industry. The boat design presented is applicable for inland fisheries in other non-industrial areas. The emphasis is on full employment (hence the artisanal rather than industrial approach), low capital, and product quality, all of which make this a useful reference for project officers in small-scale economic development.

Boats From Ferrocement, MF 26-658, book, 131 pages, UNIDO, 1972, ID/72, Sales No. 72.II.B, out of print.

"There is no doubt about the urgent need in most developing countries for

fishing boats that will help solve their acute food problems and for boats that will facilitate transportation in areas where rivers and channels are the most commonly used communication routes .... Ferro-cement boat-building is perfect for developing countries. It requires a minimum of qualified personnel, imported raw materials and capital equipment and the boats produced compare favourably with those made from other materials in terms of price, performance, maintenance costs and life span."

This book is a very detailed survey of the equipment, materials and methods used in ferrocement boatbuilding. Many sources of further information are mentioned.

"The basic qualities that make ferrocement ideal for boat construction are the ease with which it can be moulded to any shape, and the unit weight per square foot."

Anyone building ferrocement boats will find many specific instructions in this book, but there are no complete boat plans.

Boatbuilding with Plywood, book, 278 pages, by Glen L. Witt and Ken Hankinson, 1978; 1989 edition available for $25.95 from Glen-L Marine Designs, 9152 Rosecrans, Bellflower, California 90706, USA.

Plywood has many advantages as a boatbuilding material for amateur and small-scale builders. The type of wood, and more importantly, the type of glue used to laminate the thin wood panels will determine if the plywood is suitable for marine applications. Plywood boats can be faster and easier to build and lighter than those made from alternative materials, but care must be exercised to benefit from these characteristics.

Where most boatbuilding books treat plywood as a material for interiors and above-deck construction, this book gives detailed instruction for building boat hulls from plywood. Each step is illustrated with numerous photographs and clear two-dimensional drawings. The boat examples provided are mostly recreational craft with the high standards of construction for performance and appearance common in affluent areas. But quality construction (along with good maintenance) is more critical with plywood than with perhaps any other material, and this book provides the amateur builder with insights evidently gained through long experience. Not every design can be built with plywood, and not all plywood is suitable for boatbuilding, but when all the conditions are met, this book should be useful.

The Dory Book, MF 26-674, book, 275 pages, by John Gardner, 1978, available from the International Marine Publishing Company, Mystic Seaport, Mystic, Connecticut 06355, USA.

"Of the simplest design, built from the most common materials, the dory has the ability to handle the most demanding tasks." Relative ease of construction, low cost, and legendary seaworthiness are the main advantages that have made this a popular design for small work-boats. Primarily distinguished by the use of wide planks (increasingly replaced by plywood) and the lack of a keel, dories have remained relatively unchanged for several centuries. Where conditions require seaworthiness and suitable building materials are available, this design may still find application.

This book begins by tracing the evolution of the dory with a scholarly, yet quite readable account of pre-industrial and early industrial boatbuilding. There is

also a compendium of dory designs with construction details and text that provides guidance on the relative merits of each variation. But the most useful part (comprising about one-third of the book) is the section on layout and construction, aimed at the home or small-enterprise builder. The focus on one type of boat, and the abundant, clear three-dimensional drawings make the construction procedures much easier to understand here than in many boatbuilding books. A chapter on new materials could go into greater depth, but does provide helpful information for those with access to alternative building materials. First time or amateur builders should find this book very useful either by itself or as a supplement to more technical boatbuilding books.

Small Boat Design, MF 26-684, book, 79 pages, edited by Johanna Reinhart, ICLARM, 1979, $12.00 from International Specialized Book Services, 10230 South West Parkway, Portland, Oregon 97225, USA.

A conference on small boat design held in New Caledonia in l975 generated the 16 papers assembled in this book. Considerations for the design of work-boats are briefly covered by a variety of representatives of fishery development organizations and the marine industry. Many papers focus on the South Pacific, though the information is applicable elsewhere. While the new-found energy consciousness of the mid-70s is evident, a "small" boat is considered to be anything from a home-built craft powered by a recycled lawnmower engine up to a high-speed boat propelled by marine diesel motors costing several thousand dollars. This broad focus reflects the variety of conditions in which fishing is carried out but may limit the usefulness of the book for many readers.

The collection begins to cover the complexity of matching small boat design to the needs of fishers in less developed regions. While not as comprehensive or systematic as it could be, it contains many important points for planners and builders in small-scale fisheries. Some of the topics are: engine selection, building materials, person-hour estimates for construction, design requirements for a "typical" village fishery, loan repayment calculations, etc. A list of addresses for the participants is included.

Sails as an Aid to Fishing, MF 26-693, book, 139 pages, by MacAlister Elliott and Partners for the Overseas Development Administration, 1988, free from MacAlister Elliott and Partners Ltd., 56 High Street, Lymington, Hampshire SO41 9AH, England.

"Fuel is often expensive now and locally in short supply. Today, when sails are fitted to working boats, they can reduce running costs and make fishing easier. We can retain the advantages of engines for efficient fishing, but can also save fuel, add speed and increase safety, by the use of sail .... In good conditions, a well-designed sail fitted to a small fishing boat can move the boat as fast as the engine will, and on many days of the year will save almost all the fuel. And if the engine breaks down, you can always sail to safety, whatever the distance."

"Most boats can make use of sails. The few exceptions are:

- boats with little natural stability, such as some small dug-out canoes;
- boats that are too weak to carry rigging forces, such as reed boats or rotten boats;
- boats that simply have no space on deck for sailing equipment."

There is a clear explanation of how a sail works, and recommendations for boat improvements. Detailed instructions are provided for making masts, spars,

rigging, and sails. Five different sail types that cover most needs are also presented in detail.

Installation and Maintenance of Engines in Small Fishing Vessels, Engineering Applications: 1, FAO Fisheries Technical Paper 196, MF 26-689, book, 127 pages, by Brian Mutton, 1979, $9.50 from UNIPUB or FAO.

This is intended to be "a basic handbook covering all details of installation (of small diesel engines into small boats) and the necessary maintenance procedures to be adopted for small boatyards, boat owners, and fishermen."

"On wooden boats the craft must be in the water and left for several days before trying to align the engine. This is because a wooden boat changes its shape as the wood becomes soaked, and it may take time to do that.

"On boats made of other materials, e.g. fibreglass, the alignment may be done as soon as the boat is in the water."

ADDITIONAL REFERENCES ON TRANSPORTATION

"**Technology for the Masses**" contains an excellent article on the modernization of the bullock cart; see BACKGROUND READING.

A Landscape for Humans has some unusual and interesting recommendations for road building; see LOCAL SELF-RELIANCE.

Small Scale Cement Plants: A Study in Economics and **Rural Small Scale Industry in the People's Republic of China** take a look at the relationship between transportation infrastructure and the development of small-scale industries in China; see LOCAL SELF-RELIANCE.

Bearing Design and Fitting should be a useful reference to people working on improved cart designs; see THE WORKSHOP.

Oil Soaked Wooden Bearings tells how to make durable bearings for slow-turning cart wheels and other applications; see AGRICULTURAL TOOLS.

Alcohol fuel production is covered by several items in ENERGY: GENERAL.

Small steam engines can be used on vehicles and in boats; see ENERGY: GENERAL.

The Handcart Handbook describes simple handcarts that can be used to transport small amounts of goods.

Books on bridge design and construction are in HOUSING AND CONSTRUCTION.