

PRACTICAL ACTION
Technology challenging poverty



A Guide for the Construction of the
DRY IT
SEMI - CONTINUOUS TRAY DRIER

By

B L Axtell & A J Jones

technical guide

DRYIT – Semi Continuous Tray Drier

Preface

This manual is intended to assist engineering workshops that wish to construct a semi-continuous tray drier based on Practical Action's design.

Practical Action has found that this drying system conveniently fills a gap between solar (and assisted solar) dryers. These have a low throughput and are only suited to certain climates. The larger industrial equipment is being used in seven developing countries drying a diverse range of materials and Practical Action is currently pursuing a programme of greater dissemination in Latin America.

Construction plans are available from Practical Action and have been successfully used both in the UK and abroad. In some cases, however, workshops have had some difficulties, and so it was thought appropriate to also develop a step-by-step manual to guide engineers through the construction process.

The drier consists of a cabinet of trays, trays contain material to be dried, and the whole system is connected to a thermostatically controlled heat source. Most commonly the materials to be dried, are herbs, fruits or vegetables. However, the tray drier has also been used to dry colouring materials and textiles.

It is hoped that this manual is helpful for construction and Practical Action welcome comments or suggestions in regard to this manual. Drawings for a smaller tray drier (batch drier) and a case study book are now available.

B L Axtell and A J Jones originally prepared this manual in 1995, it was revised in January 2004. If you require further information you can contact:

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Practical Action (formally known as The Intermediate Technology Development Group) was founded by the late Dr. E.F.Schumacher. Practical Action enables people in the Third World to develop using technologies and methods, which give them more control over their lives and which also, contribute to the long-term development of their communities.

Check List

Fingers move smoothly together fully up and down.
 Tray width = distance between fingers at lowest position minus 2 mm,
 Doors open and close easily.
 Tray lifting point reinforcements are recessed or ramped.
 Tray dividers are approximately 20mm lower than tray outside walls.
 Base, drying cabinet and doors are painted (no lead paint!) before cladding is fixed on.
 All angle irons used are straight and square.
 Washers and locking nuts are used in the lifting mechanism.
 Any glue used is waterproof.

Tools

The following tools will be needed to make the Practical Action tray drier:

Tape Measure	Hacksaw	Arc Welder	File
Straight Edge	'G' Clamps	Hammer	Plane or rasp
Set Square	Locking Pliers	Spanners	Pencil
Spirit Level	Vice	Power Drill	
Scriber	Centre Punch	Drill Bits	
Cross Cut Saw	Chisel	Tennen saw	

An angle grinder may be needed (where suggested)

Contents	Page
Glossary	1
Introduction	2
Description	3
Construction	
General Assembly	
Operation and Maintenance Heating	

Glossary

MS -	mild steel
Hx. Hd.-	hexagon headed
St./St.-	steel
OD -	outside diameter
CSK -	Countersunk head
RD -	Dome headed (wood screw)

Important Notice to Constructors

This manual is intended to be used with Practical Action's engineering drawings TD001 to TD102. These are available on the website to download electronically, alternatively you can contact Practical Action and have them sent electronically or on paper.

Most of the drier is made from mild steel angle, which should be as straight, flat and square as possible. The drier should be built on a horizontal, flat floor; otherwise fitting the trays will be very difficult.

Particular care must be given to ensuring parts are correctly positioned before they are welded.

Where materials are not available in the sizes specified in the manual and drawings, give serious thought to how substitution with material of a different size will affect the function of that part of the machine:

- Will this substitution alter other dimensions?
- Will the change weaken the finished machine?
- Will it make the machine less durable?

It is usually better to use a larger steel section than a smaller one.

Components, which slide together, should not be painted on the sliding surfaces but should be oiled as the unit is assembled.

Lead paint must not be used to paint any part of the drier, being a toxic substance it could contaminate food being dried.

On page 3 of this manual is a checklist, which should be read before and after completing the drier.

Introduction

This manual is designed primarily to aid the construction of the Practical Action Semi-continuous Tray Drier.

The machine is described in detail and its construction outlined.

This manual compliments the engineering drawings TD001 to TD102, which are essential if a drier is to be made.

The manual does not cover the heat source and ducting required for a complete drier, but this is discussed briefly.

The drier consists of a cabinet containing a stack of 15 trays, which hold the material to be dried. The cabinet is mounted on a base and has a lifting mechanism, (to lower/ lift the trays). This mechanism is mounted on a frame over the drying cabinet.

Semi-continuous operation is achieved by the use of the lifting mechanism. The mechanism allows a tray of dried product to be removed and replaced by one with fresh material, without interruption of the drying process. The drier is made from mild steel angle, plywood, steel plate and bar, and a small amount of hardwood for bearings. The trays are made of hardwood with nylon mesh bases and mild steel angle rein-forcers.

In this manual the drier has been divided into seven main areas. These are:

- 1.) The base
- 2.) The upper frame
- 3.) The drying cabinet
- 4.) The lifting mechanism
- 5.) The trays
- 6.) The cladding
- 7.) The drying cabinet doors

Areas 1 to 4 are shown in the exploded *diagram*, figure 1.

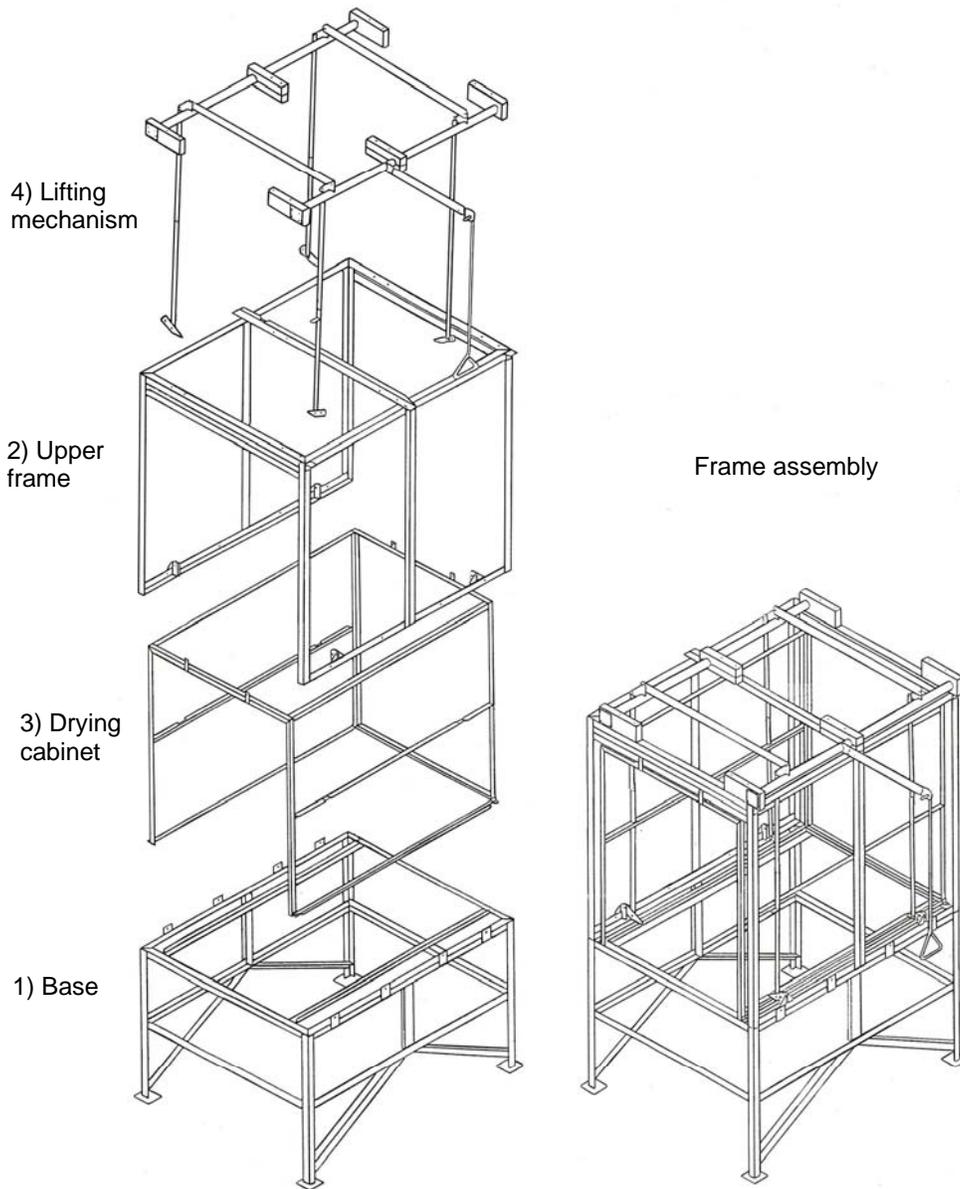


Figure 1: base, upper frame, drying cabinet and lifting/ mechanism

The trays, cladding and doors are shown in the position on the completed drier in figure 2.

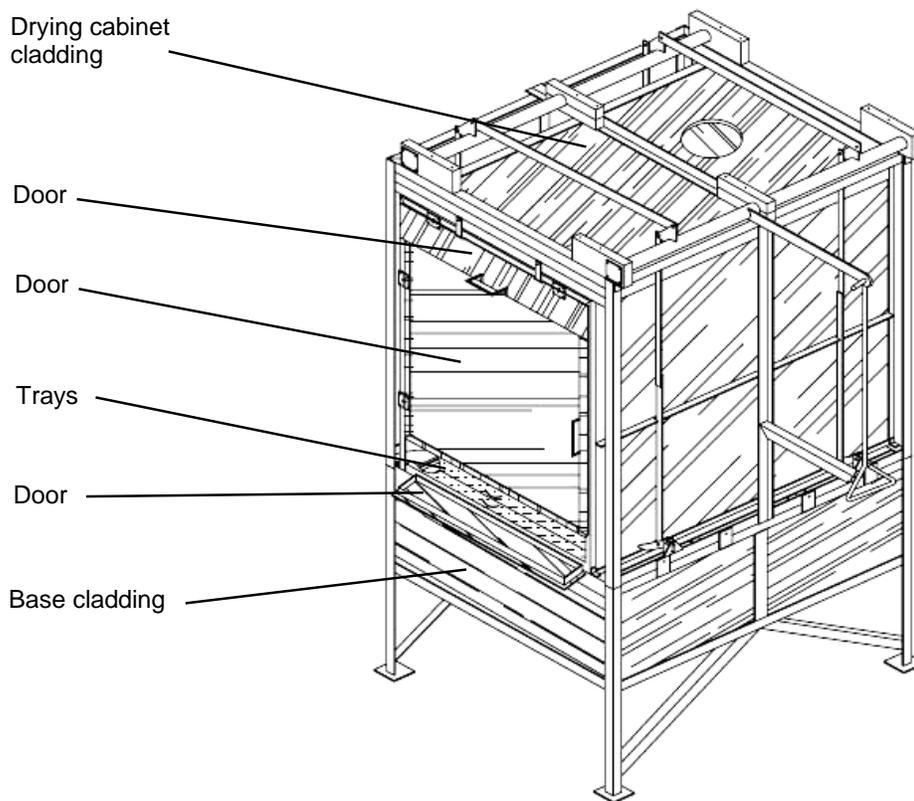


Figure 2: Cladding trays and doors

Construction Of Tray Drier

This section describes each major component together with a possible construction procedure.

Base Frame

See drawing TD001

The base is made from mild steel angle, steel bar and steel plate. It consists of two rectangles, 1110 x 1420 mm with four legs welded on the outside at the corners, bracing, feet and two tray supports.

Mild steel angle is usually manufactured with a radius on the inside corner. Therefore, for the legs to fit closely to the rectangles' outside corners, the corners must not be sharp. A way to avoid sharp corners is to use 'snub' ends, as shown in figure 4.

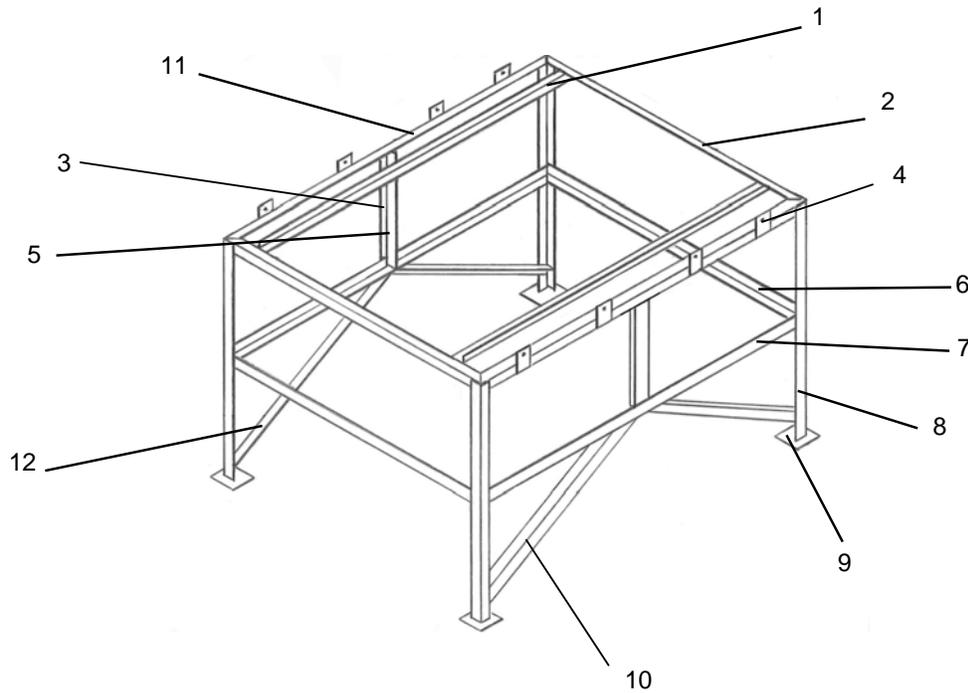


Figure 3: Base Frame

Part	Name	Qty	Dimensions		
1	Tray Support	2	40 x 40 x 6 x 1340	Long Angle	MS
2	Top Beam	2	40 x 40 x 6 x 1098	Long Angle	MS
3	Strap	2	6 x 60 st.bar x 1340	Long	
4	Pad	8	64 (approx.) x 6 St. bar x 80	Long	
5	Rib	2	60 x 50 st.bar x 441	Long	
6	Bottom Beam	2	40 x 40 x 6 x 1098	Long Angle	MS
7	Bottom Beam	2	40 x 40 x 6 x 1408	Long Angle	MS
8	Leg	4	40 x 40 x 6 x 909	Long Angle	MS
9	Foot	4	40 x 40x 6 st.plate		
10	LH Cross Tie	2	40 x 40 x 6 x 780	Long Angle	MS
11	Top Beam	2	40 x 40 x 6 x 1408	Long Angle	MS
12	RH Cross Tie	2	10 x 40 x 6 x 780	Long Angle	MS

If snub ends are not used on the top and bottom beams', therefor lengths must be increased by 12 mm each, and the sharp corners ground off after the rectangles have been welded up.

Construction

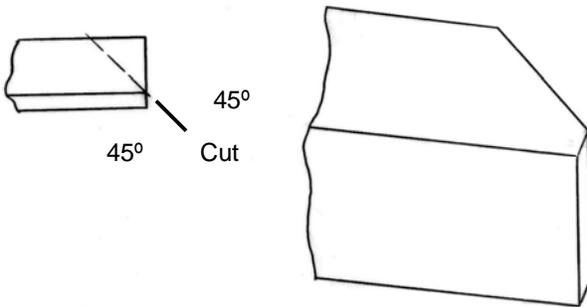


Figure 4: snub ends

- 1) Cut beams to length, with snub ends, as shown in figure 4.
- 2) Tack weld two long beams and two short beams together to form a 1420 x 1110 mm rectangle. Ensure the rectangle is flat and square (for flatness use flat surface or eye; for squareness equal diagonals) then fully weld. Repeat this with the bottom beams.
- 3) Cut four legs to size, clamp and weld a leg to each corner of the top rectangle ensuring each is set square to, and flush with, the top edge of the angle iron (see figure 5).

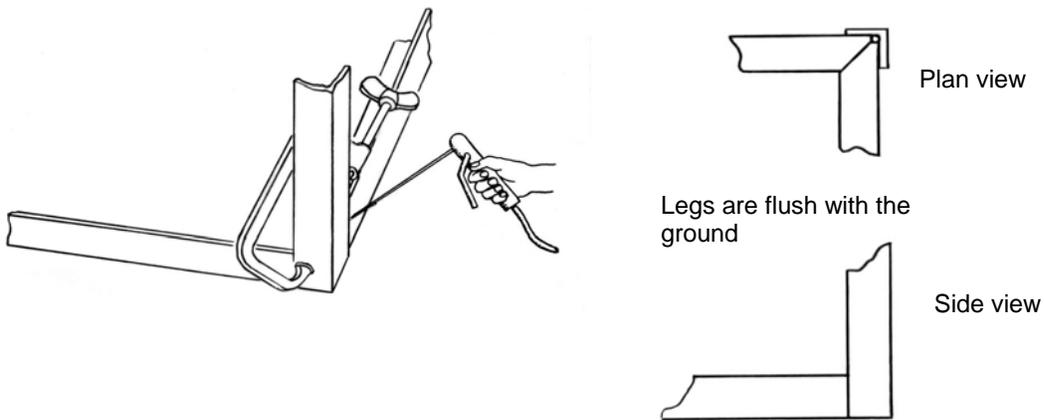


Figure 5: legs to corners

- 4) Clamp the lower rectangle in position and weld to the legs.
- 5) Cut the strap, ribs, cross ties, tray supports, pads and feet to size, drill the pad holes and weld them to the long top beams in the positions shown in engineering drawing TD 001.

Note that the tray supports are made from 50 x 25 x 6 mm angle. If this is not available, 25 x 25 x 6 mm or 50 x 50 x 6 mm mild steel angle can be modified accordingly. Also 3 and 5 form a 'T' piece, which would be replaced by two lengths of angle back to back.

6.) Mark the positions of the 4 x 8mm diameter (MB) holes (see TD 001) used for locating the tray compartment on the base but DO NOT drill them.

II Tray Compartment

The tray compartment is made entirely from 25 x 25 x 6 MS angle to drawing TD003

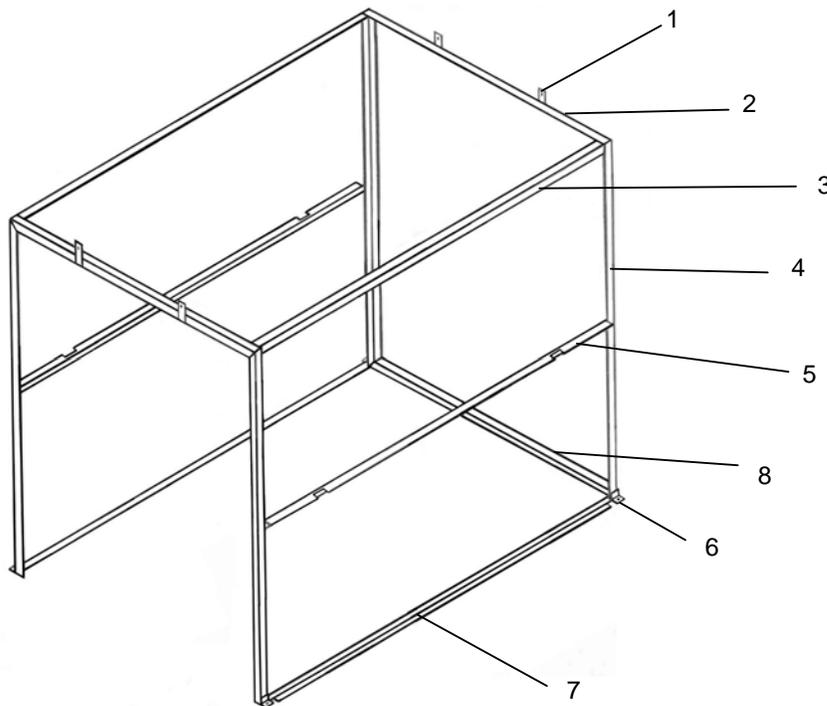


Figure 6: Tray Compartment

Part	Name	Qty	Dimension	
1	Pad	4	25 x 70 x 6 THK.MS	Flat
2	Top beam	2	25 x 25 x 6 MS angle x 942	Long
3	Top beam	2	25 x 25 x 6 MS angle x 1370	Long
4	Leg	4	25 x 25 x 6 MS angle x 1225	Long
5	Centre beam	2	25 x 25 x 6 MS angle x 1370	Long
6	Angle pad	4	25 x 25 x 6 MS angle x 25	Long
7	Bottom beam	2	25 x 25 x 6 MS angle x 1370	Long
8	Bottom beam	1	25 x 25 x 6 MS angle x 942	Long

Construction

- 1) Cut each part from 25 x 25 mild steel angle. The cutaways in the centre beams are for the rods connected to the lifting fingers.
- 2) Weld the two back legs (4) and the back top and bottom beams (2, 8) to form a flat, square rectangle with mitre joints at each corner. Weld the two front legs (4) to the front top beam to form a square, flat goal post arrangement with two mitre joints.
- 3) Parts 3, 5 and 7 are butt jointed to the rectangle and goal posts. Butt joints are used for flush fitting cladding.

A detail of the mitre and butt joints are shown in figure 7

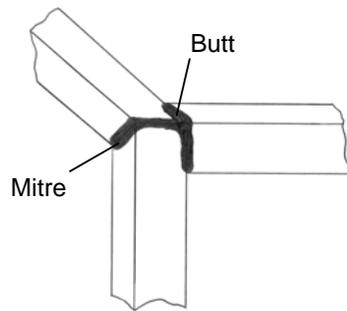


Figure 7: Mitre and butt joints

- 4) Weld the lower beams (7) to the bottom of the legs as shown in figure 8

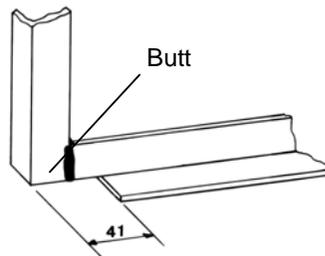


Figure 8: lower beam-ends are flush

- 5) Drill the angle pads then weld them in position, flush with the bottom of legs, as shown in figure

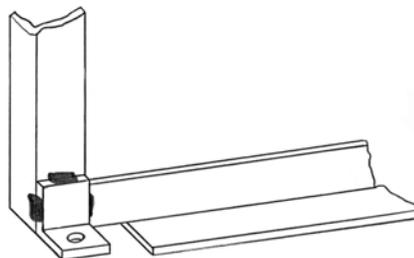


Figure 9: Angle pads

- 6) Mark and drill the upper pads then weld to the frame, in the position shown in TD003

Upper Frame

The upper frame supports the lifting mechanism and is made almost entirely from 40 x 40 x 6 mild steel angle.

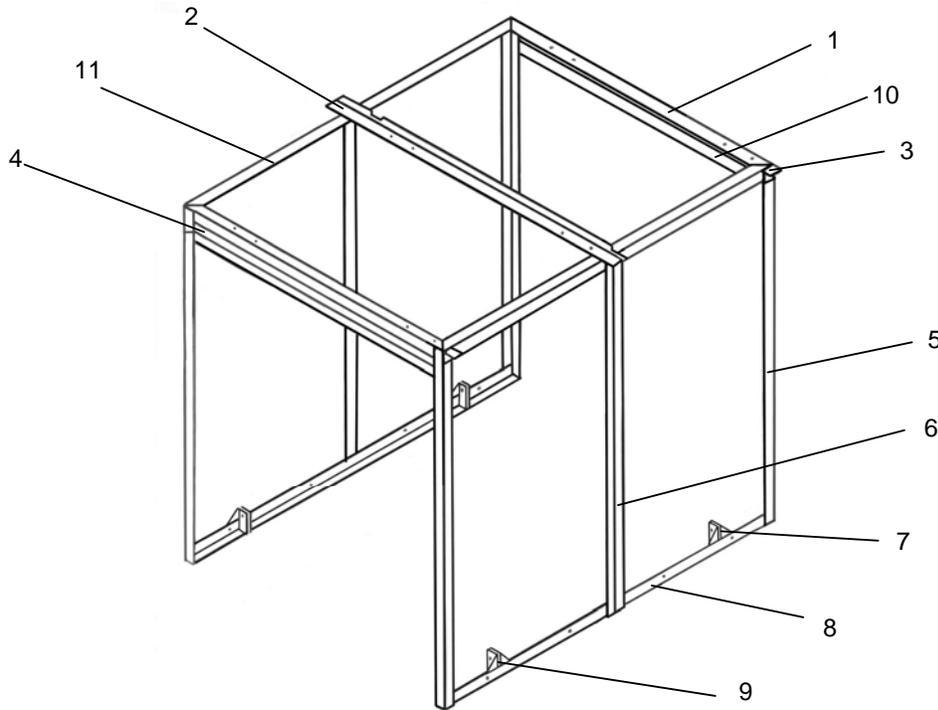


Figure 10: Upper frame

Part	Name	Qty	Dimensions (mm)
1	Short beam	2	40x40x6 MS Angle x 6548 long
2	Centre beam	1	40x40x6 MS Angle x 1150 long
3	Bearing block support	2	40x40x6 MS Angle x 40 long
4	Front centre support	1	40x40x6 MS Angle x 1098 long
5	Leg	4	40x40x6 MS Angle x 1350 long
6	Centre Legs (LHS & RHS)	2	40x40x6 MS Angle x 1350 long
7	Right finger support	4	40x40x6 MS Angle x 90 long
8	Bottom beam	2	40x40x6 MS Angle x 1110 long
9	Left finger support	4	40x40x6 MS Angle x 90 long
10	Top beam	2	40x40x6 MS Angle x 1408 long
11	Rear centre support	2	40x40x6 MS Angle x 1122 long

Construction

The upper frame can be divided into 3 sub assemblies – the top rectangle and two sides – and the following construction procedure can be used:

- 1) Cut the top beams (1 and 10) with snub ends (see figure 4, base)
- 2) Weld the rectangle (overall dimensions 1110 x 1420 mm)

3) Cut out and drill the finger supports (see TD002) and then weld them to the two bottom beams, as shown in figure 11. Minimise distortion by restraining the lower beam (with vice, clamp etc) during welding and cooling and by keeping the weld material uiaed to a minimum. Note that weld is not applied to the underside of the over hang. This area must be clear, for positioning of the base joining pads.

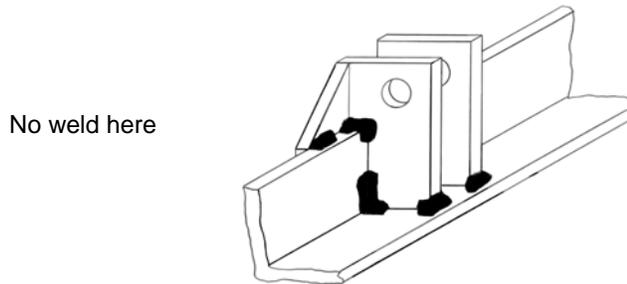


Figure 11: Finger supports

CORRECT POSITIONING OF THE SUPPORTS IS ESSENTIAL FOR CORRECT FUNCTIONING OF THE LIFTING FINGERS. THE POSITIONING AND DIMENSIONS OF ALL MEMBERS ARE GIVEN IN TD 002.

4) Chamfer the ends of the lower beams to achieve a square, flush fit with the legs, as shown in figure 12.

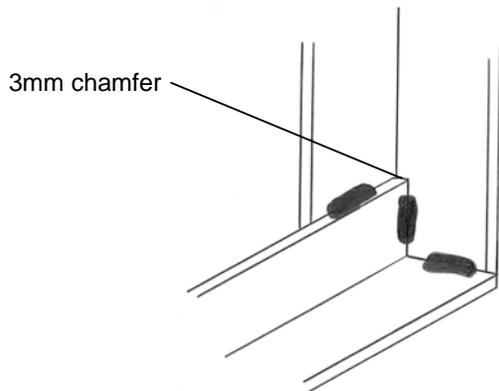


Figure 12: Chamfered end to lower beam

5) Weld two legs to each bottom beam, ensuring they are square

Now assemble these with the rectangle and add the centre beam, centre supports, centre legs and bearing block supports. Do not weld on the top side of the bearing supports as the bearing must sit flat. Note: the cut-outs in the centre beam are for the bearing shafts. Take care to ensure the frame is square and vertical before full welding.

DO NOT drill any holes apart from those in the finger supports at this stage. The hole positions shown in the drawing TD002 are theoretical and are actually located by marking through holes in other assemblies, as described in General Assembly

Lifting Mechanism

The lifting mechanism is the most critical part of the drier. It is mounted on the upper frame and enables the user to lift all the trays above the bottom one. This tray is then removed and the user drops the other trays down using the mechanism.

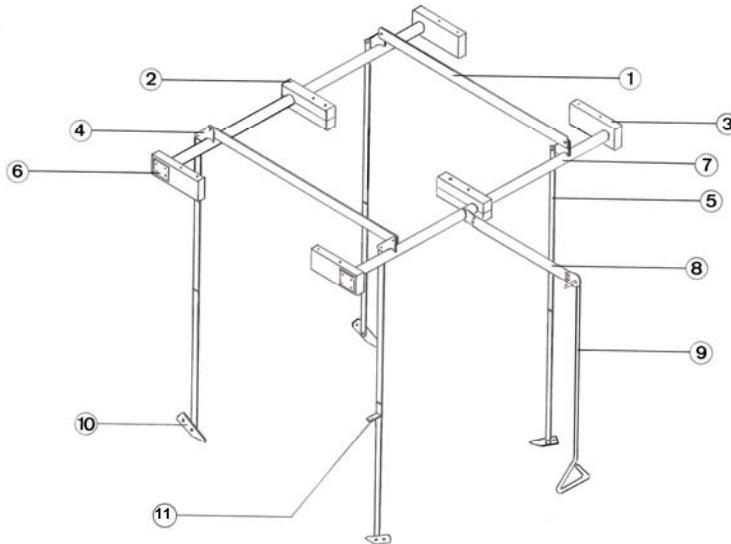


Figure 13: Lifting mechanism

Part	Name	Qty	Dimensions	DRG
1	Link	2	6 x 50 x 1030 long	TD006
2	Split bearing	2	250 x 40 x 96	TD010
3	Plain bearing	4	250 x 40 x 100	TD010
4	Cam	4	150 x 130 x 6 plate	TD014
5	Tie rod half	8	25 x 6 x 700 long	TD005
6	End plate	4	80 x 80 x 6	TD011
7	Bearing shaft	2	OD 42 x 5 x 1415	TD007
8	Operating lever	1	OD 42 x 5 x 620	TD008
9	Lever ext.	1	OD 16 x 1500	TD009
10	Lift finger	4	135 x 40 x 8	TD004
11	Stop bar	1	25 x 30 x 6	TD005
12	Handle hook	1	40 x 40 x 6 x 1300	TD017

Notes: The dimensions listed are overall dimensions of the material from which each component is manufactured.

12) The handle hook is not shown in figure 13

Construction

1.) Link

The two links, which connect the bearing shafts (via cams), are drilled and cut according to drawing TD 006.

2.) Split Bearings

The split bearings should be made from oil impregnated hardwood. For a circular-bearing surface it is necessary to drill the large hole after the two halves have been made, see drawing TD010.

Saw and plane each bearing block to size, clamp the halves together and then drill the 42 mm diameter bearing hole and 8 mm fixing holes.

Chamfer one edge for flush fitting to the top centre beam, 2.

3) Plain Bearing

Make to drawing from oil impregnated hardwood (TD 010)

4) Cams

The four cams convert the rotational movement of the bearing shafts to horizontal and vertical movement. It is important that these items are manufactured accurately to the drawing (TD 014).

5) Tie Rods

Each tie rod is made from two bars. Cut and drill these according to the TD 005 drawing. These are assembled in conjunction with the rest of the lifting mechanism as described in the general Assembly section.

6) Bearing End Plates

Make according to drawing TD011

7) Bearing Shafts

Make according to drawing TD 007 Note that the shafts' ends should be flat and square for smooth operation.

8) Operating Lever

This is made from similar tube to the bearing shafts. Once cut, each end is flattened and holes cut or drilled.

9) Operating lever extension and handle

This is cut and bent before the thread is cut according to the drawing. TD 009. The bends are made using a hammer and anvil/vice. Localised heating of the bar at the bends is recommended.

10) Fingers

For effective functioning the fingers need to have the same profile. To achieve this the manufacturing note on the engineering drawing (TD 004) must be followed.

11) Stop bar

The stop bar is cut according to the drawing and welded to the tie rods during assembly of the lifting mechanism. (See drawing TD 009).

12) Handle hook

Cut the MS angle and weld up according to the engineering/drawing.
In the assembly of the lifting gear various nuts and bolts are used. This are listed below and sketches of the fixing configurations given.

Name	Purpose	Qty	Dimensions and spec
Bolt	Connecting Finger-tie rod -cam/link	16	M12 x 40 Hx HG. St
Plain Washer	Use with above	44	Standard for M12
Locking Nut	Use with above	16	M12 Hx Hd. St
Locking Nut	For lever extension Fixing brg. blocks	1	M16 Hx. Hd. St
Bolt	Fixing brg. blocks	12	MS x 120 Hx Hd. St
Plain Nut	Fixing brg. blocks	12	MS Hx.
Plain Washer	Fixing brg. blocks	12	Standard for MS

Nuts bolts and washers –layout

1. Finger to finger support on upper frame

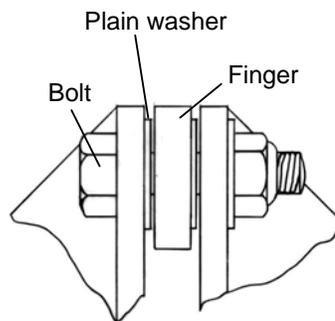


Figure 14: finger in support

2. Finger to tie rod.

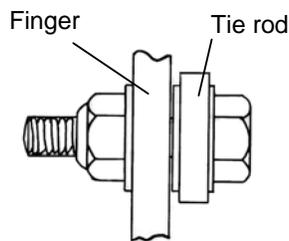


Figure 15: finger/tie rod

The tie rod/cam and cam/link connections are the same as that for the finger/tie rod.

Trays

The parts list for a tray is given on the engineering drawing TD 015.

The basic requirement of each tray is that it holds the material to be dried without damaging it whilst allowing maximum airflow through it. Also the tray should be, durable, cheap, easy to make, using locally available materials.

The trays are constructed of wood and each one has six sections: four with a mesh base and two open at one end. By positioning the open ends alternately in the stack of trays, the air is able to flow in a zigzag manner up through the stack.

To allow horizontal airflow in the tray stack (see figure 28) the internal partitions (dividers) must be approximately 20 mm lower than the outside walls of a tray.

For correct operation the overall width (to outside of corner reinforcers) of the trays must be 1 -2 mm less than the distance between the tips of the lifting fingers when they are at their lowest point.

Corner reinforcements at the lifting points protect the tray from being damaged by the lifting fingers. In the standard design these reinforcements protrude from the tray side, and tend to catch on the tray guides during batch unloading and loading. The design of the tray guides means that this is not a problem during normal operation.

To overcome this, the angle can be recessed, or fillets can be put in to 'ramp' the protrusions as shown in figure 16.

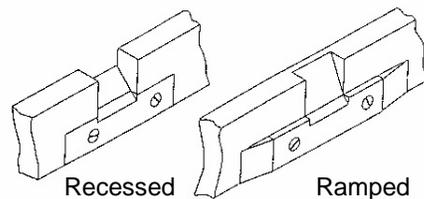


Figure 16: recessed and ramped

If the reinforcers are recessed care must be taken to increase the timber frame width and alter the cutaways.

If ramps are used they must be well fastened to the tray, e.g. pinned and glued, using waterproof glue.

The ends of the trays, which have the small, open compartments, should be clearly marked to avoid confusion. When operating the drier ensure that the trays are alternately positioned in the cabinet. This is best done by painting all these ends in colour so that when fully loaded the stack of trays will alternate -painted, unpainted, painted, unpainted. This will then facilitate zigzag airflow.

Bottom Tray Removal

This is a potentially dangerous operation. Never remove the bottom tray by hand. Always use some device. The most common one in use is a metal crook (see operation and maintenance).

Construction

- 1.) Cut, plane and sand wooden members according to drawing TD015. Note:
 - (i) cutaways are different if corner reinforcements are recessed
 - (ii) Internal partitions (dividers) are 19mm lower than outside wall
- 2.) Screw and glue the frame together, using water resistant glue
- 3.) Place the nylon gauze over the drying compartments and fix in position with the plywood (exterior grade) sandwich strips and nails
- 4.) Nail sandwich strips around vent end of tray
- 5.) Construct a long handled metal hook for tray removal
- 6.) Drill tray ends and attach a rope removal handle at each end

Cladding and Tray Guides

Exterior grade plywood cladding 12mm thick, is used on the base and drying cabinet to direct and contain the drying air.

The base and drying cabinet should be painted (no lead paint!) before the cladding is fixed in position.

The cladding must be measured and cut to size from the completed base and drying cabinet. Hence the dimensions given in the parts lists are approximate.

1.) Base Cladding

The completed base with cladding is shown in figure 17

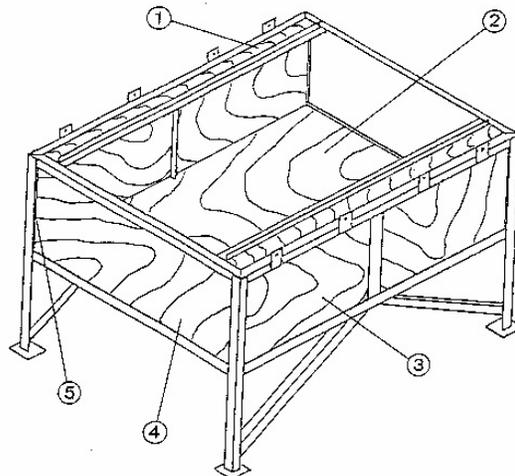


Figure 17: Base with cladding

Part	Name	Qty	Dimensions (mm)	Chamfer (3mm)
1	Top	2	1406 x 135 x 12	Long edge 1 side
2	Bottom	1	1406 x 1096 x 12	All edges 1 side
3	Side	4	700 x 429 x 12	Short edges 1 side
4	Front	1	429 x 1096 x 12	None
5	Fillet	6	385 x 40 x 6	None
-	Wood screws	100	No. 8 x 15	RD or CSK
-	Wood screws	20	No. 8 x 15	CSK

The 3mm chamfers are for flush fitting of the cladding in the corners of the angle iron.

These dimensions are based on the configuration shown in figure 18.

Wood screws can be used to hold fast the cladding. Only the free edges have to be fixed. Countersunk screws must be used to fix the side cladding of the tray guides.

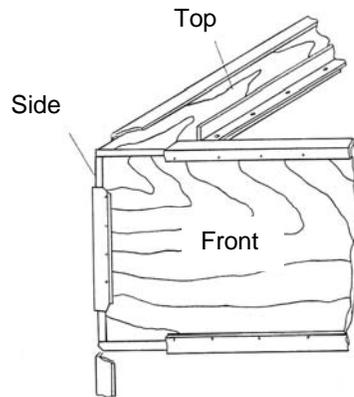


Figure 18: Cladding configuration

Construction

- 1.) Measure and cut along the cladding, noting the above
- 2.) Plane chamfers on the edges described in parts list above
- 3.) Drill the frame and fix the cladding using wood screws at 150mm centres, on the free edges.

2) Drying Cabinet Cladding

Description

The completed drying cabinet with cladding and tray guides in position shown below.

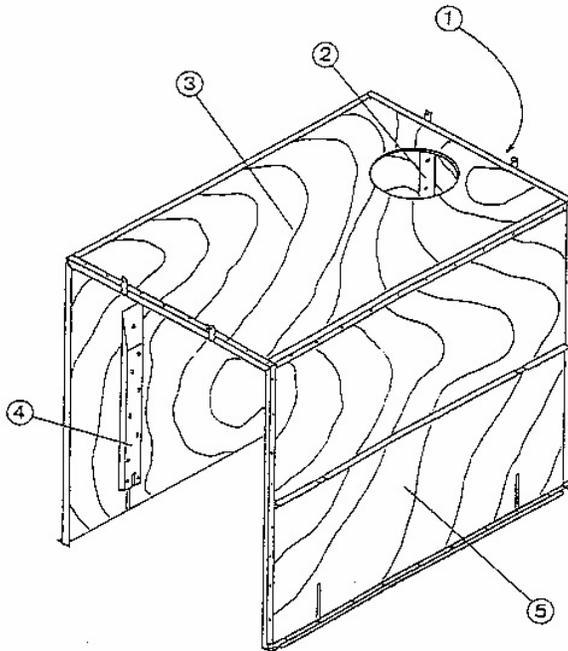


Figure 19 - drying cabinet with cladding and tray guides

Part	Name	Qty	Dimensions	Chamfers
1	Back	1	1201 x 906	1 short edge 1 side
2	Back Tray guide	2	50 x 7 x 1150	None
3	Top	1	1408 x 930	4 edges of 1 side
4	Side tray	4	75 x 14 x 960	See TD016
5	Side	2	1408 x 1213	2 short edges 1 side 3
-	Woodscrews	100	No. 8 x 15	Long

Dimensions are based on the configuration shown in figure 20, which is a cutaway of the top left-hand corner at the back.

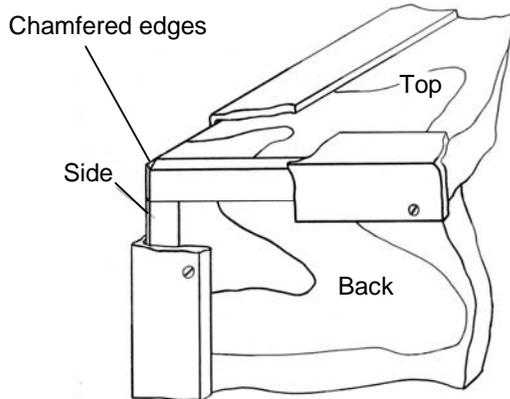


Figure 20: cladding configuration

A large hole is cut in the top of the cladding for the air exit. This should have a diameter of at least 300mm to avoid excessive backpressure. The hole is positioned centrally towards the back, as shown in figure 19.

To allow free vertical movement of the lifting fingers (see figure 31), slots are cut in the side cladding. The slots' positions are also shown in figure 19. Profiling of the bottom back corners of the side cladding is necessary to prevent leakage. This is shown in figure 21.

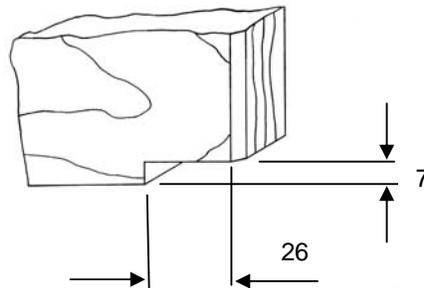


Figure 21: Profiling

Construction

Follow instructions for cladding the base. Note that the holes in the MS angle for fixing the cladding to the framework must be as close to the edge of the MS angle as possible.

Also see the section on Tray Guides as ideally the tray guide should be fitted to the cladding before fitting the frame.

Tray Guides

Tray Guides are needed to align the trays in the drying cabinet. This is to ensure that all the trays fall neatly when the bottom tray has been removed and that trays are then properly positioned for 'pick up' by the fingers.

The guides are fixed to the plywood cladding.

Two guides run down each side and they are positioned to line up with the corner reinforcements. These guides have full chamfers down each side to prevent trays from catching during loading.

There are two guides on the back cladding to line up the trays centrally over the base.

The guides are fixed to the cladding using wood screws:

Part	Name	Qty	Dimensions
-	Woodscrews	25	CSK GALV. ST. No 8 x 15 long
-	Woodscrews	40	CSK GALV. ST. No 10 x 25 long

They are shown in position in figure 19.

Construction

- 1.) Cut and plane the guides to dimensions shown in the engineering drawing TD016
- 2) Screw (using countersunk screws, galvanised if available) and glue (waterproof glue) the guides in position on the cladding side guides and top of finger slots in cladding lined up before the cladding is fitted to the drying cabinet.

Drying cabinet doors

There are three doors in the drying cabinet; two small doors for use in the semi continuous drying mode and a large door for bulk loading and unloading.

The doors consist of MS angle frames with plywood cladding. The cladding on the small doors' overhangs on three edges, to minimise air leakage. On the big door there is an edge strip which serves the same purpose. The cladding on the small doors must be chamfered, and 10mm from the angle corner, on the hinged edge, to allow opening of more than 90 degrees.

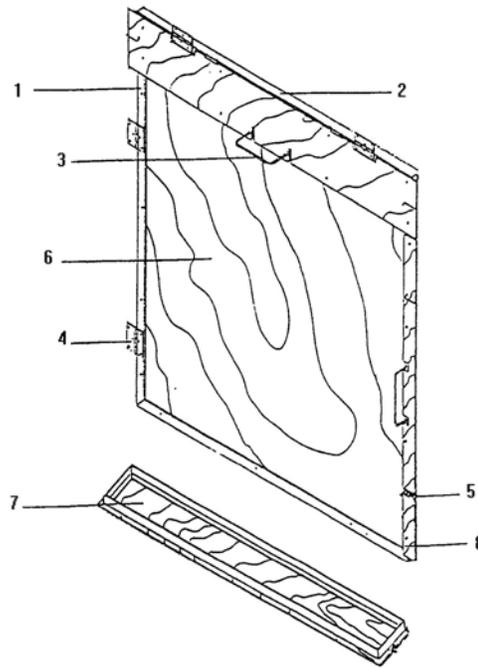


Figure 22: Drying cabinet doors

Part	Name	Quantity	Dimensions	Drawing
1	Large frame	1	25 x 25 x 6 x 3550 long	TD012
2	Small frame	2	25 x 25 x 6 x 2072 long	TD013
3	Handle	3	Diam. 6 x 250 long	TD012
4	Hinge	6	50 x 65 (approx)	TD101
5	Latch	6	60 long (approx)	TD101
6	Large clad	1	876 x 875 x 12	TD101
7	Small Clad	2	936 x 175 x 12	TD101
8	Edge strip	1	50 x 838 x 12	TD101
-	Woodscrews	70	No. 8 x 15 long	-
-	Woodscrews	7	No. 10 x 30 long	-

Construction

1. Make the doorframes from a single length of MS angle cut and bend, as shown in figure 23, or discrete lengths, welded together.



Figure 23: Bent mitre

2. Weld or bolt hinges, handles and latches to each door in the positions given in TD012 and TD013

Where suitable hinges and latches are not locally available they can be fabricated to the design shown in figure 24.

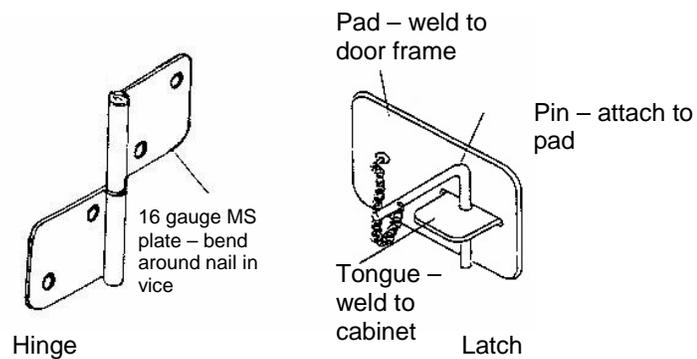


Figure 24: Hinges and latches

General assembly

This section deals with the assembly of the drier components. This assembly of the drier needs at least two people.

Follow these steps:

- 1.) Place the upper frame on top of the base (cladded) and line up the four legs with each other.
- 2.) Clamp the meeting faces together and drill the holes in the upper frame using those in the pads of the base for positioning.
- 3.) Put the nuts and bolts in place, tighten them and then remove the clamps
- 4.) Slide the drying cabinet (cladded) into position; the back and front of the cabinet should be flush with the edges of the base, and the sides should be equidistant from the base tray supports. Mark the positions of holes in the base through those in the angle pads.
- 5.) Drill the holes in the base and fit the nuts and bolts
- 6.) Drill the holes in the upper frame through those in the drying cabinet upper pads and fit nuts and bolts.

Set up the lifting mechanism by following the steps below:

- 7.) Bolt the four plain bearings to the upper frame and place the lower halves of the split bearing in position.
- 8.) Weld two cams to each bearing shaft in the positions shown in figure 25.

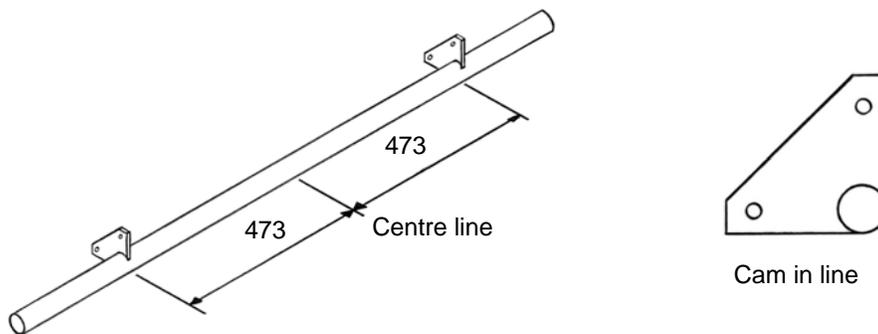


Figure 25: Cams on shaft

- 9.) Mount the bearing shaft in the bearing blocks. Fit the bearing end plates and bolt on the upper half of the left-hand split bearing.
- 10.) Bolt the links onto the upper holes of the cams and set the cams at approx 25 degrees as shown in figure 26.

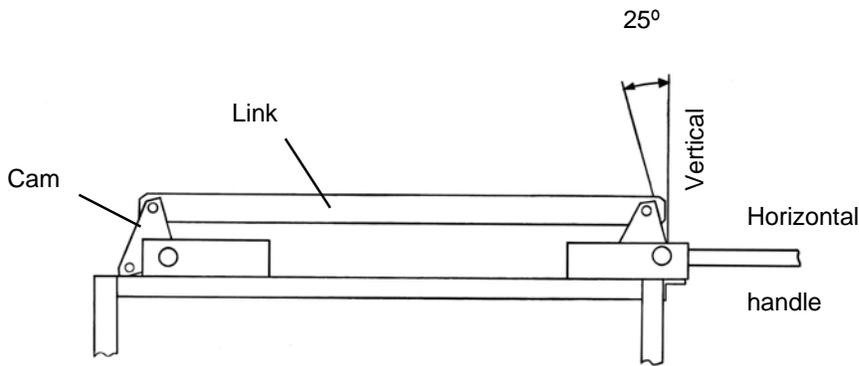


Figure 26: Set at 25 degrees

- 11.) Weld the operating lever to the right hand bearing shaft in a horizontal position. (see drawing TD102)
- 12.) Bolt the fingers in position (see figure 14 for fixing configuration) between the finger supports
- 13.) Connect the top portion of the tie rods to the cams' lower holes, and the bottom portion to the fingers.
- 14.) With the finger – in their lowered position (i.e. resting on the tray support (base) and the operating lever horizontal, clamp the top and bottom portions of the tie rods together (See figure 27)
- 15.) Check the operation of the lifting mechanisms. All the fingers should move exactly together i.e. when one finger horizontal, all horizontal; when one finger raised fully, all raised fully. If all the fingers do not move together equally, then make small adjustments to the lengths of the tie rods. When all fingers are correctly positioned, weld top and bottom portions of the tie rods together.

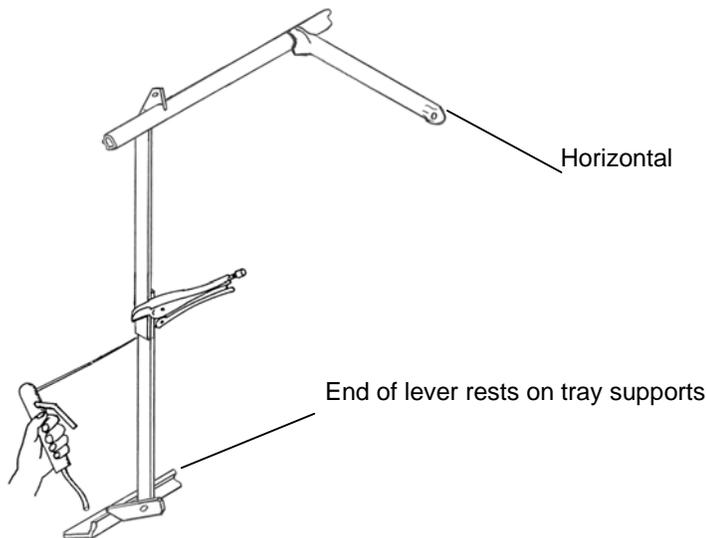


Figure 27: Welding and lifting mechanism

Stop bar and Handle Hook

Before fixing the positions of the stop bar and handle hook four trays are needed to take up any play in the lifting mechanism. Therefore, the section on tray construction must be followed before continuing.

The stop bar is welded to one tie rod assembly to prevent the fingers being raised too high, which would result in the mechanism jamming.

The handle hook is used to retain the handle of the lifting lever extension bar whilst the fingers are in their raised position, allowing the loading and unloading to be performed by one person.

To fix the position of the stop bar:

16.) Place four trays into the dryer.

17.) Fix the operating lever extension to the operating lever and pull down, to raise the second bottom tray and those above it by 25 mm. The fingers will now be in the fully raised position.

18.) Mark one of the tie rods where it passes through the slot in the horizontal beam of the tray cabinet.

19.) Lower the trays and weld on the stop bar at the position marked in stage 18.

Positioning the handle hook requires two people.

To fix the position of the handle hook:

20.) Remove the four trays. One person holds down the operating lever so that the stop bar is hard up against its stop. The other person places the hook on the upper frame centre support, so that the end is roughly in line with the handle (see figure 2) Put the back corner of the handle over the hook end and move the hook down the centre support until it holds the handle in position. Mark the holes in the hook upright through to the upper frame. Remove the handle hook, drill the holes and bolt the handle hook on.

21.) Fit the drying cabinet doors by welding or bolting the hinges in position.

22.) Fit door latches

The drier is now complete, ready to be connected to the heat or hot air source.

It is recommended, however, as it will operate under moist internal conditions that all cladding should be covered with at least two coats of good quality varnish.

Operation and Maintenance

Operation

What follows is a step-by-step description of the use of the drier.

1. Load 15 trays fully and evenly with the material to be dried.
2. Load the trays into the drier with the open ends alternating between back and front, with the bottom tray opening at the front, as shown in figure 28
3. Close the doors and start the blower
4. Now fill the spare tray with material be dried.
5. After the specified drying period for the particular product, pull down on the operating lever and put the handle under the handle hook.
6. Open the small lower door and remove the bottom tray using the long handled metal hook NOT by the tray wall.
7. Remove the lever from the handle hook and raise it in a controlled manner. There will be a bang as the trays fall past the lifting fingers.
8. Open the top door of the drier and carefully slide the filled spare tray in and close the top door.
9. Empty the removed tray of dry product and refill it with material to be dried.
10. Wait for the specified drying period and then remove the bottom tray as described in 4 and slide in full tray etc. etc.

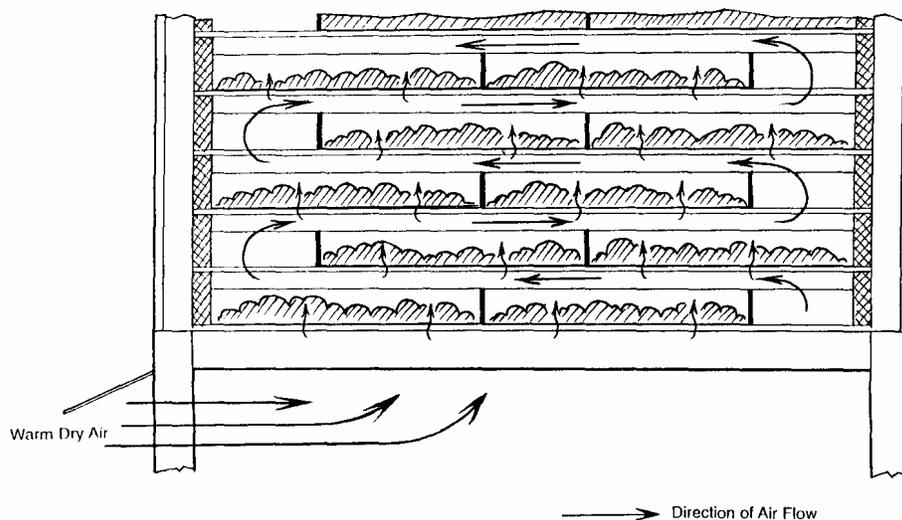


Figure 28: Alternating open ends and airflow

The movement of the fingers during operation is shown in figure 29.

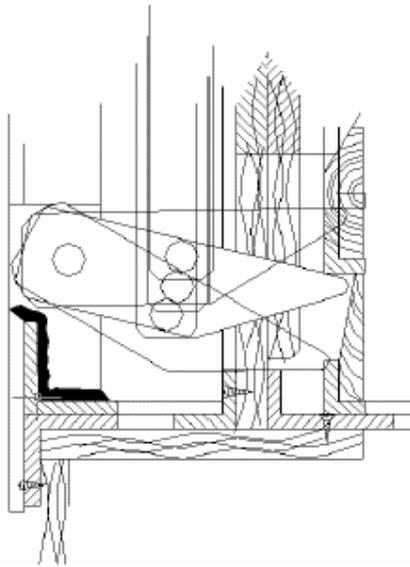
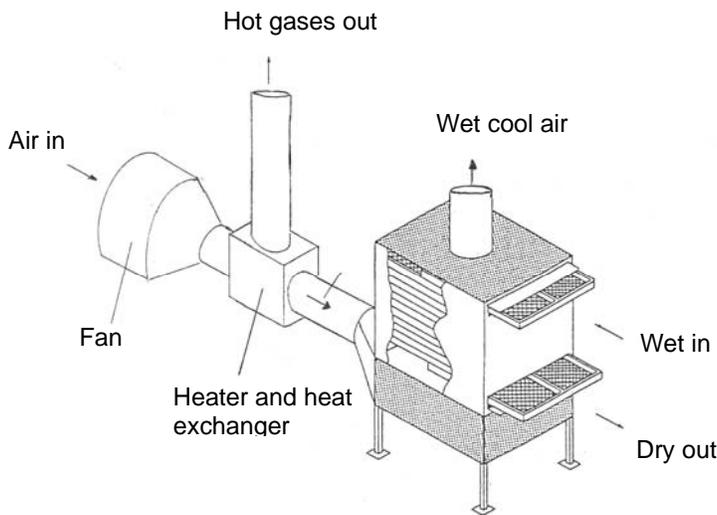


Figure 29: Lifting finger operation

Operational Safety

The drier is perfectly safe if the following simple rules adhered to:

1. Don't put fingers near moving parts
2. Always use the metal hook to remove the bottom tray. NEVER put hands in the gap between the trays



Maintenance

The drier requires very little routine maintenance

- oil moving parts monthly
- thoroughly clean monthly

Other maintenance will be of repair (e.g. tray mesh) and painting nature.

Heating

For effective drying of the produce, warm (max 80 degree), dry, clean air has to be driven through the drier. Hence the drier can utilise any medium grade heat source combined with a heat exchanger and blower.

Most operational units outline an indirect (fuelled) thermostat heater blower, either diesel or gas fired. One model that has been found particularly appropriate is the Benson-Jetaire Zeta, with an output of 60KW (220,000BTU) and an airflow of about 1700 cfm.

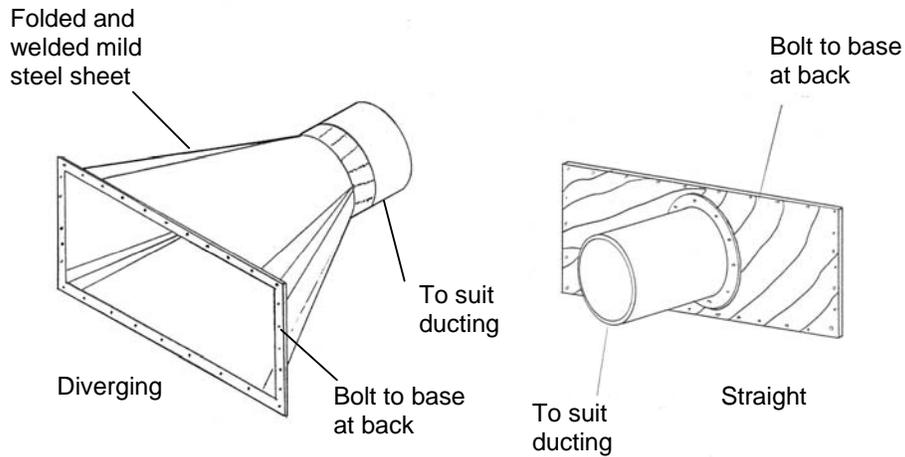


Figure 31: Diverging and straight connectors

Diverging connectors have been used in the past for their low-pressure loss. The alternative, straight through connector shown would be a lot cheaper, without significantly increasing pressure losses, but has not been tested.

Trouble Shooting

1. Difficulty with loading trays into cabinet
 - Check dimensions of tray guides
 - Is the angle iron ramped or recessed to the corners of the trays?
2. Tray not falling properly at top of stack
 - Check tray guides, have tops of the tray guides been chamfered
3. Trays not falling cleanly at bottom of stack
 - Check width of tray with the angle iron lengths attached. Is the tray width the distance between fingers lowered position minus 2mm
 - Are all the fingers fully lowered when lifting handle is horizontal? (if not see below)
4. Unable to properly raise trays
 - a. Check that all fingers are fully lowered when lifting handle is horizontal. If not make necessary adjustments to length of tie rod and/ or stop mechanism
 - b. Check that all fingers move up together when handle is pulled down
 - If not check the lifting mechanism for slack i.e. properly tightened nuts and bolts
 - If the fingers are still not moving up together make adjustments to length of tie rods to ensure that when fingers are in the fully raised position the stack of trays can be lifted clearly and evenly (i.e. trays do not slip off end of finger)
 - If the trays are still slipping off the fingers, Small adjustments can me made to the finger length by building up the tip with held?
5. Doors
 - All doors should be open and closed easily. If during construction of frame the doors operate properly but once cladded the doors do not open or shut properly it may be that the inner frame has shifted out of square. It will be necessary to adjust the doors accordingly. A temporary measure is to correct the inner frame shape using a wedge of wood jammed between the inner and outer frames.
6. Heater Blower
 - A manual is provided with the UK manufacture heater blower unit most commonly used with the Practical Action Tray Drier

Additional Points

A flue must be connected to the heater unit to take away exhaust gases. This should not contain any sharp bends (smaller than 45 degrees) as otherwise the efficiency of the burner is affected.

Operation at high altitude: At high altitudes there is less oxygen available for combustion and there is less weight of air per unit volume being forced through the drier. Unless adjustments are made to the burner - for example, smaller injector nozzle size and/ or increasing amount of air entering burner – then combustion efficiency will be poor.