be used to raise or lower the temperature of the bed.

Problems. We have experienced two teething problems with the system. Firstly, the ordinary domestic heating pump that we initially installed could not cope with the 1456m of alkathene pipe that is in the system, so a larger industrial pump was fitted.

The second problem was air-locks in the alkathene loops, so each loop had to be bled individually, and a piece of pipework modified to bleed off the air once it was in the return header. Since these two problems have been solved, the system has run without a hitch for the past 18 months.

Cost. The cost of the system, at 1985 prices, was about £2,800, which includes £1,000 for the purchase and installation of the boiler, £1,000 for the sand and polystyrene to construct the beds, and £800 for the pipework.

EXPERIENCES WITH FOUR BASE HEAT SYSTEMS

B. E. HUMPHREY

Notcutts Nurseries Ltd.
Woodbridge, Ipswich, Suffolk

The provision of basal heat for providing optimal conditions for rooting cuttings has been accepted for many years. The phrase "cool tops, misty middles, and hot bottoms", was coined for MacPenny's Mist System at a precursor of these meetings held many years ago at the old Kent Farm Institute in Swanley, Kent.

ENERGY

Costs. In the balmy days of low energy costs the use of electrical heating cables controlled by fairly crude rod type thermostats set on 20°C to 21°C was the order of the day. Today much work, particularly at Efford Experimental Horticulture Station, has investigated the use of lower temperatures than the normal of 20°C, also the provision of restricted heating periods utilising times of low cost electricity availability.

Three other important steps have been taken to reduce bottom heat energy costs: the use of extensive insulation to prevent heat escaping to areas where it is not required; the use of alternatives to electricity which can often result in lower running costs and perhaps most importantly the use of accurate controllers to ensure that heat is only provided where it is required at precisely the right temperature.

Sources. Electricity is still an important energy source because of its flexibility, versatility, and convenience. Its high running cost compared with most alternatives has been narrowed substantially by the application of the principles discussed above. It normally has the advantage over other methods of being a low capital cost installation.

Cheaper sources of energy such as gas, oil, coal, etc. normally provide basal heat via hot water circulated through pipes of various diameters, though some systems utilise hot air distributed appropriately.

MATERIALS HANDLING

Apart from the need to provide low cost bottom heat there has been an ever increasing requirement for improved materials handling in the propagation area. The traditional propagation bench with its inherent problems of difficulty of access and loss of useable space has tended to give way to either mobile benching or more commonly in Britain propagation beds on the floor of the glasshouse.

The use of materials such as concrete has meant that transportation is not necessarily limited to defined paths, though the use of gantries can give similar benefits of accessibility to all parts of the house.

BOTTOM HEATED FLOORING SYSTEMS DESIGNED FOR MATERIALS HANDLING REQUIREMENTS

System 1. warm water with no-fines concrete. This system was designed before the "oil crisis" but was a response to the increasing cost of electricity and the need for improved materials handling. The basic design features are:

Use of oil as a primary heat source supplying heat through warm water.

Warm water is circulated through polythene pipes to reduce the installation costs and avoid the long term problems of corrosion associated with metal pipes.

The use of 'no-fines' concrete (see below) to provide the advantages of concrete without the disadvantage of lack of drainage.

Construction of System 1. The site should be thoroughly drained with close-spaced (3 metres) land drains covered with washed rejects, brought to the surface, the whole glasshouse area then being covered to a depth of 75mm with 10mm washed gravel.

Concrete headwalls are cast *in situ* with holes appropriately spaced to take 15 or 20mm polythene pipe. Timber battens (100 × 50mm) treated with mould oil are laid at 3m distances across alternate 3.5m bays; 50mm thick slabs of expanded polystyrene wrapped in polythene should be laid on top of the 10mm gravel before placing the battens, to give insulation.

No-fines concrete is placed one bay at a time in alternate bays, finished level with the top of the battens to give a 50mm deep layer. It should be covered with polythene and cured slowly.

Fifteen to 20mm polythene pipe, straightened and pushed through the appropriate holes in the headwalls, is held in position at 125 to 150mm centres by galvanised 'saddle straps' screwed onto the 100 × 50mm battens. Check each pipe run for a leak.

Road forms, or 100mm wooden battens, are placed in position in alternate bays on top of the first layer and no fines concrete placed above the original layer and over the polypipes to a depth of 100mm.

Flow and return manifolds which have been specially fabricated are now placed in position behind the previously constructed headwalls in ducts created between the headwall and the brick work at the gable ends of the glasshouse. Connections are made by pushing the poly pipe onto the spigots of the manifold. This is not an easy operation and it is very important that a water-tight joint is made. Normally this is only possible by heating up each pipe individually and pushing the spigot in while the plastic is soft. It is probably best to have a threaded connector in each spigot and treat the operations of connecting polytube to metal pipe and metal pipe to manifold as two operations.

Connect manifolds into flow and return pipework supplies to the house in the normal way.

Other points on system 1. No-fines concrete comprises 8 to 10mm aggregate with all the fine sand removed. This is then coated with cement for this application, using a strong 6:1 mix. The material produces a honeycomb effect which gives instant drainage. The amount of water added to the mix is very critical; too much and the cement runs off the individual aggregates; too little and the cement fails to coat each aggregate properly.

It is best to add water on site as the material sets very rapidly (say 30 to 45 min.) and you need plenty of people to lay the material. Laying requires some care as the surface must not be trowelled over for there is a real danger of producing a skin of cement on the surface which prevents drainage. The material may be moved by shovelling or raking and the final finish is produced by pressing into place. A roller is a good tool for this job.

No-fines concrete provides such excellent drainage that in practise it is necessary to blind the surface with a layer of sand brushed well in.

Water temperature is critical for polythene pipework. Polythene pipe will not indefinitely withstand water at boiler temperature and it is normal to use temperatures around 38°C. It is always advisable to consult a heating engineer on the best ways of achieving this but there are at least three possible methods:

1. Use separate boiler for the bottom heat installation and run it

at the required temperature. As this is likely to cause damage to the boiler eventually it is usual to use secondhand boilers for this approach.

2. Use an appropriately rated calorifier. This provides the safest and most reliable approach.

3. Use an appropriate mixing/proportioning valve. This is normally cheaper than a calorifier and modern valves are highly reliable. A "fail safe" system must be incorporated which prevents water that is too hot being fed to the system in the event of a mixing valve breakdown.

System 2—Warm Water From Solar Panels. This system was designed after the oil crisis and took into account the need for good energy conservation by using low cost energy and providing lower thermal inertia (response to heat or cold requirements) than the no-fines concrete system.

Constructional details are similar to System 1 up to the provision of polystyrene insulating slabs. Above the slabs are laid Robinsons Polypanels. These are in effect solar panels manufactured for heating swimming pools, etc. and comprise hundreds of small channels or tubes fabricated from polypropylene and built up into sheets approximately 8mm thick. Each 1.2 m wide sheet is welded onto a header pipe (manifolds) which provide the source of supply for water which is circulated through the sheets. Sheets can be made from 3m (standard) up to 7m long according to particular requirements.

Polypanels are laid side by side, as required to cover the area, the manifolds connected by suitable short connecting pipes to provide a ground level (they could be used in a bench, of course) source of bottom heat. To protect the panels and provide a reservoir of moisture a layer of capillary matting is placed over the top and the propagating receptacle is placed on this.

As with System 1 water temperatures should not exceed 38°C.

Materials handling in this system is dependent upon gantries, because although the polypanels can be walked on—and in practice over a period of nine years have proved tough and durable—they will not withstand heavy traffic.

System 3—Warm Water and Sand. This system is a modification of System 1, the no-fines concrete being replaced by carefully compacted sand of the grade recommended for capillary beds. Well compacted sand is remarkably stable if not too wet and it may be possible to traverse such a bed with a mechanical vehicle, though it is unlikely it could withstand a forklift truck.

In one installation I have seen Mypex is used as a cover over the sand. This may break the capillary connection between the sand bed and the rooting receptacle. An alternative approach may be to bury an industrial membrane such as Terram about 25mm beneath the surface. This would give strength and stability to the sand without losing the valuable benefit of capillary connection. It is likely that a gantry system is required for efficient materials handling with this type of construction.

System 4—Warm Water and Concrete. Replacement of no-fines concrete by conventional concrete provides the ultimate work surface and the greatest flexibility in materials handling. The thickness of concrete can be reduced to 100mm and it must be laid to careful levels to provide sufficient falls for good drainage into gutters. The system has much to recommend it but of course provides no capillary "pull" to drain rooting receptacles. This can be quite a disadvantage in the late autumn period under mist when some of the newer rooting/growing media used in direct sticking can become very wet.

COSTS

It is very difficult to give meaningful costs at a given moment in time. Prospective users are urged to make their own investigations. The most expensive system is likely to be the Polypanel system where prices as high as £35.00 per square metre for the panels alone have been quoted. An equivalent price for 20mm pipe to cover the same area would be £6.00.

No-fines concrete is some 10 to 20 per cent cheaper than conventional concrete but this saving is lost if the thinner 100mm thick slab of conventional concrete is used against the 150mm no-fines slab. Current costs of no-fines is approximately £3.70 per square metre (September, 1987). Polystyrene slabs, common to all installations, are approximately £2.50 per square metre.

A no-fines system without polystyrene insulation installed in 1976/77 cost £11.08 p per square metre and the Polypanel system, which included polystyrene insulation and was installed in 1978, cost £18.50 per square metre.

The no-fines concrete installation will carry substantially higher labour inputs than most of the other systems though the sand beds may be close in final labour costs. The Polypanel system will almost certainly carry the least labour inputs and, unlike the systems using concrete, any mistakes can normally be rectified.