PART TWO

COOKING POTS, ALTERNATIVE FUELS AND COOKING METHODS

J. Cooking pots

If real fuel saving is to be achieved, it is important to pay careful attention to the design of the cooking pots that are to be used on the stove. Ideally, the pot should be lowered into the fire-box in order to present the **largest possible heating surface** and thus derive the maximum benefit from the heat generated. This was the practice in Europe and North America, where cooking pots for wood-burning stoves were usually equipped with rims which supported the pot on the heating plate and prevented air from penetrating the fire-box. Usually they were made of cast-iron which is a strong, durable material with a high thermic inertia.[11]

Cast-iron pots, however, are usually too expensive for poor rural communities and aluminium, which is now increasingly used in developed countries, is the most convenient and suitable substitute. Production presents no problems as standardised pots may be manufactured, at no additional cost, by those local firms which already supply traditional models.

The most common traditional pots in India, Pakistan and East Africa are made from aluminium. Thin sheets, about 1.0 mm or 20 gauge, are spun into the required shape, while thicker sheets are formed with presses. In both cases it is necessary first to manufacture a hard-steel mould. The pots are usually produced in sets of fourteen, starting with 33.5 cm diameter and descending to 19.5 cm. The pots fit into each other and may thus be stacked together.

Attention should also be given to the manufacturing of pot lids. These should be easy to handle and allow vapour to condense, thereby returning water to the pot and preventing leakage, as well as saving energy — see discussion on Community stoves on pages 62 to 70.

The pots described in this section are already being manufactured in Kenya and Pakistan. Wherever possible, quality should be further improved by using thicker aluminium sheets.

Dimensions of cooking pots. The openings of heating plates should be equipped with rings to take different sizes of pot. The pots should be standardised and made rather large. Indeed, the larger the pot the better the heat absorption and the greater the fuel economy of the stove. In view of this, it is suggested that no more than two sizes of pot be used. It is quite acceptable to cook small amounts of food in a large pot as this process gives rise to significant savings in fuel.

The importance of well-designed pots to better cooking and fuel economy often escapes the attention of people who do not themselves cook. It is, indeed, difficult for non-cooks to appreciate the suffering caused to women by badly designed pots which, in addition, do not recuperate the maximum of heat from scarce fuels. It should be stressed, however, that all the stoves presented in this booklet will also function well with most of the aluminium pots available on local markets in developing countries. The principal requirement is that the pots should possess (as most do) a rim.

Figure 8 shows a traditional cast-iron pot together with the aluminium pots designed specifically for the stoves presented in this

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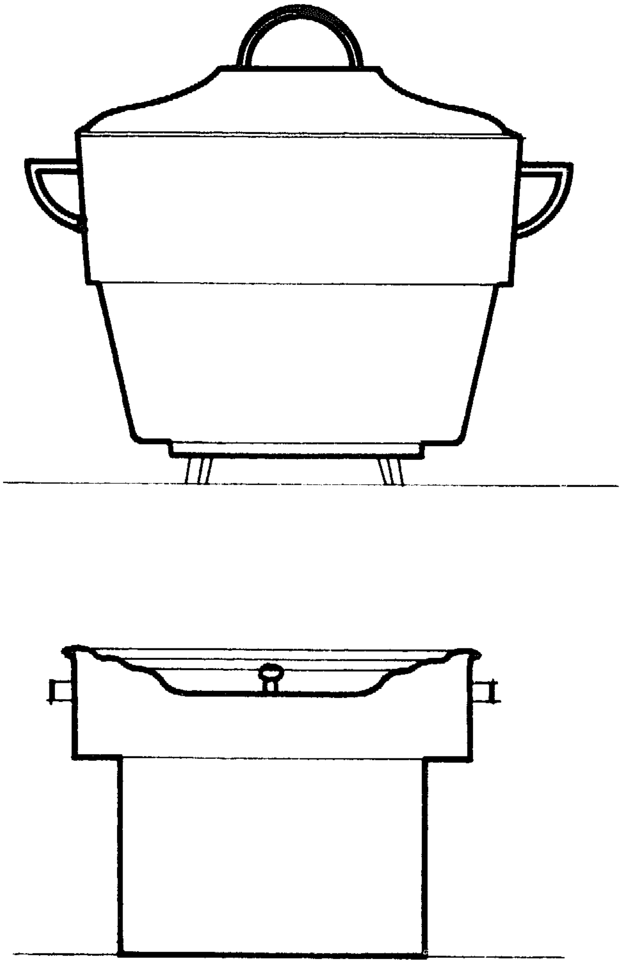
[11] The flat-bottomed cooking pots which are used in developed countries became fashionable in less energy conscious times and were primarily intended for use on **gas or electric stoves**. It is interesting to note that, with the advent of gas and electric stoves, public utility corporations in industrialised countries popularised the new cooking methods by offering attractive prices for old wood-burning stoves which they replaced with gas or electric models on advantageous terms. The following winter this rapid changeover was deeply regretted by many people who found that, in the absence of their trusty wood-burning stoves, their kitchens had become cold and damp. Encouragingly, wood-burning stoves are coming back into fashion in European regions with a plentiful supply of firewood. In conjunction with this trend, rimmed pots which can be lowered into the fire-box may gain in popularity once more.

booklet. Naturally, the shape of the pot may be modified to suit local conditions — for example, some communities may prefer to use pots with rounded rather than square bottoms.

Figure 8 *Traditional European cast-iron pot and a newly-designed aluminium pot.*



Heat absorption. That part of the pot which is in direct contact with the fire soon becomes black. This surface absorbs heat well and **does not need to be cleaned** unless, due to faulty combustion, it becomes covered with a layer of tar which will insulate the pot and reduce efficiency. This will rarely be the case if the pots are correctly used on the stove models presented in this booklet. For easy cleaning, some women smear the cold pots with a liquid mixture of clay and ashes.

The author displaying a cast-iron heating plate equipped with an efficient, properly designed cooking pot.

K. Alternative fuels

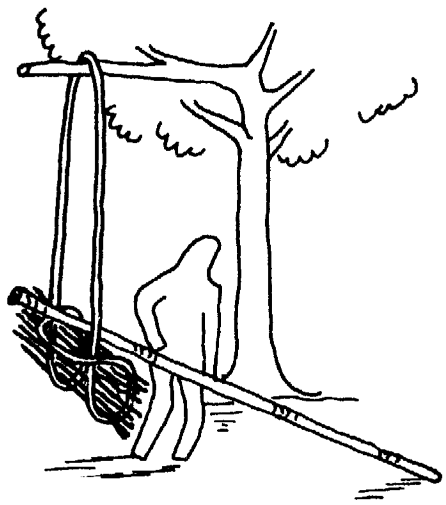
Unfortunately, many fuels such as electricity or bottled gas, which could eventually be used as alternatives to firewood in areas where wood shortage is most acute, are at present beyond the means of poor rural communities — especially when distribution expenses and cost and maintenance of equipment are taken into account. Other energy sources — such as biogas and solar energy — are only in the early stages of development, and more patient effort will be required before they may be used on a massive scale.

In the meantime, however, considerable savings in the use of firewood may be achieved by encouraging techniques which make greater use of abundant materials such as shrubs, twigs, bark, straw, hay, weeds, dry leaves, rural waste and combustible municipal garbage.

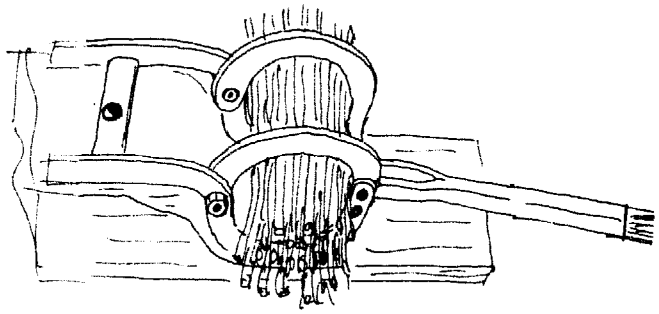
Bundles and faggots

The major drawback with the above-mentioned materials is that they all burn too quickly to be used for cooking purposes. This difficulty can, however, be overcome if they are made into bundles, or small faggots. This process diminishes the access of air and thereby slows combustion. Efficiency can be further enhanced if each

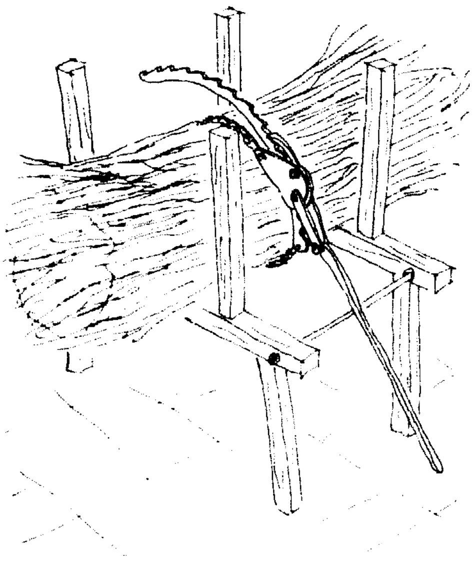
Figure 9 *Simple devices for pressing bundles and faggots.*



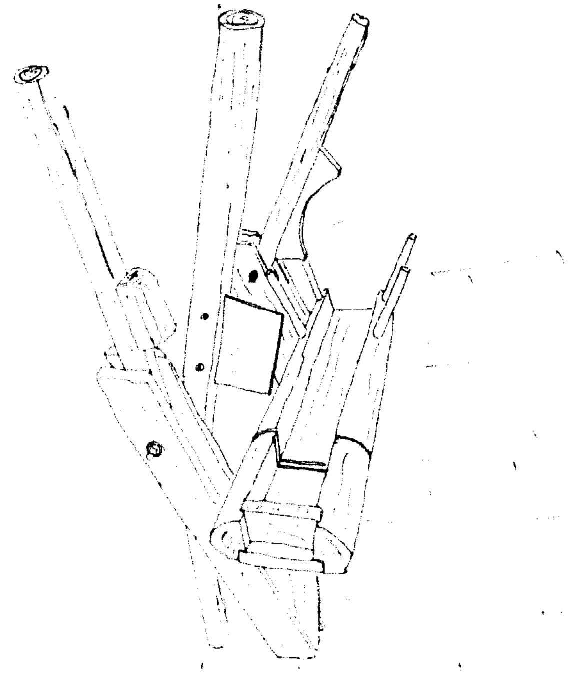
a) Pressing bundles with a rope and stick



b) A metal 'fork' press



c) A 'baker' press for larger bundles



d) A wood press with guillotine for cutting bundles

bundle or faggot contains a piece of wood at its centre. During combustion these pieces of wood will change into glowing embers on the grate, pre-heating the primary air and generally maintaining a high temperature in the fire-box.

Bundles may be fashioned very simply by hand, but their heat value increases if they are pressed using simple devices, such as those illustrated — which were among those demonstrated in 1980 at the "Wood for Survival" exhibition organised by the author, under the auspices of the Bellerive Foundation, in the grounds of the United Nations office at Geneva.

Bundles and faggots should not be looked upon merely as a poor wood substitute. Indeed, for many uses they are even **more suitable** than larger pieces of firewood. For example, bakers traditionally use faggots composed of branches of between 3 and 5 cm in diameter to heat bread ovens.

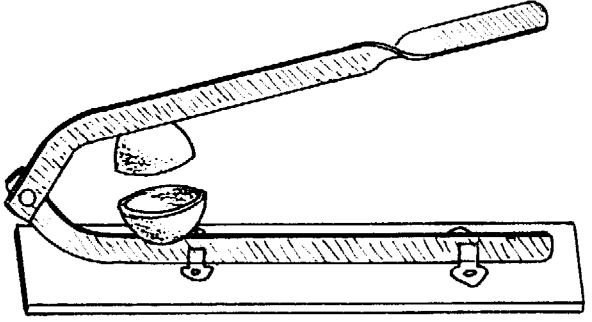
Briquettes

In towns and villages alike there is a vast quantity of waste material — including dry weeds, husks, cotton waste, coconut fibre, olive residue, fish waste, wood shavings, sawdust and municipal garbage — that may be converted into excellent fuel if shredded into small particles and pressed into briquettes with the aid of special machines capable of exerting a pressure of about 1,000 kg per cm^2. Rural and urban populations can, however, compress all available waste quite adequately with the aid of simple hand-operated presses.

Paper ball briquettes. Useful briquettes may be made by hand by pressing well soaked newspapers into the shape of tennis balls. The resulting briquette will be even harder if the newspapers are sprinkled with wood ash before being compressed. In Switzerland during the Second World War paper ball briquettes were made with the aid of a simple two-handled press similar to that shown in Figure 10.[12] As can be seen from the illustration, the lower arm of the press was fixed to a wooden board. The pressure exerted varied from 50 to 100 kg (or 5 to 10 kg/cm^2) depending on the size of the ball (the paper balls become increasingly difficult to compress as their size is increased).

Binders. A binder is a sort of glue (preferably combustible) which is compressed with the briquettes in order to prevent it from falling apart. With industrial presses exerting high pressure, binders are not necessary and may even hinder the proper functioning of the machine. This is not the case, however, with simple hand presses. Resin, tar, fish waste, certain plants,[13] sewage mud and, if necessary, cow dung[14] are all suitable binding materials.

Figure 10 *Simple paper ball press.*



When dealing with highly calorific waste, such as charcoal dust which needs a particularly strong binder, the use of **non-combustible** binders such as clay, mud or slime may be justified as a **last resort.**[15] However, it is more advisable to mix the charcoal dust with organic waste which gives a higher heat value.

Preparing the materials. The first operation is the **chopping of the chosen material** for which the most suitable tool is a machete or broad axe. For production on a somewhat larger scale, a hand-operated straw chopper (still widely used in some parts of Europe) may be employed. Materials such as charcoal may be **crushed** into small pieces or a coarse powder in a wooden mortar. Once chopped, the material may be soaked in water for about 24 hours to render it more elastic and amenable to the manufacture of briquettes.

The next step is to press water out of the mass and to blend in suitable binding materials. Adding used motor oil to the mixture increases heat value, but tends to make the briquettes crumble. It thus acts as an **anti-binder** and should be used sparingly, if at all.

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[12] Paper rollers, producing hard newspaper rolls suitable for burning in household hearths, are still found in many European countries, such as the 'Rol-Buche' produced by Godin S.A. in France.

[13] Algae were successfully used as binding material in Swiss towns during the First World War.

[14] The use of animal manure is **not** to be encouraged **and must be avoided whenever possible,** as this precious material forms part of a natural cycle which should not be disturbed. Quite apart from the ecological consquences, the burning of dung is also a major cause of eye and lung disease in developing countries.

[15] Briquettes made in this way are available in certain African towns, including Nairobi. Their heat value is relatively small (around 1,000 kcal/kg) and the ash content high. However, they do have the merit of usefully employing waste substances that would normally be discarded.

Transparent plastic bags, which burn well and give off no noxious gases, may prove a welcome addition. **However, great care should be taken not to burn plastics containing chlorine or any other substances which could be harmful to health.**

Next it is necessary to **compress** the materials from which the briquettes are to be made. Few waste materials can be moulded into satisfactory briquettes merely with the hands, and it is usually necessary to have recourse to some form of press.

Hand press. The manual press illustrated in Figures 11 and 12 is just one example of the variety of manual presses that have recently been designed and built in Switzerland. Certain of the presses have already been field-tested in developing countries.

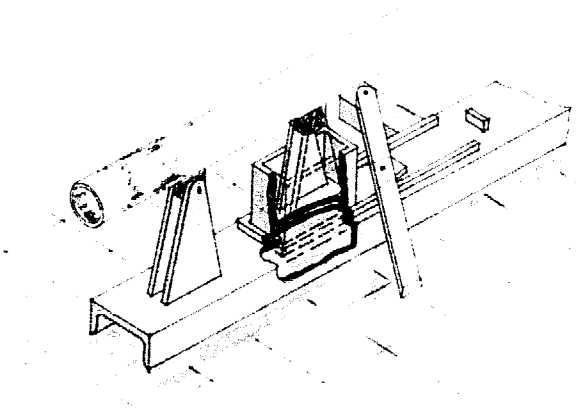

Figure 11 *Hand press.*

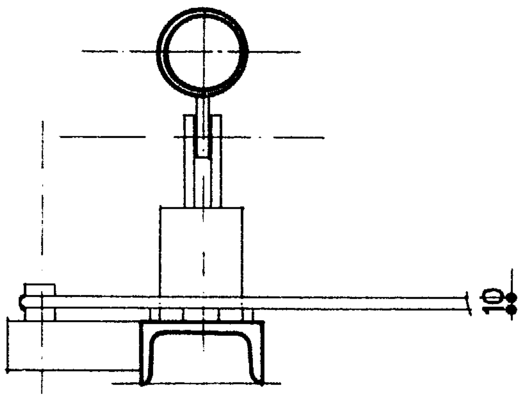

Figure 12b *Front section.*

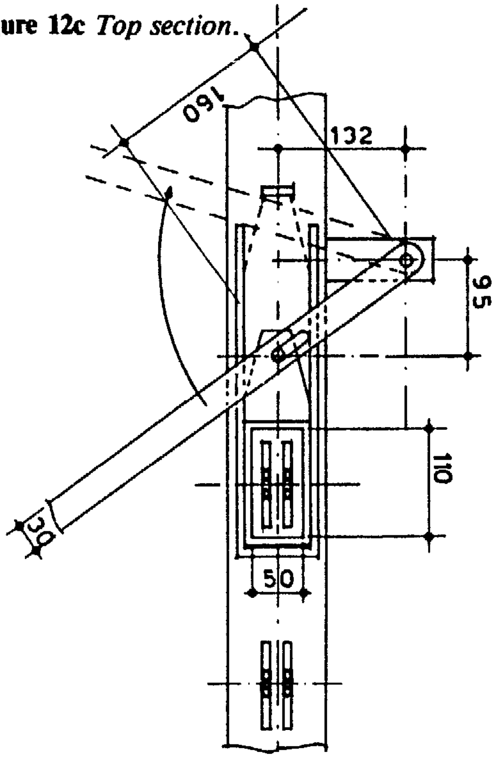

Figure 12c *Top section.*

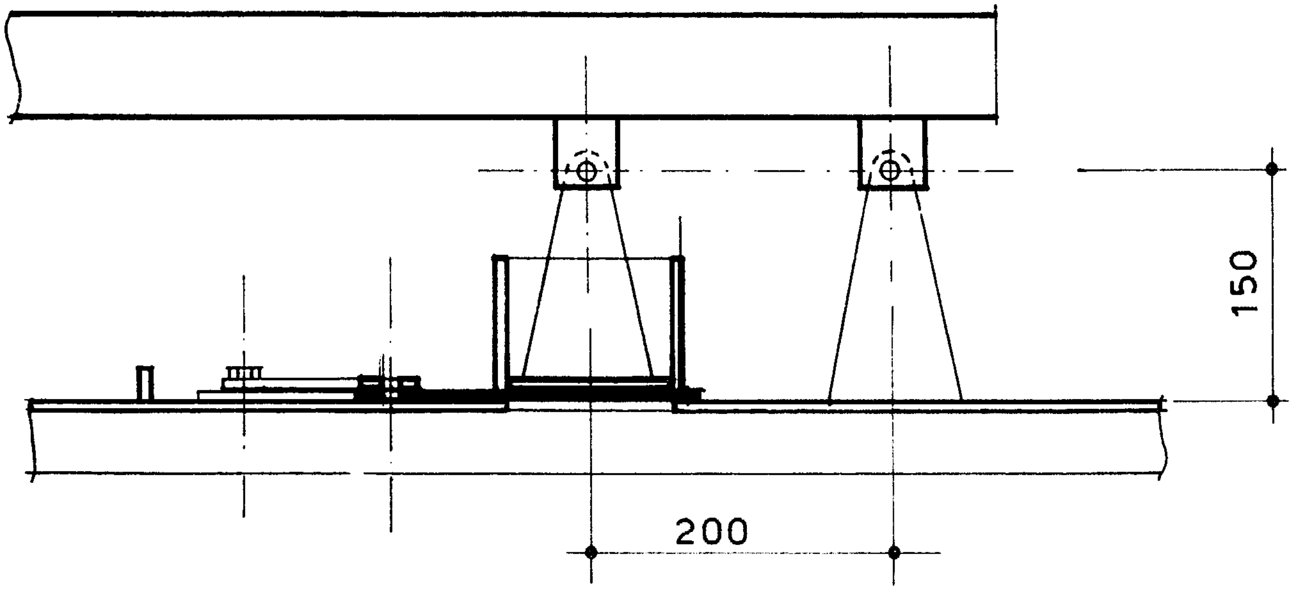

Figure 12a *Design of the hand press — side section.*

As can be seen from the illustrations, the press is made of a salvaged "u"-shaped steel bar in which there is a square **opening** covered by a **movable plate**. Built over the opening is a **square box** (11 cm long, 5.5 cm broad and 7 cm high) into which the materials to be compressed are placed. A **lever** is attached to two supports which are welded to the base bar. This lever works a **pressure plate** which enters the square box and compresses the briquette. The lever is then raised and the movable plate at the bottom of the square box is pushed aside, allowing the briquettes to be forced out of the box.

The press exerts a pressure of over 500 kg or about 10 kg/cm^2. The lever is made out of 2 inch steel pipe and can be **extended** by means of a wooden pole to further increase the pressure. Satisfactory briquettes were made with this press by the author in Nairobi in February 1981. The heat values recorded by these sample briquettes are given in Table 1.

The higher the pressure that can be exerted by the press, the higher the density and heat value of the resulting briquettes. Thus, wherever possible, it is desirable to use equipment capable of producing high pressure. It is possible, for example, considerably to increase pressure, and reduce physical effort, by resort to simple hydraulic presses. Obviously this would involve more cost, but the quality of the briquettes would be significantly improved.

Earth block press. Such a machine is a manually operated piston press which was initially developed[16] for making earth

Table 1. Technical characteristics of briquettes

Type	Composition	Humidity	Ash %	Net heat value in kcal/kg	Remarks
Waste paper balls pressed by hand	Paper soaked in water and powdered with wood ash	6.9	2.9	3,825	—
Straw and cow dung pressed by hand	50% manure 50% straw	5.4	9.5	3,599	—
Charcoal dust and clay pressed by hand	—	—	73	975	Briquette found in Nairobi market
Rural waste pressed by hand	Hay, dry leaves, wood shavings, charcoal dust, 10% cow manure	8.0	19.0	3,502	Briquette made in Nairobi
Rural waste pressed on Terstaram press	40% straw 40% sawdust 20% manure	9.2	14.0	3,266	—
Rural waste pressed on Terstaram press	30-45% chopped twigs, 30-45% charcoal dust & 15-20% cow manure	2.4	32.2	4,408	High content of ash is probably due to sand present in charcoal

Source: Laboratory tests carried out by the Research and Development Centre for Energy Economy in Warsaw.

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[16] By the Inter-American Housing and Planning Centre (CINVA) in Colombia.

building blocks out of a mixture of soil and cement. This press, which is known as the Cinva Ram, can be readily converted to produce excellent briquettes from agricultural waste simply by **reducing the dimensions of the compression box** with the aid of wooden boards. The press is then capable of producing briquettes of about 5 cm in height. The length and width of the briquettes will remain the same as for building blocks but, once thoroughly dry,[17] they can easily be broken into smaller pieces as required.

The author and Mr Haas demonstrating the use of a hand press for making briquettes.

Industrial presses. The industrial presses currently available are capable of exerting a pressure of about 1,000 kg/cm^2. The combination of high pressure and the heat generated during the compression process breaks down the elasticity of the materials used and enables hard, solid briquettes to be produced **without the need for a binder** which would only hinder the functioning of the machine.

The capacity of industrial presses ranges from about 100 to 3,000 kg/h. The press itself is only one element in a complete **production chain** which will usually include a grinder, a drier and a packing machine.

L. Other fuels

Kerosene

There are regions in the world where firewood shortage is so pronounced that consumption must be stopped altogether, pending the successful completion of programmes to replenish fuel stocks with new trees and fast-growing shrubs.

For such regions one must consider fuels other than wood, or even wood waste, to cook and to heat premises. One such fuel is kerosene, known in some countries as paraffin.

Research on the optimal use of kerosene was commenced during the last century by the Polish engineer, Ignacy Lukasiewicz, who in 1853 introduced the distillation of crude oil and invented the first kerosene lamp. The lamp worked with a wick which was partly immersed in kerosene. The fuel gradually soaked through to the top of the wick where the flame could be applied and receive the requisite input of oxygen.

This principle was also applied to cooking stoves and heating appliances. Kerosene lamps are still used today and render appreciable service in many parts of the world. Also, kerosene appliances working on the basis of wicks immersed in kerosene are still in use both in developing and developed countries. However, wick-type cooking stoves are now rare, as fuel efficiency is not very good and the stoves tend to give off smoke and unpleasant smelling fumes.

The best means of cooking on kerosene is to introduce air into the fuel and vaporise it before combustion. The first stove using this principle was designed by F.W. Lindquist in Sweden in 1880. The manufacture of his stoves was commenced

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[17] Drying increases the heat value of the briquettes and thus economises fuel. Ideally, briquettes should be produced well in advance of use so as to allow for thorough drying.

on an industrial scale in Stockholm in 1892 under the brand name "Primus". Ever since these stoves have given good service all over the world, and there are no reasons why they should not continue to give the same good service in regions deprived of wood or other fuels.

Basically, the stove consists of a pressure-proofed tank equipped with a hand-driven pump which serves to introduce air. Kerosene mixed with air enters a pre-heated pipe, attains its boiling point (150 to 230°C, depending on the quality) and changes into vapour. The vapour leaves the pipe via a calibrated jet and, when lit, produces a strong flame which receives additional oxygen from the ambient air.

Primus-type stoves (as is the case with all implements operating with a flame) are not devoid of danger. This, however, arises principally out of faulty operation rather than inherent design faults (which can easily be remedied). In particular, the primus-type stove will only function correctly with **clean** kerosene, a commodity which is often rare in poor households. If the kerosene contains impurities the jet will become blocked. Indeed, even when pure kerosene is being used it is necessary to clean the jet daily with the special needles supplied with each stove. In addition it is essential to pre-heat the burners properly before lighting the stove. If this is not done the primus may become flooded with kerosene — thereby augmenting the risk of fire.

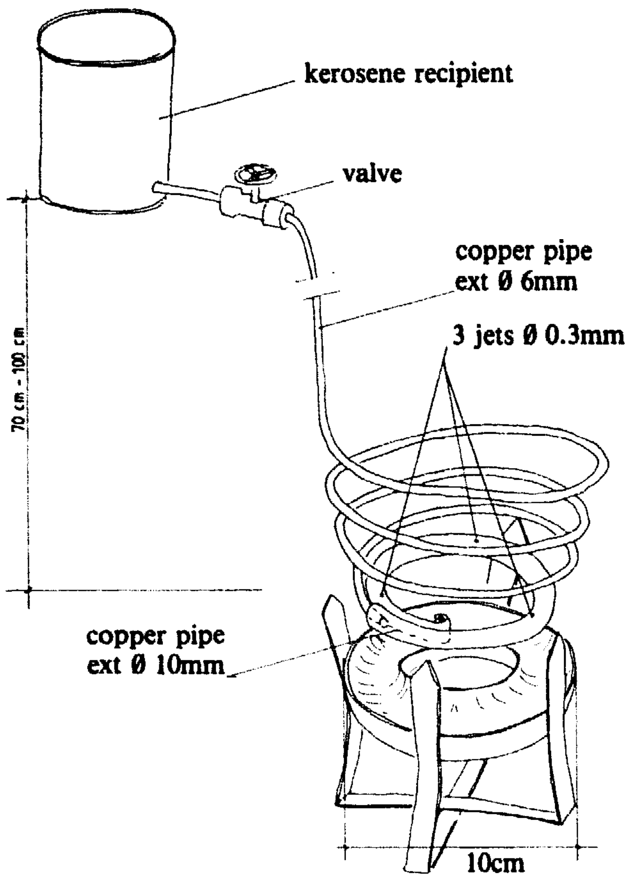
Such problems are not, however, insuperable and should not preclude increased resort to primus-type stoves in regions where there is no wood. However, there is one serious obstacle to the promotion of primus-type stoves, namely their price. Pressure-proved tanks must be properly manufactured, the hand-driven pump calls for precision working, and the burner must be produced in a well-equipped workshop. All this is reflected in the price which is normally too high for the poor people who are the first victims of firewood shortage. Also, the price of kerosene may constitute an obstacle.

In co-operation with the author, Mr Emil Haas, a retired Swiss stove expert, carried out research to reduce the price of kerosene burners. This resulted in a new model, presented in Figure 13, which represents a departure from the "wick" and "primus" principles. The new equipment consists of a container (which could, for example, be an old food can) filled with clean kerosene and placed about 70 to 100 cm above the burner. The kerosene flows from the container through a copper pipe with an inner diameter of 4 mm. The flow is regulated by a valve situated just below the container. At its lower end the pipe is twisted into a coil shape and welded to a second copper pipe, with an inner diameter of 8 mm. This pipe is twisted through one and one half turns and closed at the other end. Three holes for jets are then pierced in the lower pipe. The upper coiled pipe, or 'basket', is supported on a tripod over a circular metal plate in which alcohol or kerosene may be lit to pre-heat the basket.

As soon as the basket has been pre-heated to the boiling point of kerosene, the valve may be opened to allow the kerosene to descend from the container by gravity. It flows round the coils of the basket where it is transformed into vapour under pressure. This vapour then enters the thicker pipe, where the pressure is somewhat diminished, and is forced out through the jets. When lit the vapour produces flames which attain 700 to 800°C. Combustion of the kerosene is better than on the wick stoves but less satisfactory than on a primus-type. When the burner is hot, no noticeable amount of smoke escapes from the chimney of the stove in which it is being used. This indicates that most of the combustible volatiles have been properly burned.

The principal merits of the new burner are its simplicity for production purposes and its relatively low price. An additional advantage is that, in one simple movement, the burner may be placed in any of the

Figure 13 *Kerosene burner*



stoves presented in this publication, thus substituting kerosene for firewood. The burner may also be used to fire the hot air generator described below.

However, while the burner functions well in experienced hands it is subject, at its present stage of development, to many of the reservations that apply to primus-type stoves. In particular, the kerosene must be clean and the container free from dust and dirt. Users must also be thoroughly trained in the correct use of the system. This will involve instruction in the pre-heating of the burners, the daily cleaning of the jets and the proper use of the valve which regulates the flow of kerosene into the burner. All these drawbacks may be overcome with time, but they require further efforts and investigations which are currently being undertaken by Mr Haas and the author.*

Diesel oil

The technology needed for the efficient use of this fuel is well established and in daily use in all developed as well as in many developing countries. The fuel itself is, of course, available wherever there are routes used by trucks. A source of electric power is needed to ensure the proper combustion of diesel oil. This may be obtained either from the mains grid or from a generator. Electric power is needed to mix the oil with air and eject it under the required pressure. When lit, the oil/air mixture gives a good flame which may be used for baking as well as for community cooking.

Bottled gas

Some developing countries suffering from a pronounced shortage of firewood do possess deposits of natural gas. Others hope to discover such deposits. Natural gas is an excellent fuel both for cooking and baking. Larger towns may be supplied through municipal mains. Natural gas can also be liquefied and sold in bottles. The exploitation of natural gas and its distribution calls for considerable funds and organisational effort. However, the price of gas, in terms of calorific value, is already lower than the price of firewood in some developing countries. Elsewhere it may be a sound policy to supply bottled gas on a large scale and to plant forests intensively in order eventually to achieve a better ecological equilibrium.

Biogas

The large-scale distribution of bottled gas among poor communities may still be a remote and somewhat ambitious proposal. The local production of biogas from available organic waste, however, is of much more immediate relevance. Production of biogas in warm climates calls for a relatively small investment as the temperature of the fermenting mass can be maintained at about 30°C without insulation and without the use of external energy sources.

There is no shortage of biogas installations

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*At the time of printing, new models have been developed and tested with good results. They will be presented in the specialized press and in future editions of this book.

which have been thoroughly tested and which give satisfactory performance. The problem is that they cost more than poor communities can afford, and that they are usually difficult to operate and maintain. The best known models work on manure diluted in water, and are common in China and India. This calls for a supply of water and some hydraulic arrangements, which increase the cost of the units. Storage of the digested liquid presents additional problems. Nevertheless such installations have a proven track record and should be installed wherever the necessary conditions are found.

However, countries where the shortage of firewood is particularly acute are often located in dry regions where there is little water and rarely enough cattle manure. Often the only organic material available in sufficient quantities is dry cellulose in the form of hay, straw or dry leaves.

Thus, the author has developed a biogas installation which is particularly suited to warm, dry countries. Basically it consists of two plastic sheets. The first sheet is spread on the ground and kept within a square frame about 30 cm high. A heap of manure is built up on the sheet in the middle of the frame. The heap is moistened with several buckets of water so that the base stays in the slurry. The sheet-lined frame serves as a basin. Another sheet covers the heap of manure and is fixed to the bottom of the frame. The slurry forms a hydraulic seal and the gas is collected by a pipe fixed in the middle of the upper sheet.

A detailed description of this installation is to be published shortly in a separate booklet.

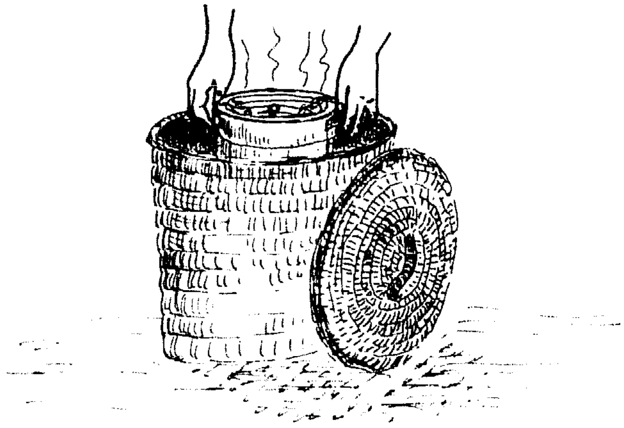
If the necessary materials are prepared in advance the installation may be erected within a day. The first family-size model was erected in Kenya in August 1981. Another larger model was built in January 1983, also in Kenya. Both models have withstood the climatic conditions quite well. The heap of manure gives methane gas for over a year.

The model described above, together with many others, enables biogas to be one of the important alternatives to firewood in many developing countries.

M. Hay boxes

Hay boxes are useful fuel saving devices which are an important part of an efficient cooking system. They are very simple to arrange and can be made in no time out of, for example, an old box (see Figure 14).

Figure 14 *Hay box.*

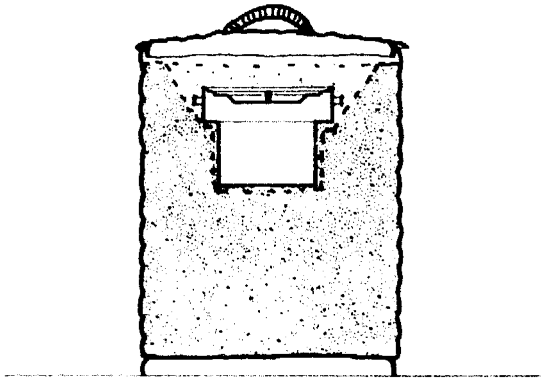


A good idea is to use a straw basket equipped with a lid and filled with insulating material such as dry hay, straw, dry leaves, wood shavings or crumpled newspaper. A nest is formed in this material to accommodate the pot. To avoid pieces of insulating material falling into the food, the nest may be lined with a piece of rag or cloth tucked in at the sides of the box.

For cooking it is not necessary to heat many foods to boiling point. A temperature of 85°C is usually quite sufficient. Thus, as soon as the food **starts** to boil the cooking pot should be transferred, in one quick movement, to the hay box nest and covered with an old pillow filled with insulating material.

Once inside the hay box, food will cook thoroughly and remain hot for several hours. Certainly, there will be no need to re-heat the evening meal for the benefit of those returning home late.

Figure 15 *Cross-section of hay box.*



Testing efficiency. The simplest means of testing the efficiency, and proper functioning, of a hay box is to touch the outside walls about half an hour after a hot cooking pot has been placed in the nest. If the box is warm, it means that the insulating material is inadequate and should be increased or replaced.

Improving efficiency. To further improve the efficiency of the hay box, a hot, flat stone or brick may be placed at the bottom of the nest. This will serve as an improvised hotplate and will keep the food warm within the hay box for an even longer period.

Care must be taken not to spill food when the pot is placed in the box as hay and straw cease to be good insulating materials when wet.

Some experimentation is advisable in order to obtain the best results from hay boxes. For instance, at higher altitudes, where water boils at temperatures lower than 100°C, it will be more difficult to maintain the temperature in the box above 85°C.

N. Cooking methods

Short-term versus long-term cooking

The theory has been advanced that even if some stoves are less efficient than a well-managed open fire for the purposes of **short-term** cooking, they present advantages in **long-term** cooking. This is not, however, a valid argument. In countries and regions where there is a shortage of firewood there can be no justification for long-term cooking. With improved cooking methods, such as the pre-soaking of dry foodstuffs (e.g. peas, beans, or cereals), cutting food into small pieces and the correct use of hay boxes, all meals may be prepared in a relatively short time. Certainly, for most foods there is no need for cooking periods which exceed one hour.

This reasoning aside, there is no logical reason to suppose that stoves that are efficient for short-term cooking should be any less so for long-term cooking. If such should prove to be the case, the stove in question should be redesigned or discarded.

The cooking system

The above remarks illustrate the importance of promoting a **complete cooking system** to complement the deployment of fuel-efficient stoves. Equal attention must be given to all the component parts of the system which include the promotion of alternative fuels, well designed cooking pots, more rational cooking methods, simple fuel saving devices such as hay boxes, the use of dry wood cut into small pieces and the proper management of the fire. If introduced simultaneously and used in conjunction with modern stoves, the above measures form a **comprehensive package deal.** Through this it is possible to achieve truly spectacular economies in fuel wood, reducing consumption to as little as one tenth of existing levels. Another integral part of the package deal must be the planting of fast-growing trees and shrubs to replenish forest reserves, thereby reversing the ecological catastrophe that threatens many regions of the world which depend upon wood for survival. We have the means; what is needed now is the will.