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Simple Methods of Candle Manufacture

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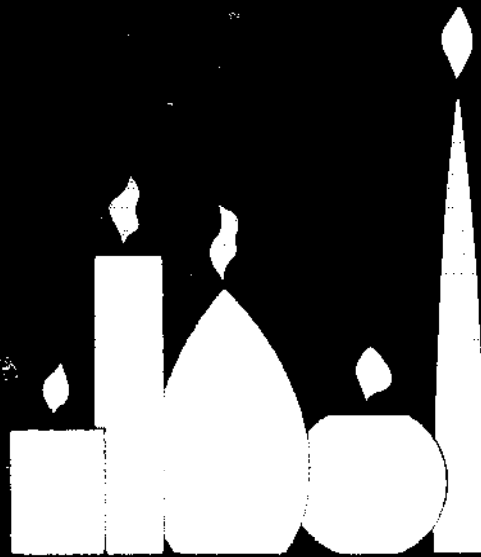
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Simple Methods of Candle Manufacture



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SIMPLE METHODS OF CANDLE MANUFACTURE

**COMPILED BY
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CONTENTS

Introduction	1
Materials	2
Candle making techniques	4
Detailed description	5
Heating equipment	11
Illustrations of equipment	13

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SIMPLE METHODS OF CANDLE MANUFACTURE

INTRODUCTION

The technology of candle making is very old and despite the introduction of mass production methods, candles can still be made by well-established methods which require only simple equipment. Much of this equipment can be made by rural craftsmen.

A candle is simply a solid cylinder of tallow, wax, or other solid fat, containing a wick to give off light when burning. When the wick is lit, the flame radiates sufficient heat to melt a small pool of wax at the top of the candle. The liquid wax is then drawn up the wick by capillary action into the flame where it is vapourised and burnt. The size of the flame is important and should be related to the diameter of the candle.

If the wick used is too thick, it will cause a large flame which generates so much heat that it prevents the formation of the bowl of molten fuel by melting the outer edge. On the other hand, if a wick which is too small is used, the small flame cannot generate enough heat to form a proper reservoir of molten fuel, as the heat radiated will not reach the edge of the candle. This results in the flame burning a hole down the centre of the candle until it is so far down that it will go out through lack of oxygen. The wick size, therefore, must be related to the diameter of the candle (as well as to the type of fuel). Although a rough guide to wick size is given later on in this profile, the only way to produce a good candle is by trial and error.

The main purpose of the wax is to provide the fuel for the flame so the burning characteristics of the wax are extremely important. A good candle wax should produce a candle which burns steadily, lasts for a long time, produces very little smoke and gives a good quality light.

In addition, candle wax has other functions. It must be rigid enough to support the wick in a vertical position; it must be suitable for processing by one of the various candle making techniques; and it must look attractive.

MATERIALS

a) The Fuel

Most modern candles are made from a mixture of several ingredients. They are paraffin wax, stearic acid (stearine), small quantities of other waxes being added usually for the sake of appearance. Probably this mixture, which can be used in all methods of making candles, will prove most suitable for nearly all projects. However, details of other materials which can be used are also given below.

Paraffin wax Paraffin wax is distilled from coal and oil shales and semi-refined grades are used by most candle makers. It is usually supplied in the form of large blocks by petrol refining companies. For the several grades available, the melting point is between 50° and 70°C. For temperate climates 58°C melting point is considered to be suitable, but in a tropical climate a higher melting point would be necessary.

Stearine Stearine is a component of many animal and vegetable fats and is supplied in flakes by oil and chemical companies. It is added to the wax to improve burning qualities and to help in easier removal of the finished candle from the mould. It also reduces the amount of smoke produced by the candle flame. Between 5 per cent and 50 per cent of stearine can be used depending on the quality of the candle required. Ten per cent is the average. Two factors should be considered: the more used the better quality the candle, but stearine is an expensive material.

Micro-crystalline wax Micro-crystalline wax is a highly refined by-product of the coal and petroleum industries. It deposits a hard skin on the surface of the candle, which improves the appearance by giving it a shiny surface and is hard enough to be resistant to minor damage. Because it is very expensive, this wax should be used sparingly. No more than 2 per cent is required to produce a good quality candle. In very simple methods of candle making it is not usually required.

Tallow Tallow, made from melted down animal fat, is rarely used in the present day manufacture of candles, because it has a greasy touch, creates an unpleasant odour when burning and does not give as good a light

as wax-based candles.

Beeswax Beeswax is obtained by melting the honeycomb of the bee in hot water, straining it and allowing it to cool. At this stage it has a brownish-yellow colour, and it is bleached before being used for candles. While it is an excellent material for candle making, it would be uneconomical to use it for making the common candle, because of its cost. It is available commercially in the form of flakes.

Vegetable waxes Many waxes occur in or on the leaves of various plants and trees and can be extracted by melting off in hot water. Only a few can be mentioned here, though many others would be suitable for candles. They are bayberry (USA), candelilla (USA) and pisang (Far East).

b) The Wick

The wick originally used in candles was of bleached twisted cotton yarn. Modern wick is woven into a flat braid. This has the advantage that it is uniform and that it curls as it burns. The curling brings the end of the wick into the hottest part of the candle flame where it burns away and the candle is consumed. In this way the exposed length of wick, and therefore the flame height, is kept constant.

Braided wick requires special machinery for its production and would normally be obtained from suppliers in those countries which already have substantial candle making industries. It is normally specified by the number of plies.

After braiding, the wick is treated chemically: it is first bleached, then mordanted in a solution of ammonium phosphate, ammonium sulphate, ammonium chloride, borax and potassium nitrate.

Because wick size is always a matter for experiment, the following is only a rough guide to the selection of wick size.

<u>Candle diameter</u>	<u>Size of wick</u>
2.5 to 5 cm	15 ply
5 to 7 cm	24 ply
over 7 cm	30 ply
Tapers	24 to 30 ply

CANDLE MAKING TECHNIQUES

There are 4 methods of producing candles on a small scale of production. These are outlined briefly, then described at greater length.

The Dipping Process This technique consists of immersing the candle wick in molten wax then withdrawing it, so that it picks up wax as it emerges. The wax is allowed to cool and the process is repeated until the required thickness has been built up. The equipment is very simple in principle and can also be simply made.

The Pouring Process This technique consists of suspending a wick over a container of melted wax and pouring hot wax from a small ladle so that it runs down the wick, cooling as it goes. Any surplus wax drips back into the main container, and can be used again. In terms of equipment this is the simplest method. To produce good candles in this way a fair degree of skill must be acquired.

The Moulding or Casting Process The moulding technique consists of filling a mould, in which a wick has been positioned with melted wax, allowing the wax to cool and then removing the completed candle from the mould. Except for very small outputs per day, a certain degree of sophistication in mould design and fairly large numbers of moulds are needed. Machines for casting candles in large numbers are available, and as they do not require power for operation, a description of them is included.

The Drawing Process

A long length of wick is passed back and forth horizontally through a bath of wax, forming a candle 'rope', which is accommodated on large drums which are manually operated. The 'rope' is then cut into candle lengths. A mechanised version of this machine does give much higher output, but at greatly increased capital cost.

Equipment The equipment for each of these four techniques and the methods used are described in the following sections. Production rate is not affected by detail of equipment design - it is largely a matter of factors such as number of moulds or dipping points etc. This is because the main factor is the cooling rate of the candle, and except in elaborate water-cooled machines, this is fixed for particular conditions.

DETAILED DESCRIPTION

The Dipping Process Candle dipping offers a method of producing several hundred candles a day with relatively simple equipment. The candles may be 30 cm long or considerably more, in which case they can be cut as described in the section on the drawing process. Diameter can be up to 10 cm or even more.

A number of wicks are suspended and repeatedly dipped into wax to build up candles in successive layers round the wicks. Excess wax drains off, but some remains at the lower end, which is therefore thicker. For this reason candles made in this way are often called tapers. However, with correct dipping technique and by discarding the lower 10 cm or so, uniform diameter candles can be produced.

The equipment for dipping can range from a stick from which the candles are suspended to an elaborate commercially-made machine (by Arthur Weissbach, Fulda, W. Germany).

To obtain a well formed candle, the candle wick should be submerged in the melted wax and withdrawn as smoothly as possible, so that the wax deposits are even layers with no drips or surface imperfections.

Using this technique a semi-refined paraffin wax with a melting point of 54°C (130°F) is required. To this 20 per cent of stearic acid should be added. The addition of about 5 per cent beeswax will improve the qualities of adhesion of the wax. Do not use micro-crystalline wax, as this tends to deposit at a faster rate than other waxes and may prevent adhesion from occurring naturally.

The paraffin wax should be broken into pieces of a convenient size, weighed to the required quantity and placed in the vat (container). Add to it the right quantity of stearic acid or stearine, and the beeswax if required. Heat gently until all the contents have melted and blended together. When this occurs, allow the blend to cool to about 49°C (120°F) before attempting to dip. It is advisable to experiment with various temperatures to find the one which suits the blend best. It is important that a sufficient quantity and depth of melted wax is maintained in the container at all times. Figure 1 illustrates a single dipping jig for dipping about 12 wicks at a time. Figure 2 illustrates a continuous dipping process for 4 or more wick holders. The production rate from this machine will obviously be much greater.

A can or wax-pot deeper than the length of the longest candles to be made is required, with sufficient height above the wax level to allow for displacement of the wax. It can be heated by any one of several methods described later, but as the wax is to be kept at a constant temperature for a considerable time and is cooled by immersion of the candles, continuous heating, insulation and, ideally, thermostatic controls are advantageous.

The wax used is 90 per cent paraffin of melting point 58°C, and 10 per cent stearine. Wicks for candles up to 3 cm are 15 ply braided.

The wicks are tied to the dipping frames and weighted at their lower ends. The wax is heated to 75°C and the first group of wicks lowered into it. They should be left to soak for 3 minutes to allow air and moisture to escape; this should be done with each new group of wicks. The pre-waxed wicks should be drawn through the fingers as they cool, to smooth off any lumps. This will ensure that the final candles are smooth and uniform.

When all the wicks have been pre-waxed, the dipping proper begins. Each dip should be carried out slowly and smoothly, leaving the candle immersed for 5 to 10 seconds. The groups of candles are worked round in turn, and the time between dips for each group should be between 2 and 5 minutes.

For practical production, conditions should be such as to give best appearance of the candles with the least number of dips. Various factors change performance:

Increasing time between dips reduces the number of dips needed.

Increasing wax temperature increases the number of dips needed.

Higher air temperature increases the time needed between dips - to compensate, reduce air temperature.

Finally, the candles are removed, trimmed at their lower ends and allowed to cool. They may be rolled in the same way as poured candles. An alternative and convenient method of removing the weights is to dip the ends in hot wax, then cut the wicks.

Equipment required

Scales	for weighing materials
Thermometer	for checking temperature of wax
Sharp knife	for trimming ends of finished candles
Scissors	for cutting wicks

Small weights	for keeping wicks vertical and taut (lead preferred)
Boiler or vat	for melting wax - must be of seamless construction
Storage rack	for storing candles between dipping operations
Wick holders (jigs) or candle hangers	required for dipping operations and drying periods
Wood boards	for shelves and working surfaces
Wheel	for use in last-mentioned intermediate equipment
Smooth slab	for rolling ends of candles. Preferably of marble, but glass or metal are adequate

The Pouring Process The wax is heated to a temperature of 75°C and using the ladle, wax is poured down each wick in turn, the wax falling off the wicks going back into the melter. It is also possible to have the excess wax fall into a separate can. As each pouring is made, the wheel is turned. During pouring the wick should be twisted slowly, which helps to form an even coating. The process is continued until the desired thickness of wax is built up.

Only a certain amount of wax can be added at each time of pouring; the wax is therefore built up in layers and extremes must be avoided. If the candles are too warm and the wax is also hot, one pouring will tend to melt the previous one off. So, the temperature of the wax may have to be adjusted according to the speed of working round the wheel, the workshop temperature and also for the exact composition of the wax.

During pouring candles may sway a bit and stick together. If this happens they can be gently separated with a knife or by tapping.

When sufficient thickness has been built up, the candles are removed from the wheel and the bottom ends with the weights cut off. They can then be rolled smooth on a warm glass, metal or stone slab, after which they should be hung by their wicks for 24 hours to cool.

The blend of wax required for this technique is the same as that used for the dipping method, i.e. a mixture of 90 per cent paraffin wax (of 58°C melting point) and 10 per cent stearine is used. For church use a proportion of beeswax might be required, although this adds considerably to the cost.

The Moulding or Casting Process Casting (or moulding) is most suitable for the following conditions:

- For a household making candles only for its own use, so that the number required is very small.
- For candles which are decorative rather than strictly utilitarian, in which many techniques of colouring, texturing and the production of special shapes are used, and for candles over 4 cm in diameter.
- In mass production of plain candles, in which case special machines are used.

Thus casting is not really suitable for use on a small industry basis if plain candles are to be produced. The technical reasons are that moulds must be really well-designed and accurately made if they are to be reliable, that continual attention during cooling is needed for topping up as the wax contracts, and that for a comparable output to, say, candle-drawing, a large number of moulds is needed. However, the method can produce highly finished and decorative candles.

The technique is again very simple. It consists of suspending a wick in a mould (tied to a rod at the top), and then filling the cavity of the mould with molten wax. When the wax has cooled and set, the finished candle can be removed from the mould and will be an exact replica of the inside shape of the mould. One advantage of using this method is that it requires very little work to be done, once the candle is removed from the mould. The wax in the mould must be allowed to cool slowly. As the wax cools it shrinks, so add a little more wax every so often, just to keep the top more or less level. When the candle has completely set, it should be possible to lift it out of the mould without any trouble. If the candle does tend to bind in the mould it is likely that the wax and temperature used were not correct for this method.

A hard wax is required for casting, as it is less likely to adhere to the mould. As hardness can be gauged by a high melting point wax which melts in the region of 60°C to 68°C (140°F - 155°F) is required. The temperature for filling a mould should not be lower than 80°C (175°F) and not higher than 88°C (190°F).

A good basic paraffin wax should be selected for moulding. It should be hard, and requires a high melting point, to the temperatures previously mentioned. A relatively high percentage of stearic acid, between 10 and 30 per cent, should be added, and to obtain a good surface finish

resistant to abrasion and dust penetration, 3 per cent of micro-crystalline wax is necessary. This will also ensure a good clean release from the mould, as it is too hard to adhere. This blend will produce a high quality, long-burning candle.

A perfectly adequate simple candle can be made using nothing other than paraffin wax, which could be sufficient, depending on the market demand. As the wax in the mould cools, after a while, each candle should be probed with a long thin rod and 'opened'. If a hole is seen, this should be filled with fresh wax. The process may have to be repeated until all the wax has solidified. During solidification, wax contracts by 20 per cent so that if this procedure is not followed there are likely to be holes in the candles, particularly in the region of the wick.

Once the wax is solid, but not yet cool, the mould can be immersed in water - if in running water, cooling is much quicker. When the wax is cool the wicks can be taken off the top metal bar(s) and the candles can be pushed out of the moulds by pressing the bottom plugs or bungs through.

If there are persistent problems of release, the following can be tried:

Increase the proportion of stearine

Tin-plate the inside of the mould tubes

Spray the inside of the moulds with silicone (expensive).

Equipment required

Scales

Thermometer

Scissors

Small weights (lead is best)

Boiler or vat

Small ladle

Bench

Candle moulds

The Candle Drawing Method A large number of candles can be produced by this method. It requires a simple machine which can be made by craftsmen, but is also available commercially (from Arthur Weissbach, Fulda, W. Germany). However the Weissbach machine (and presumably those from other firms) is arranged for steam heating, so would have to be adapted

if steam is not available. Candles up to 6 cm diameter can be made, but 3 cm is a more practical limit.

The technique requires three people to operate it, and some skill has to be acquired. This should not present a serious problem.

Wax at a temperature of 75°C is used, with a ten per cent stearine content. Wicks for candles up to 3 cm are 15 ply braided.

A 'rope' of candle is produced by drawing the wick through the trough of wax. The first pass should be rather slow to ensure that all air escapes from the wick. As the wick emerges from the trough, it should be smoothed with the fingers, or, if this is found to be uncomfortable, a piece of thick felt or any other convenient device can be used.

After the first pass through the trough the direction of winding the drums is reversed, so that the wick picks up another layer of wax and so on until the rope exactly fits the sizing ring.

Success with this machine depends on keeping the rope warm enough to remain flexible, so that the workshop must be at a temperature of at least 25°C. This makes the technique particularly suitable for tropical climates. In cooler areas the workshop must be heated.

When the rope is complete it must be cut into candle lengths. Machines are available for this; however the job can be done by hand. The rope is led on to a cutting table of any smooth and hard material, and cut into lengths with a sharp knife. This is not difficult while the wax is still fairly soft. Then about 1 cm of wick must be exposed at one end of each candle. Using a knife with a rolling rather than a downward cutting action, the wax can be cut, without at the same time cutting the wick, and the butt of the wax removed. The knack is soon picked up. In practice, cutting to length and exposing the wick are done at the same time.

If desired, the wick ends of the candles can then be tapered. To do this by hand, the end is rolled at an angle on a hard surface. However, this is not strictly necessary for utilitarian candles, though it does improve the appearance of the candle.

METHODS OF MELTING THE WAX

All methods of making candles naturally start with melting the wax. The equipment for melting depends, of course, on what source of heat is available. The safety aspect must be considered before everything else.

Wax must not be overheated, but the safety margin as far as fire risk is concerned is wide, since molten wax has a reasonably high flash point. However, wax should not be heated above 150°C as at high temperatures unpleasant and *dangerous* fumes are given off. This temperature is well above any needed in candle making but the workshop should always be well-ventilated.

Naturally, any wax spilt onto a naked flame or a red-hot electric heater will catch fire immediately, and a large-scale fire is then very likely. So, although these heaters can be used, precautions must be taken against this kind of accident.

Heating Equipment

Electricity Ideal for small and medium size workshops, if available. Tanks or melting pots can be placed on 'Black heat' type heaters, or heating elements can be bolted to the bottom of a tank. Immersion heaters are *not* suitable.

Gas Tanks or pots placed on gas heaters can be used providing the bottom is thick enough to prevent burning of the wax. Asbestos mats can be used under the pot, but they need looking at regularly, as their life-span is not great. The warning about naked flames, of course, of applies here.

Small quantities of wax - as used, for example, in the pouring technique - can be melted in a gas-heated water jacket. Melting is rather slow, but the wax will be held at the right temperature for some time. However, care must be taken not to let the water boil away, and as this is very liable to happen, water jackets are not always considered ideal.

Solid fuel Where no other fuel is available, melting pots can be placed on a specially constructed or possibly a standard type oven. A simple oven can be built from fireproof bricks.

Steam In large installations steam heating is used, the steam being led into double-walled heating pots. No attempt should be made to construct steam heating plant unless proper engineering facilities are available.

For all four methods, wax pots and tanks must be leak proof (not soldered) and should be of steel, iron or aluminium. *Copper and brass should be avoided, as they cause oxidation of the wax.*

THERMOMETERS

It is possible to make candles without a thermometer, but the operation tends to be 'hit or miss'. Fortunately, thermometers are not very expensive and several types can be used. In all cases a range of up to 100°C is needed.

Types available include the ordinary mercury in glass, reading up to 100°C, which is very cheap; secondly, the sugar thermometer, normally in domestic use for bottling, jam-making etc; thirdly, the commercial rotary-type all-metal thermometer, which tends to be rather more expensive; and lastly there is the remote dial or washing machine-type thermometer, where the bulb is fixed into the tank and the dial mounted on a convenient bracket nearby - this is an expensive thermometer.

FURTHER INFORMATION

The candle making equipment described in this publication can be made from locally available materials, so no attempt has been made to indicate the costs of manufacture. The Industrial Liaison Unit of the Intermediate Technology Development Group is in touch with manufacturers who could provide commercial machines similar to those illustrated in Figs 2, 4 and 5. Enquiries should be directed to:

Industrial Liaison Unit
Huncote House
24 Brook Street
Huncote
Leics. LE9 6AB
U.K.

FIGURE 1

Dipping

A simple stand and boiler suitable for dipping candles. The wick holder is made of wood and holds approximately 12 wicks. The wick holder is placed in a jig which is slid up and down on guides, thus immersing the wicks each time until the required thickness of candle is achieved. The wick holder is then removed and another one inserted.

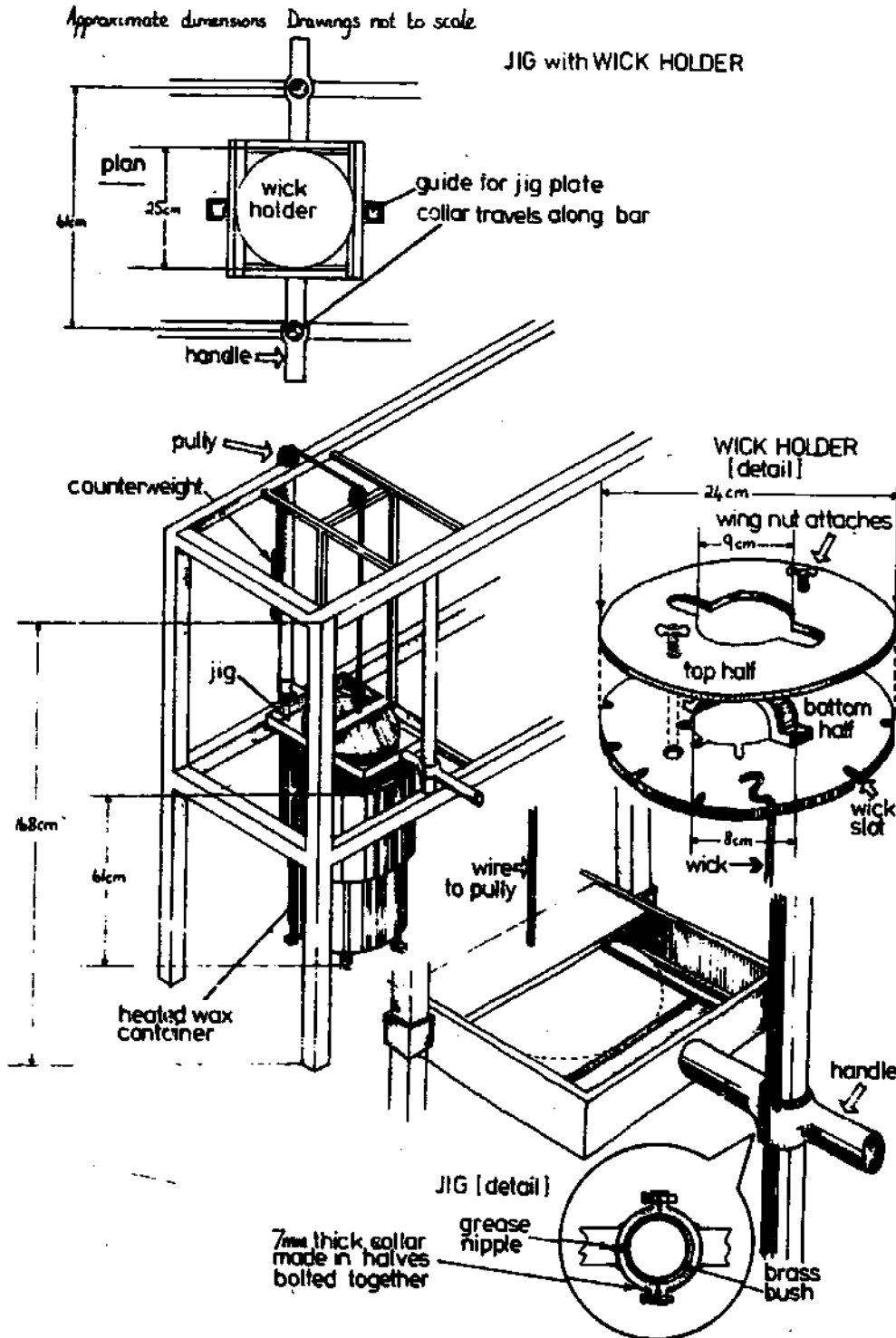
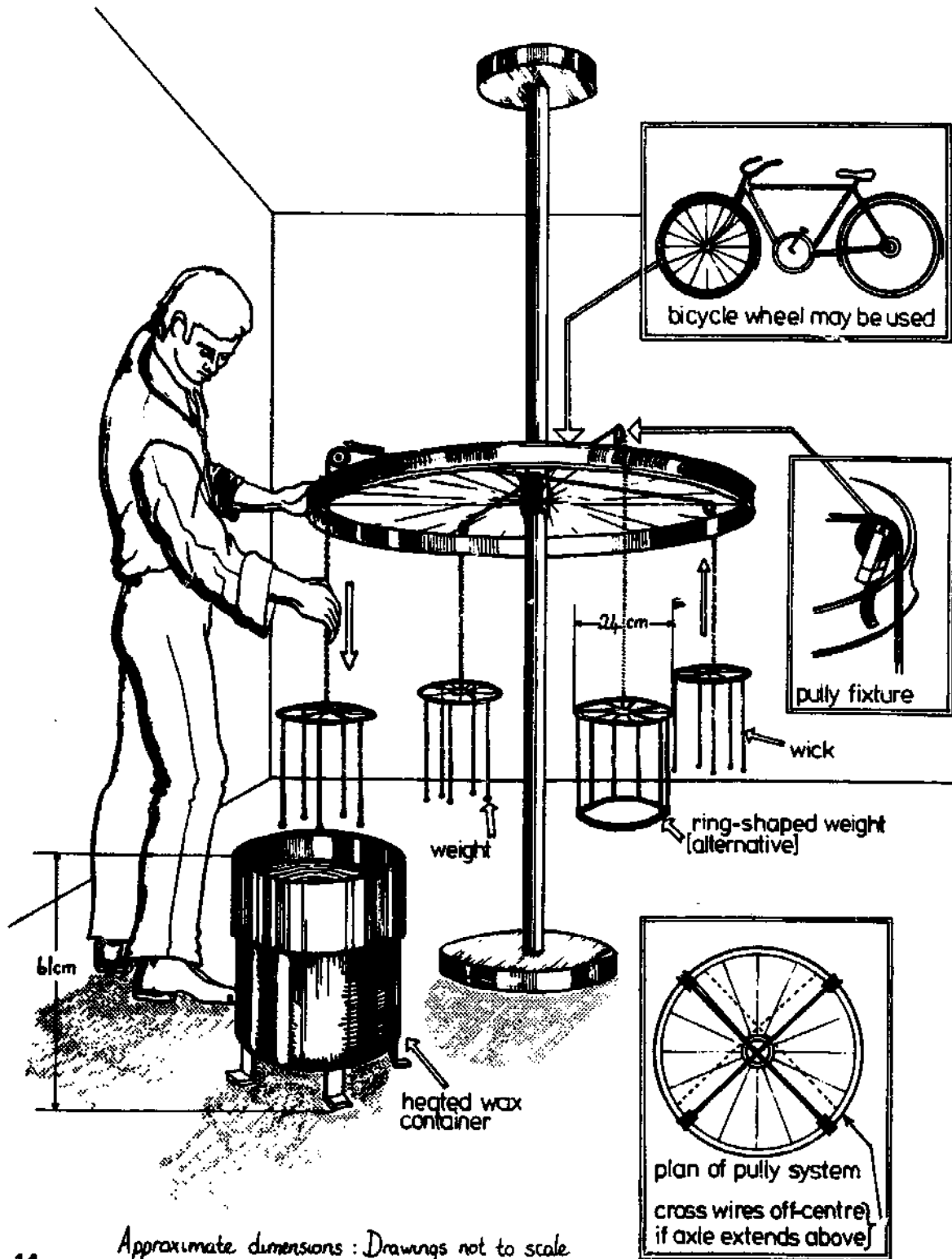


FIGURE 2

Dipping

A continuous dipping process for four or more wick holders.
The production rate from this machine will obviously be much greater than that from the single wick holder shown in Fig. 1.



Approximate dimensions: Drawings not to scale

FIGURE 3

Pouring

This rig consists of an old cycle wheel in a horizontal plane supported by a vertical shaft, the length of which is determined by a suitable working position. The bottom end of the shaft should be located in a heavy base-plate, so that the whole construction is safe for working. The wheel must be able to rotate freely. Small metal hooks made from approximately 3 mm diameter wire are fixed to the outer rim of the wheel, from which the candle wicks are suspended and kept rigid in a vertical position using small lead weights at the bottom of each wick. A heated container, similar to that used in the previous technique, is positioned so that the outer rim of the wheel is above the centre of the container. A small ladle is required for pouring the heated wax over the wick.

Approximate dimensions: Drawings not to scale

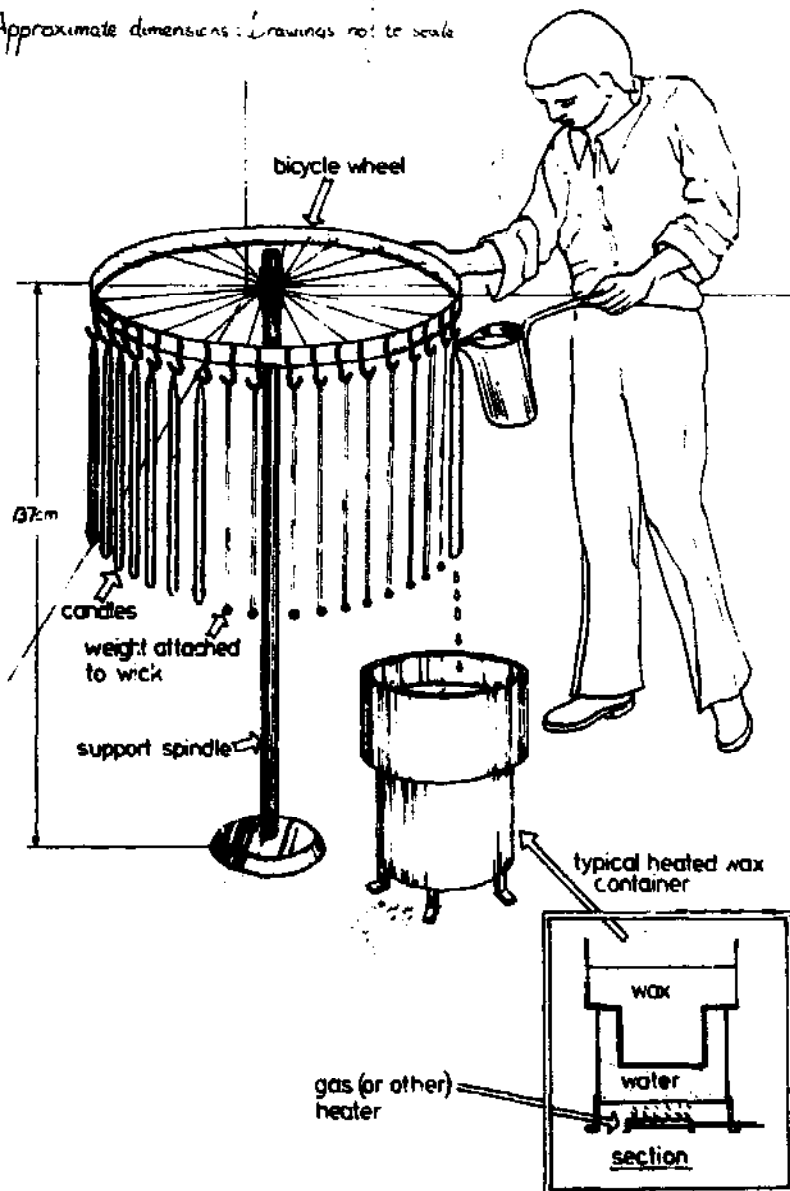


FIGURE 4

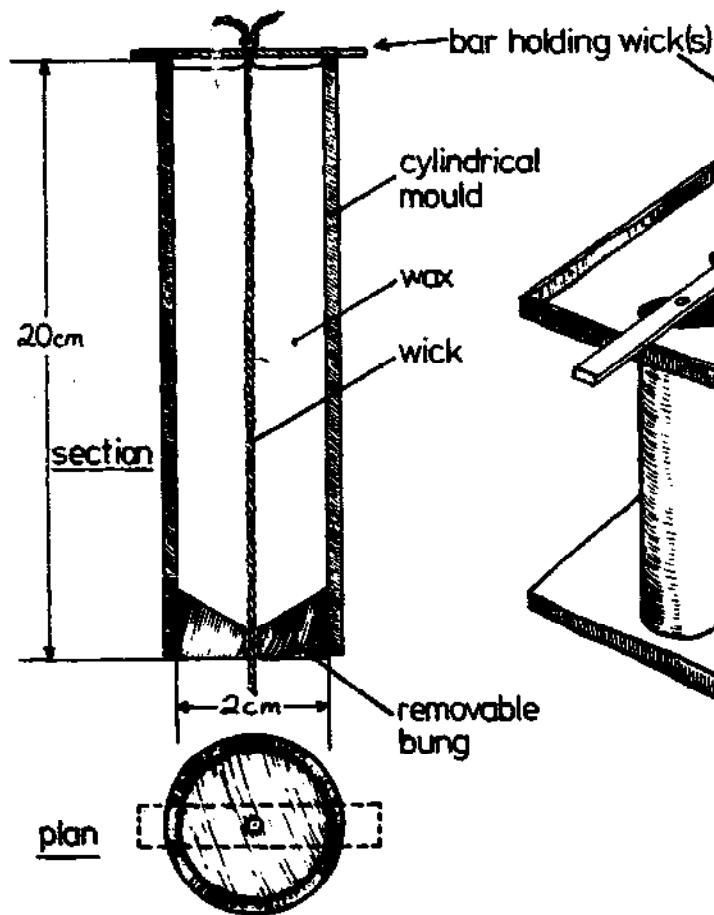
Moulding

The illustration shows a bench, boiler and moulds required for this method. The reason why only rough dimensions are shown on these sketches is because it is felt that these requirements are best left to those who are able to assess the most suitable size of the bench and moulds together with the number to meet their own individual requirements on output. A more modest design of a set of moulds is shown.

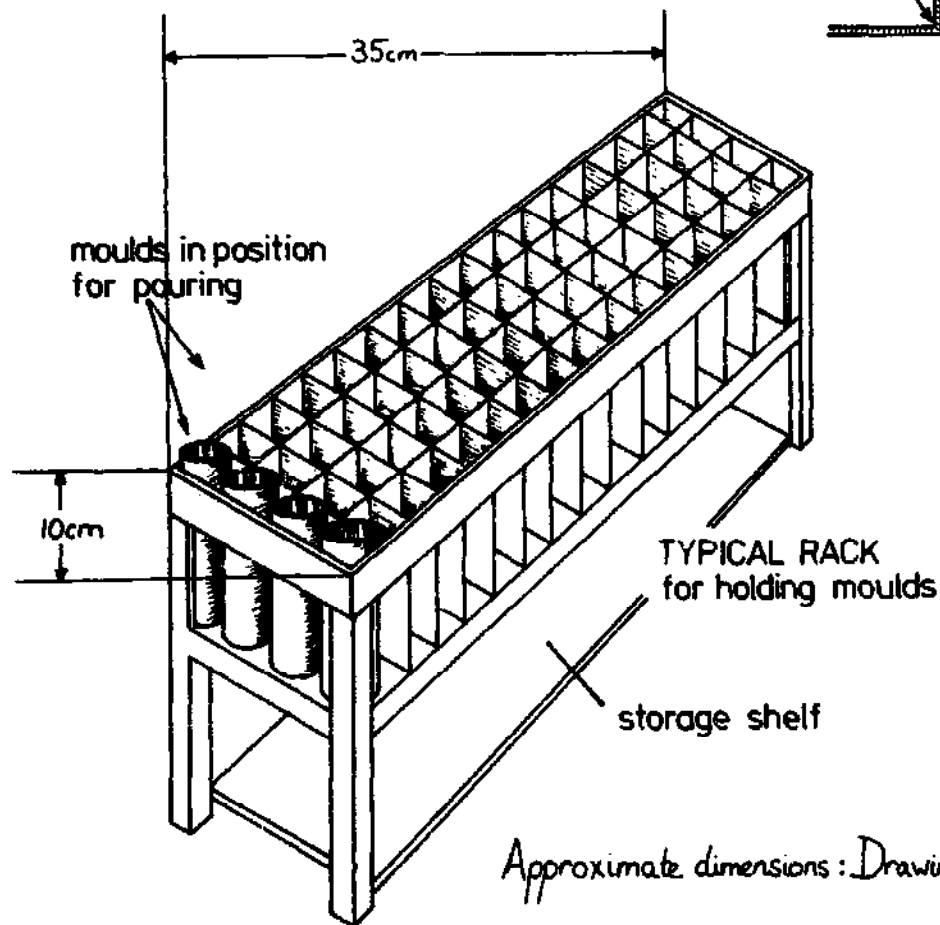
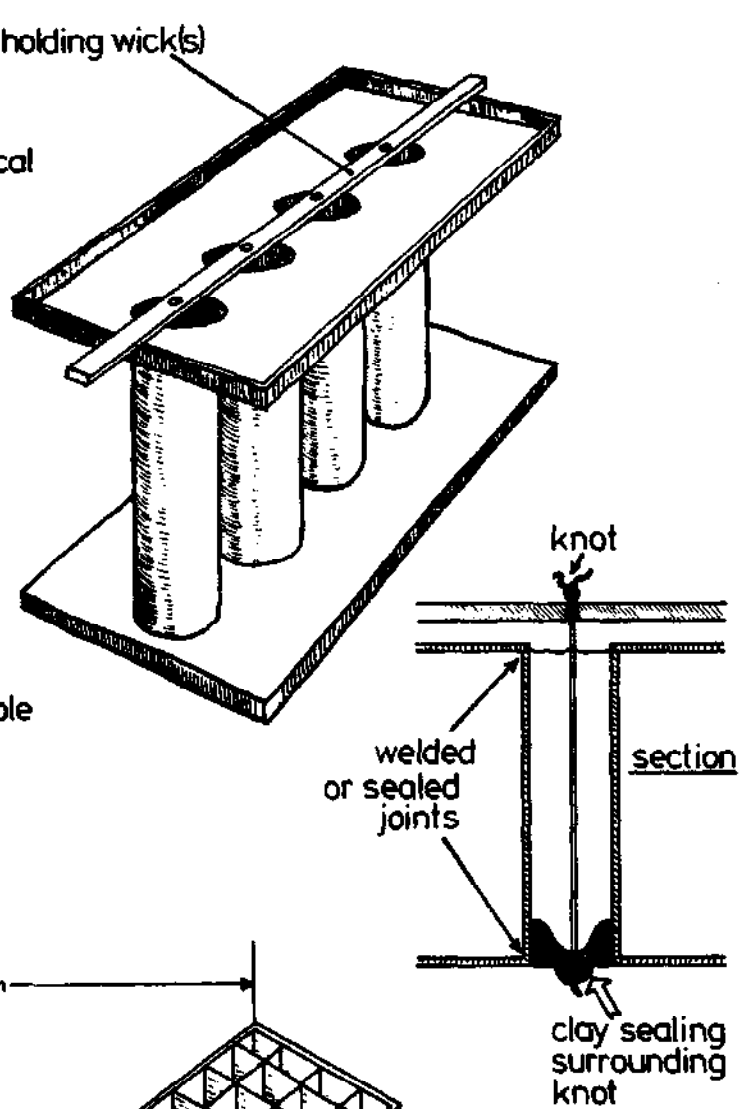
The bench can be of wood construction, but it is suggested that the main surface should be covered with a layer of thin metal sheet. This ensures easier cleaning of any surplus wax that may overflow from the moulds whilst pouring. The reason why the top section of the bench is divided into small square boxes is to ensure that the moulds remain in an upright steady position, thus avoiding any accidental overturning of the moulds whilst the pouring action is in progress. The position of the wax boiler is not necessarily where shown, but should be located in a convenient position to ensure easy access to the wax.

The mould is made from a metal seamless pipe, but any suitable container can be used, providing the inside is smooth and parallel, thus ensuring easy removal of the candle when completed. The metal bung at the base of the mould gives a suitable shape to the top of the finished candle, but it could also serve another purpose - it can be pushed in an upward direction, thus assisting in the removal of the finished candle without damage. The small metal bar at the top of the mould is for supporting the candle wick.

SINGLE MOULD



MULTIPLE MOULD

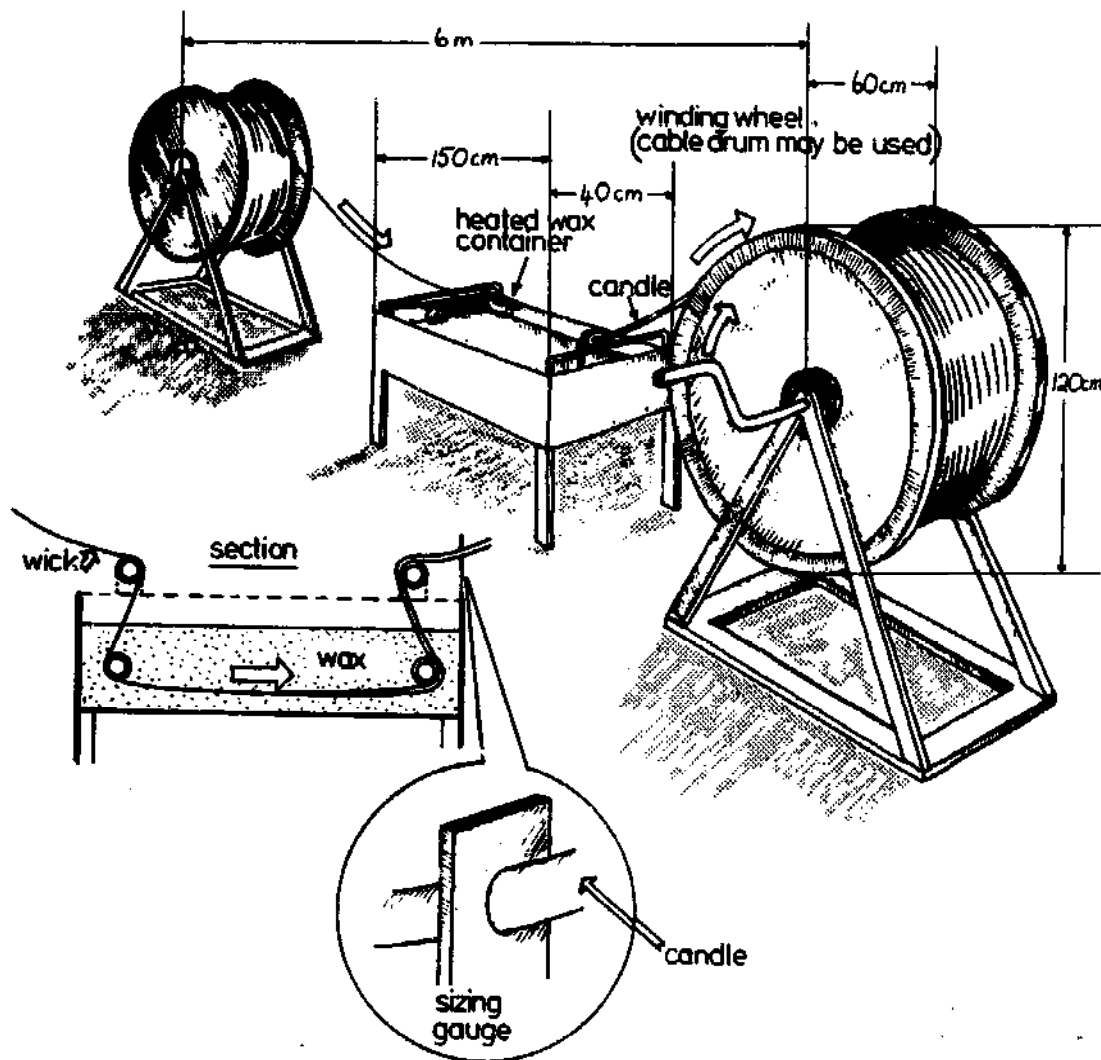


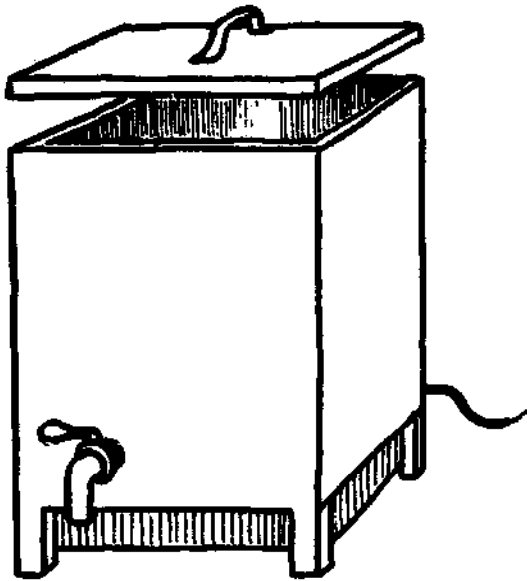
Approximate dimensions: Drawings not to scale

FIGURE 5

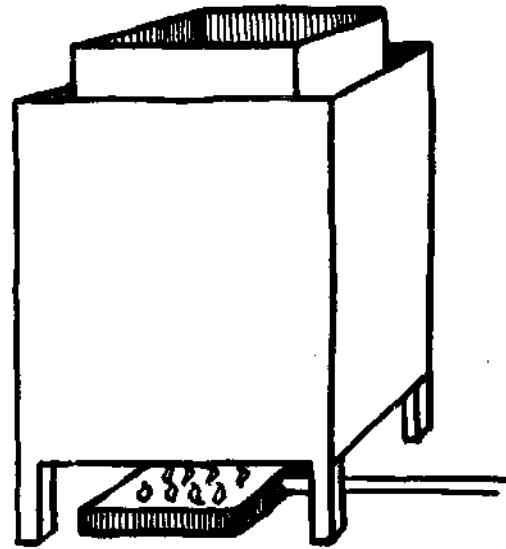
Drawing

The wick is first coiled on a large drum about 120 cm in diameter and 60 cm wide, mounted with its axle horizontal and fitted with a handle for turning. It then passes through a heated trough containing wax. This trough should be about 150 cm long, 40 cm wide and 14 cm deep. At the end of the trough is a sizing gauge, consisting of a ring of steel (or hardwood) with a series of varying size holes drilled through it, the wick being passed through one of the holes which controls the finished size of the candles. Finally the wick is led on to a second drum similar to the first.





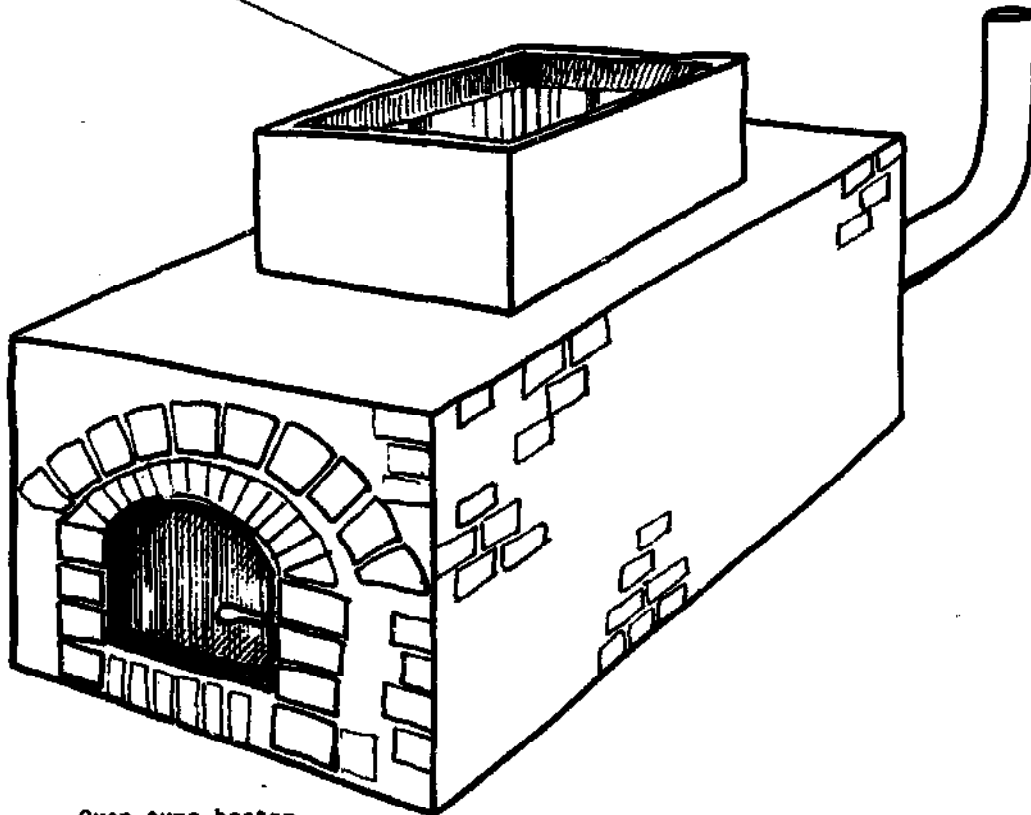
Electric heater



Gas heater

Wax containers can be of any suitable size provided they are leak-proof and not soldered. They can be of iron, steel or aluminium, and heated by electricity, gas or over a simple oven.

7l. tin or oil drum



Oven-type heater

IT PUBLICATIONS

Some Intermediate Technology publications are listed below. For a full publications list with prices write to Intermediate Technology Publications, 9 King Street, London WC2E 8HN, U.K.

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Methane

Methane Digesters - for Fuel Gas and Fertilizer

The Energy Primer

Health Manpower and the Medical Auxiliary

The Training of Auxiliaries in Health Care: An Annotated Bibliography

Paediatric Priorities in the Developing World

Simple designs for hospital equipment (12 leaflets)

The Iron Foundry: An Industrial Profile

The Stirling Engine

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A Manual on the Automatic Hydraulic Ram Pump

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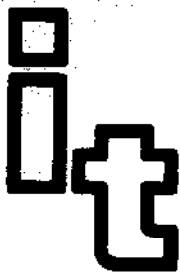
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Aid and Self-Help by Elizabeth O'Kelly

Water Treatment and Sanitation



The Intermediate Technology Development Group was formed in 1965 by a group of engineers, economists, scientists and others from industry and the professions, to provide practical and effective self-help techniques for developing countries. It is a non-profit organisation registered as a charity.

Its aim is to demonstrate and emphasise that aid must be designed to help the poor to help themselves.

The most urgent and intractable problem of the less developed countries is rural unemployment and mass migration to the cities. The highly sophisticated capital-intensive, labour-saving methods and equipment currently being exported create few jobs and waste scarce capital resources, whereas the technologies most likely to be appropriate for the poor countries are those which are labour-intensive, capital saving, use local materials and are simple enough to be used and maintained by the people themselves.

The Group is an action group which concentrates on research and development into self-help technologies for use in rural and village life; tests and demonstrates the results through field projects, programmes and consultancies; communicates the information to the developing countries through governments, organisations and individuals and by publishing material through its subsidiary, Intermediate Technology Publications Ltd.

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