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Droits d'auteur

A Homebuilt Threshing Machine For Smallholders

A design manual for a small scale threshing machine

(Draft subject to revision)

By Stephen Simpson

July 2011

Disclaimer

This design manual is intended as a guide to facilitate the sharing of knowledge and technology transfer. Whilst every effort has been taken to ensure the accuracy of the information in the manual, the author assumes no responsibility or liability for any injury, loss or damage incurred as a result of any use or reliance upon the information presented. It is a sad state of affairs that this notice is required in today's litigation culture.

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Contents

1. Introduction

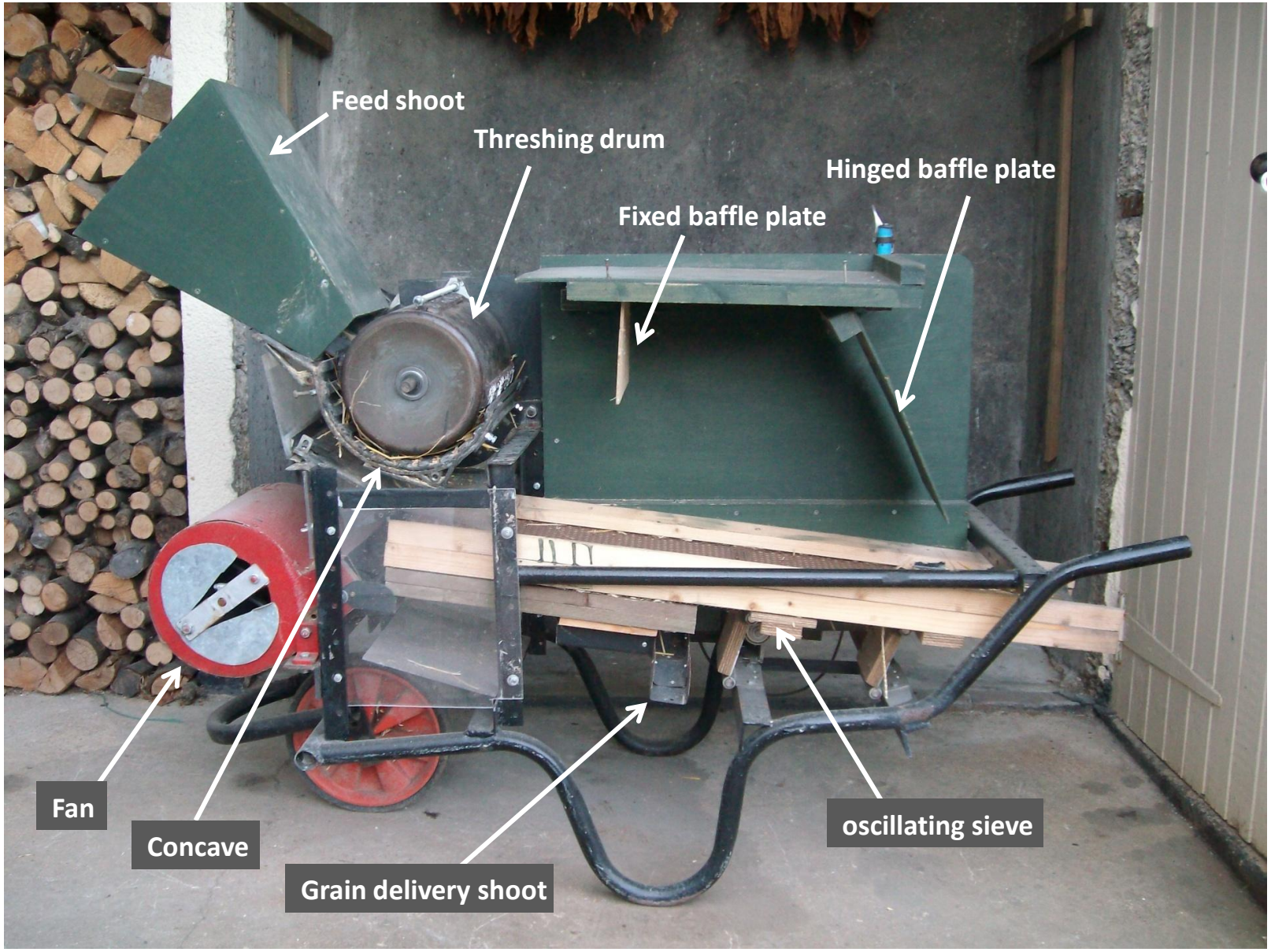
This threshing machine was developed to address labour shortages when harvesting wheat and other small grains in a smallholder situation. The machine may also be suitable for small-scale (market garden) vegetable growers who would like to grow wheat as a break crop in their rotation and use the straw for mulching. The design presented may appeal to the enthusiast, while others may consider it complicated or too costly. The following passages are for the enthusiast with mechanical aptitude or those considering “back to the land “ type lifestyle changes. The reader is urged to view any investment in building - and using - the machine as an investment in skills and knowledge to pass on to the next generation. For further investigation of the economic viability of this machine, the reader is referred to the work of E. F. Schumacher in his publication, Small is Beautiful: *A Study of Economics As If People Mattered*.

The machine is operated by holding a small bundle of the crop (heads first) against a rotating threshing drum, which beats out the grain and strips off the heads to be threshed against a concave. The straw bundle is then discarded to one side and the process repeated.

This document outlines the construction of the threshing machine using competent fabrication skills and mostly second hand or recycled components. The metalworking skills required include cutting, grinding, electric arc welding, bending, drilling and thread tapping. The reader should appreciate there is a degree of tolerance in the measurements given and scope for substitution of materials and modification/improvement to suit local conditions. All measurements shown are in millimetres unless otherwise stated.

The power source shown is a three hp single cylinder gasoline engine. Actual power requirements have not been calculated but are thought to be around ½ hp. **Alternative power sources such as, DC motor with solar/wind charged battery, animal draught and mechanical wind or hydro power in certain locations should be considered. A pedal powered variant of this machine is discussed further on page 8.3.** No patents are applied to the design and providing the author is acknowledged it may be freely copied and distributed.

1.1. Overview of the major components



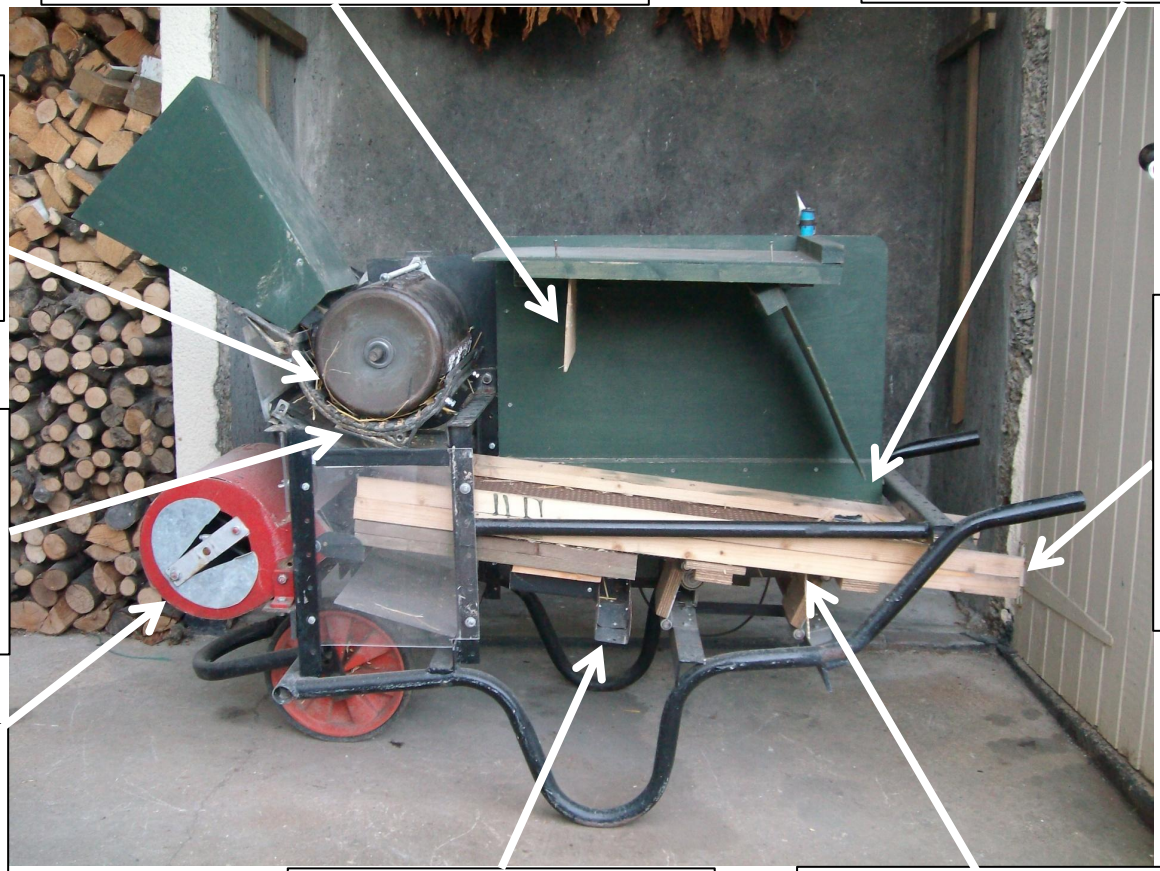
Note: Right hand side panels and emergency stop linkage removed for clarity

1.2. How the machine works

Grain and chaff thrown out by the threshing drum is deflected into the fan air stream by this baffle plate.

The hinged baffle plate concentrates the air flow at this point to improve sieve cleaning.

The grain is beaten or rubbed out of the heads as it passes between the rotating threshing drum and concave.



Most of the chaff, threshed heads and light straw is discharged at the end of the top sieve here.

The grain falls through slots in the concave and passes through the fan air stream onto the sieves.

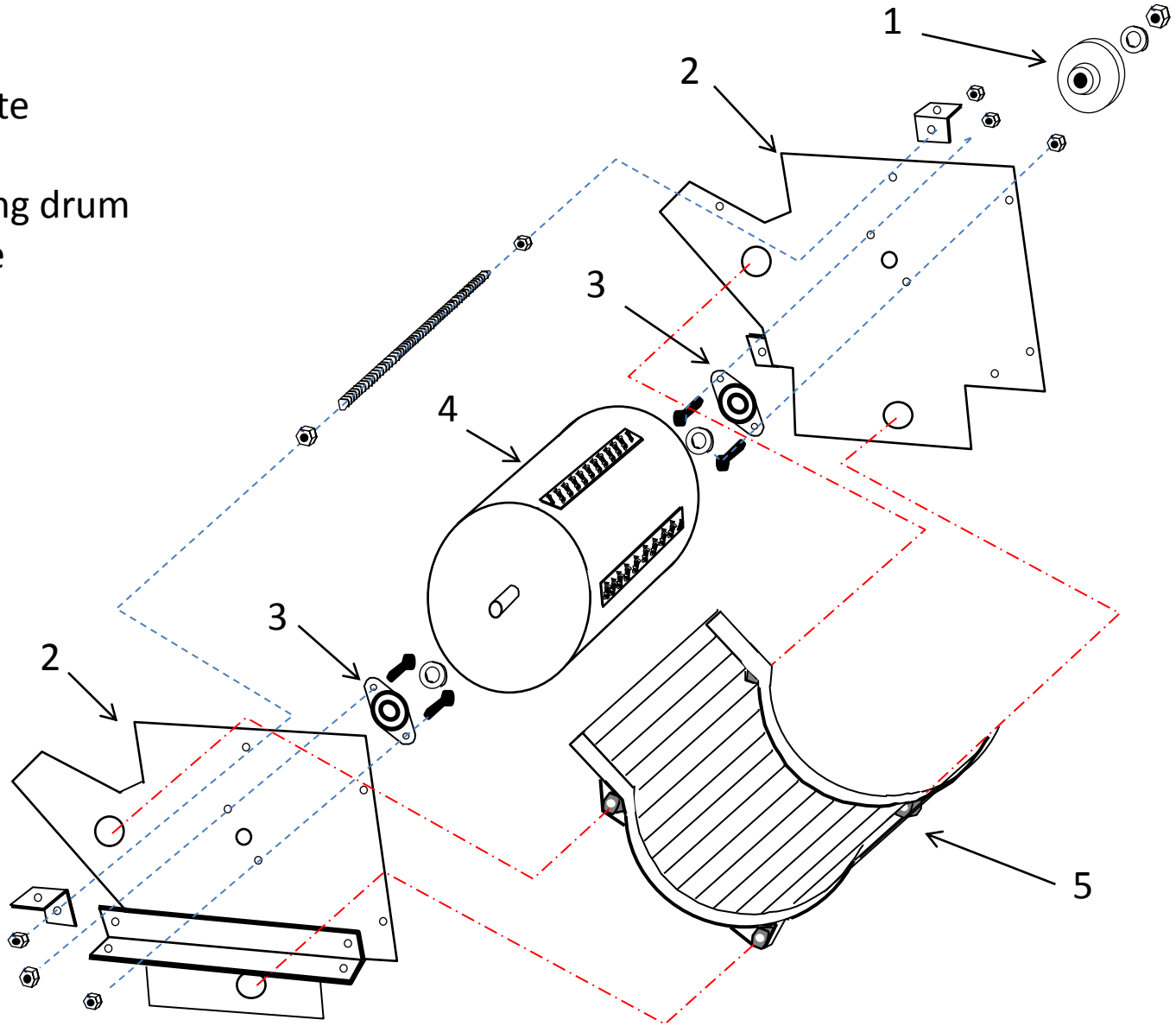
The fan separates the chaff and light straw from the grain. The air flow is adjusted by opening or closing the choke on the fan air intake.

Clean grain is discharged at the end of the bottom sieve here.

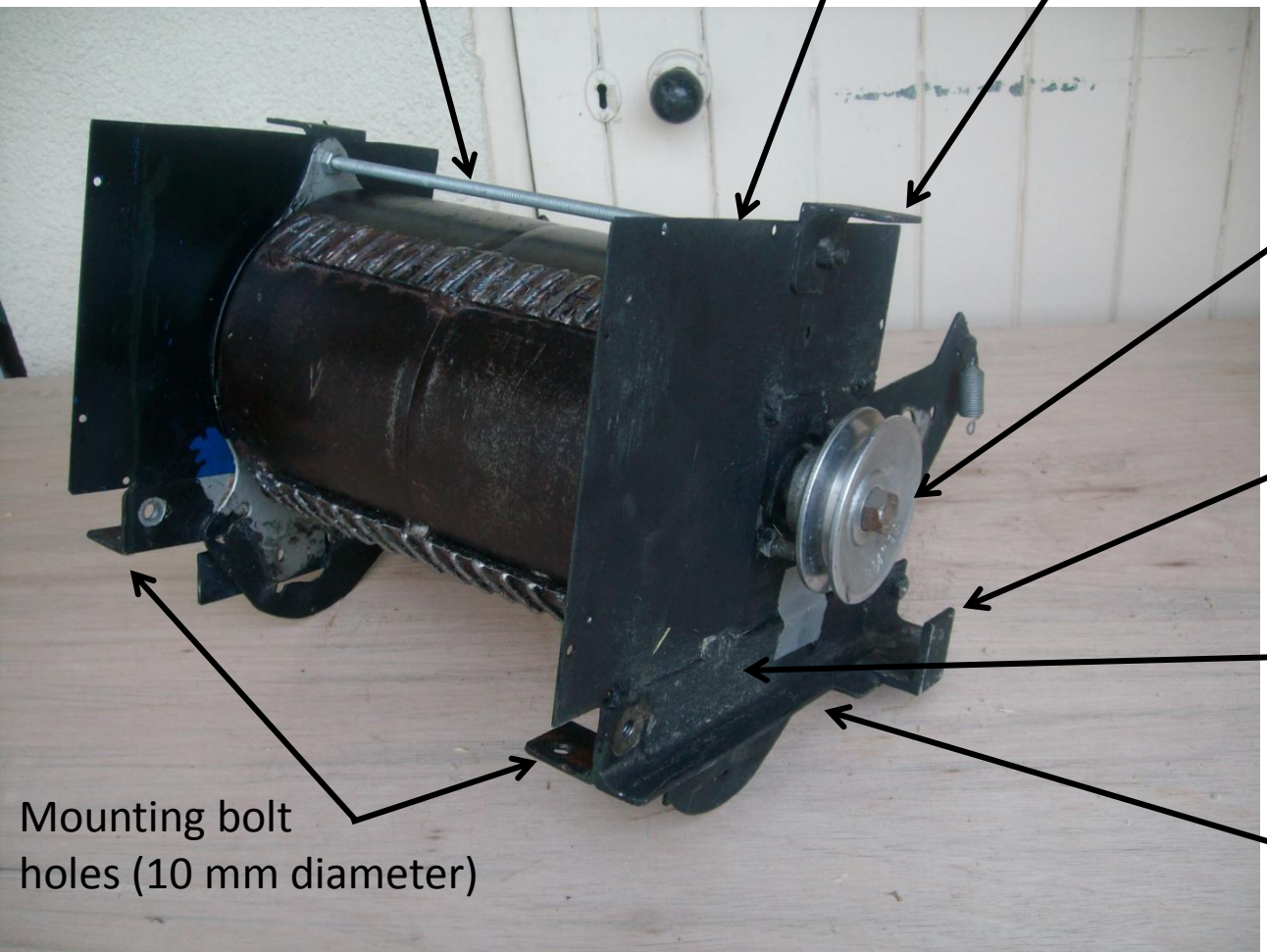
Unclean grain and incompletely threshed grain is discharged from the middle sieve. This is collected and put back through the machine for further threshing/cleaning .

2. Threshing drum and concave

1) Pulley
2) Side plate
3) Bearing
4) Threshing drum
5) Concave



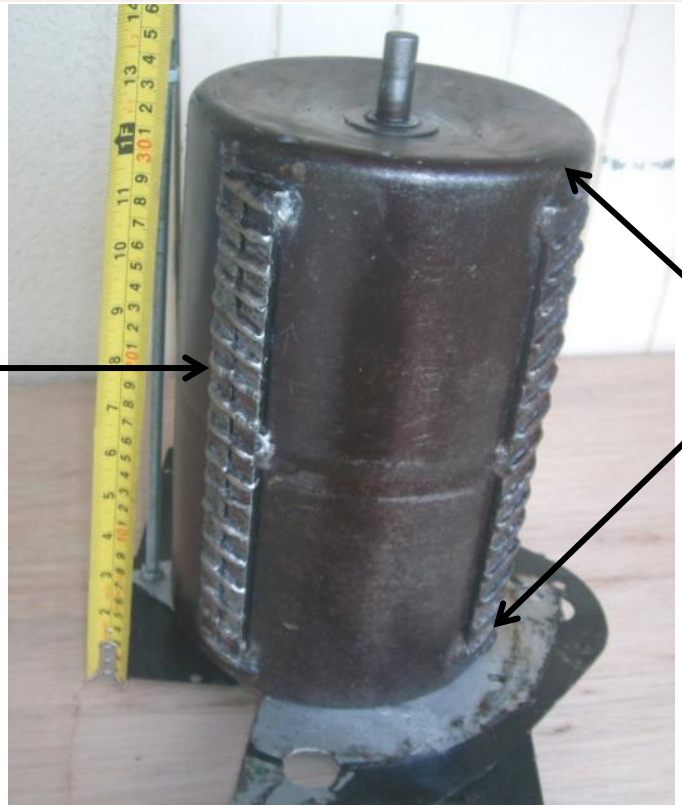
2.1. Threshing drum assembly



2.2. Threshing drum

The threshing drum is made from the rear roller of a lawn mower (typically 300 mm long and 190 mm in diameter)

Four rasp bars are formed from 14 mm x 5 mm flat steel (two pieces per rasp bar) Weld the rasp bars to the drum at exactly 90 degrees to each other.

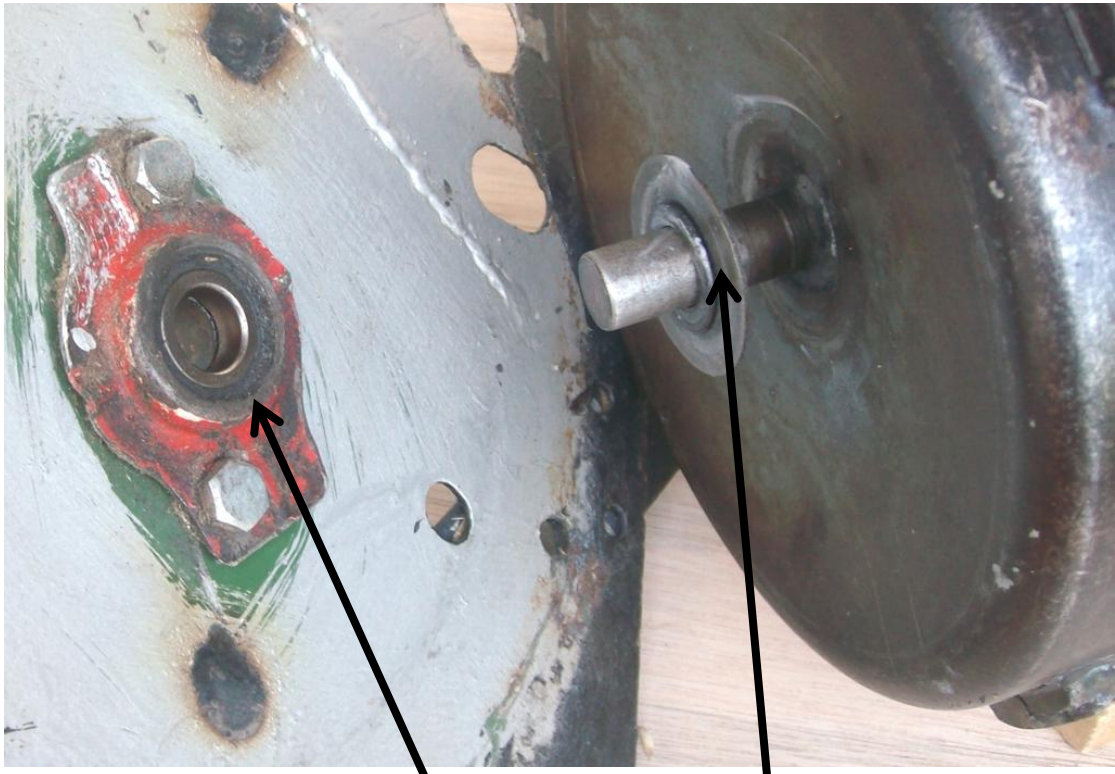


30mm clearance between end of rasp bar and edge of drum

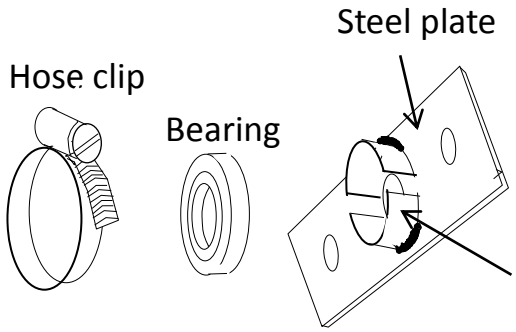
Lay runs of weld along the rasp bars to cerate the teeth. Angle the alignment of the teeth to the right on the first rasp bar, and to the left on the second bar, and then to the right on the third, and finally to the left again on the forth bar. Grind away any high spots so all the teeth protrude the same amount. Try and keep the amount of weld used on each bar roughly the same as the drum will need to be balanced later (see page 8.).

2.3. Drum bearings

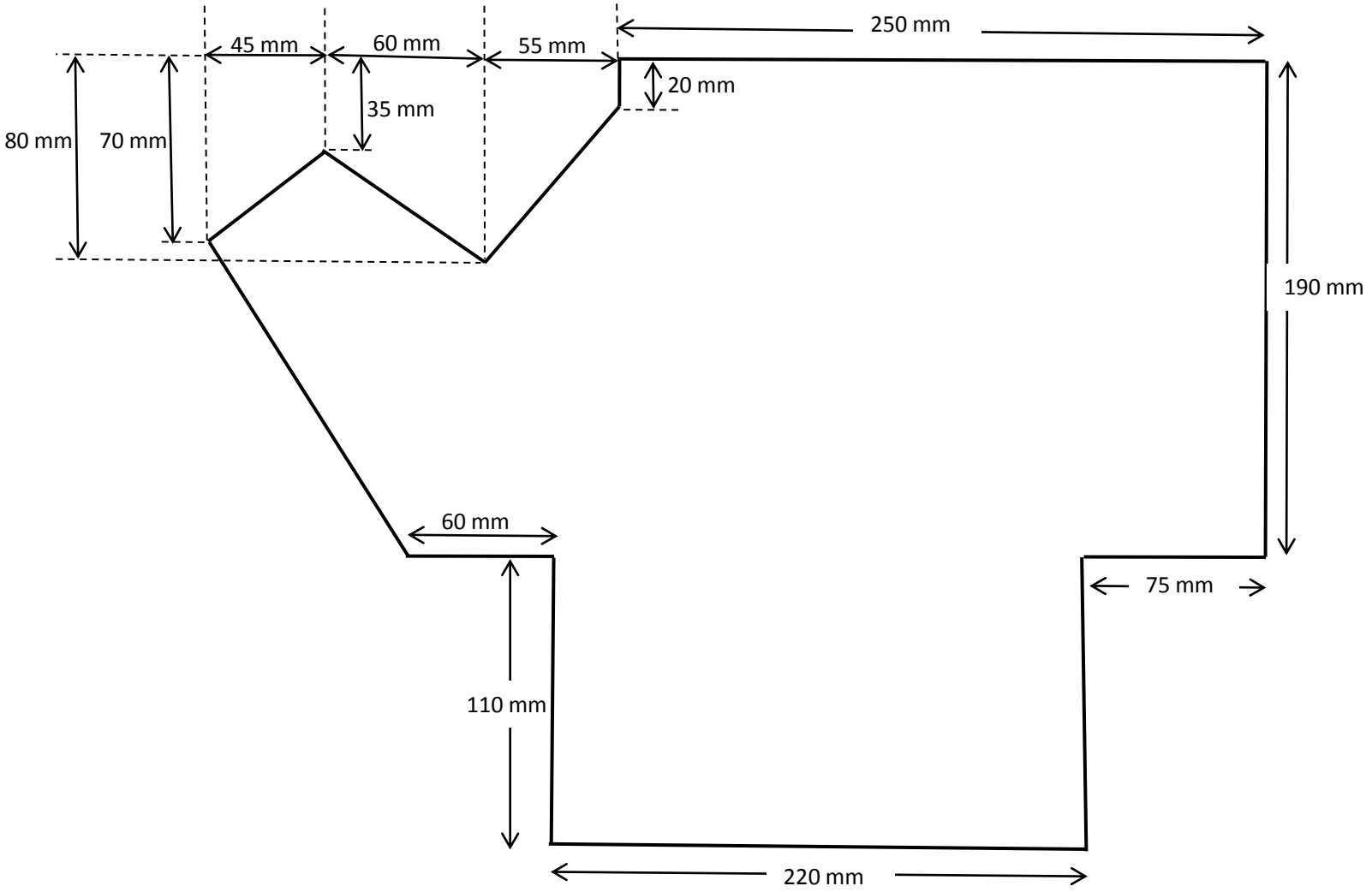
It is important to use sealed bearings because of the dusty environment.



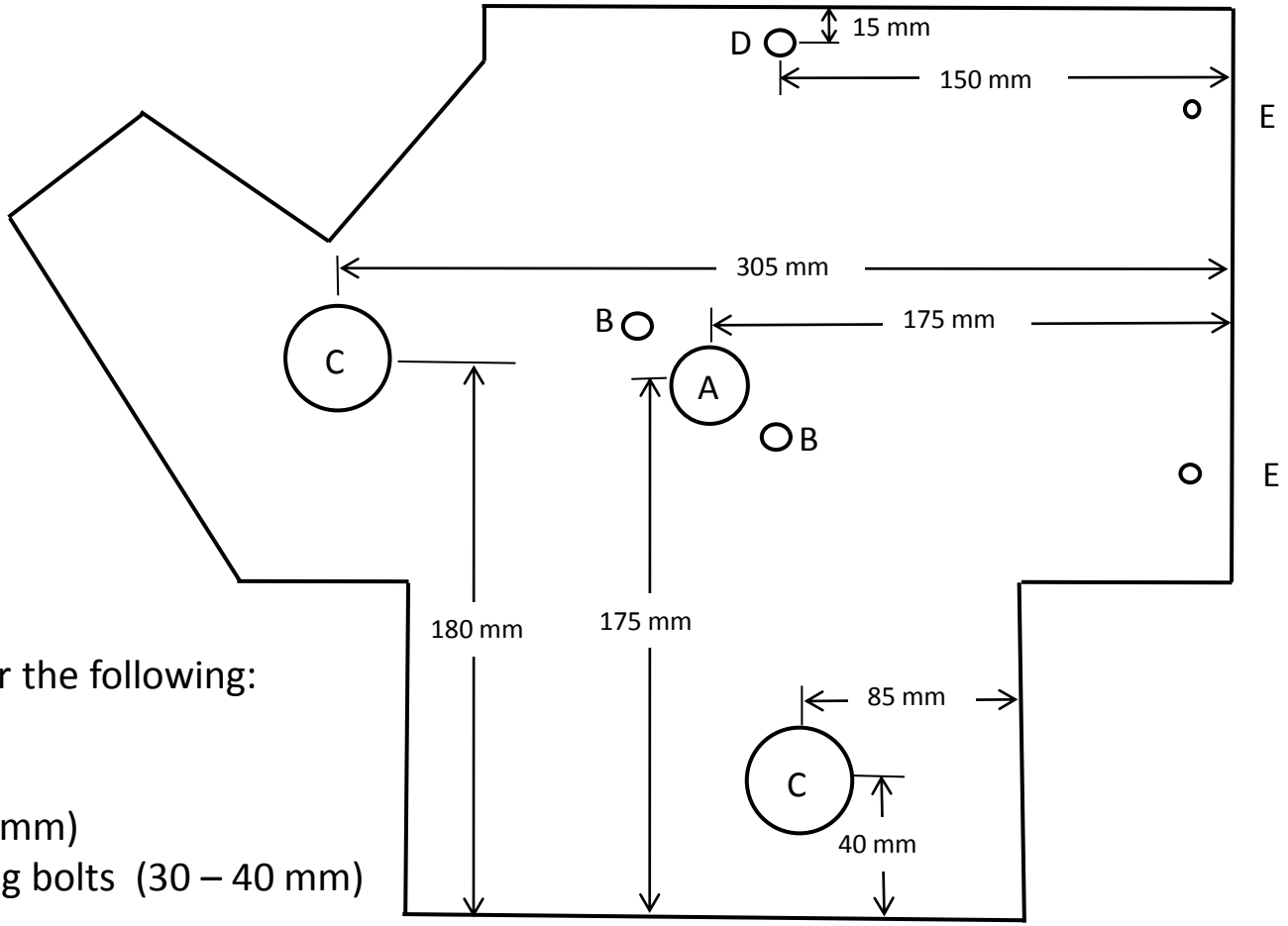
Home made bearing housing



2.4. Side plates



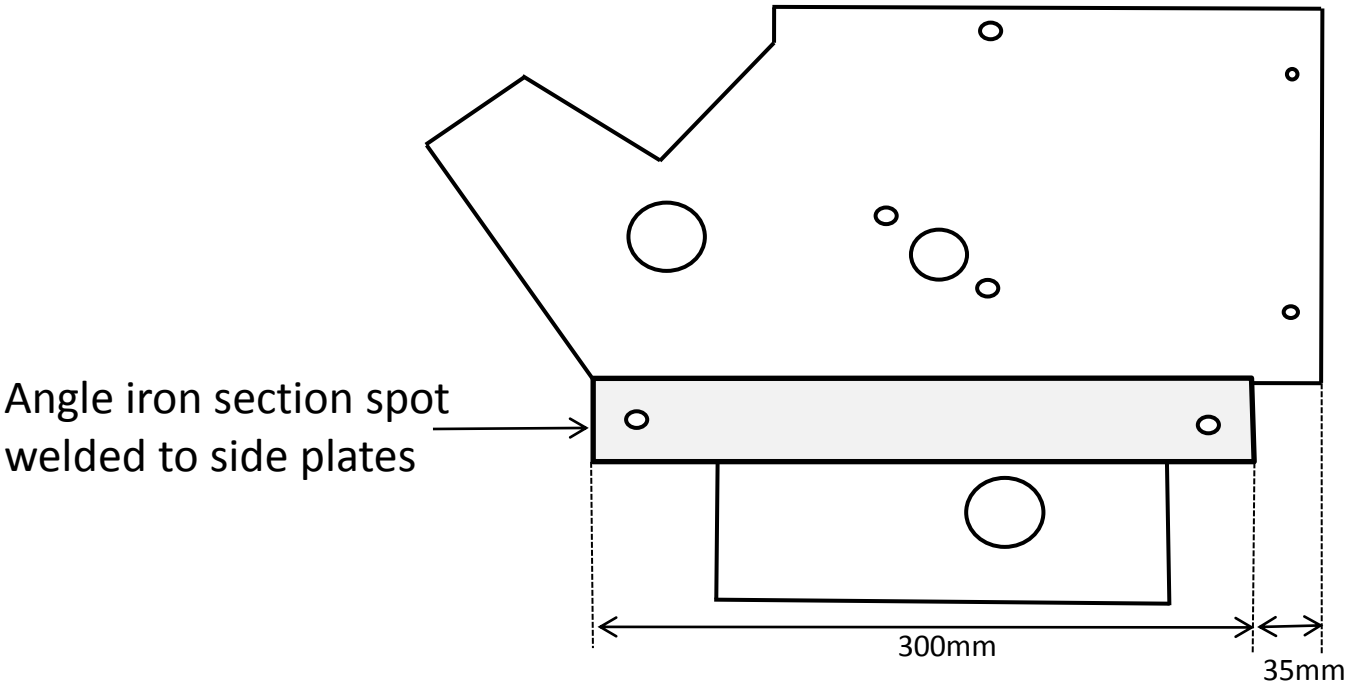
2.5. Side plates continued



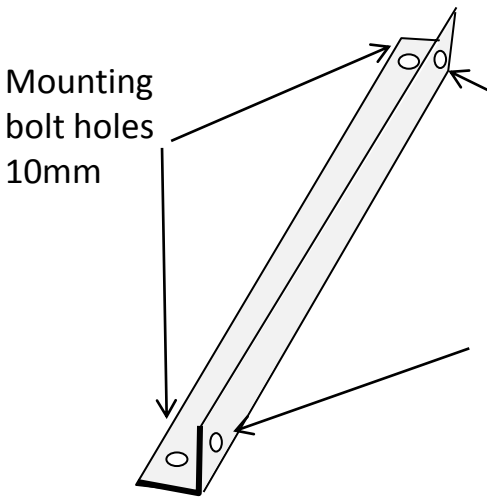
Location of holes drilled for the following:

A, Drum shaft (3/4”)
B, Bearing housing bolts (8mm)
C, Drum clearance adjusting bolts (30 – 40 mm)
D, 8mm threaded bar
E. No. 6 Wood screws

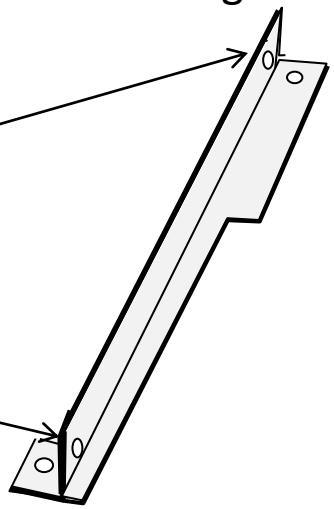
2.6. Side plates continued



Right hand angle iron section

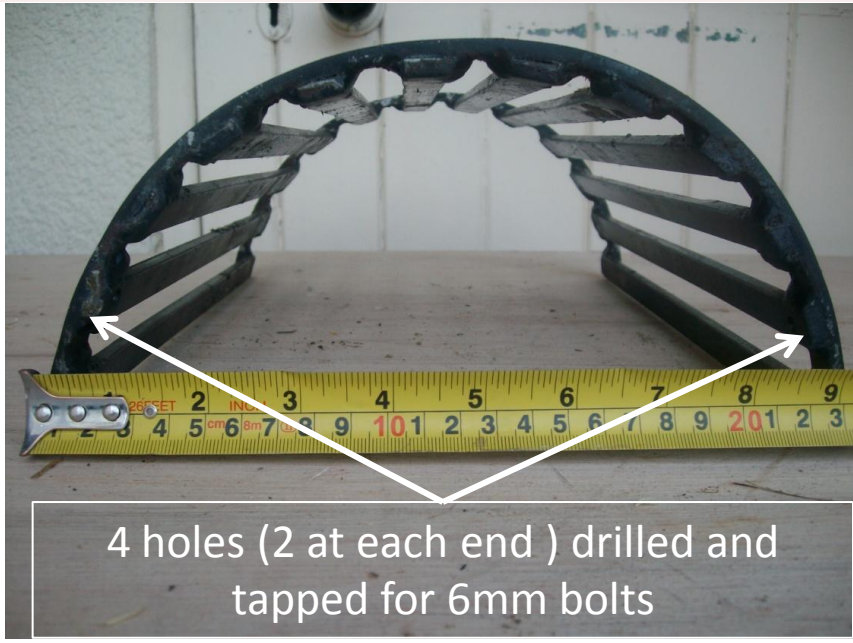


Left hand angle iron section



2.7. Upper concave section

Fabricated from 14 mm x 5 mm flat steel
Radius around 115 mm
Overall length 305 mm
Width of slots 14 mm

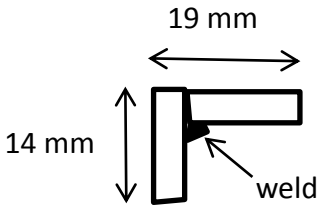


Make the upper concave section first and then use it as a former to build the lower concave section around it

2.8. Lower concave section

Horizontal slats fabricated from 14 mm x 5 mm flat steel
Curved end sections made from 30mm x 4 mm flat steel
Radius (formed by the upper concave)
Overall length 310 mm
Width of slots 12 mm

Note: each horizontal slat uses two pieces of flat steel welded to give an L shape. This stops the slats bending.



Mounting for feed shoot welded after assembly on the main frame (dimensions are not critical, set the angle to give correct height for the feed shoot, (see page 3.3.).

Drum clearance adjusting bolts, (8mm nuts welded to concave section)

Elongated holes for 6 mm bolts

2.9. Upper and lower concave assembly

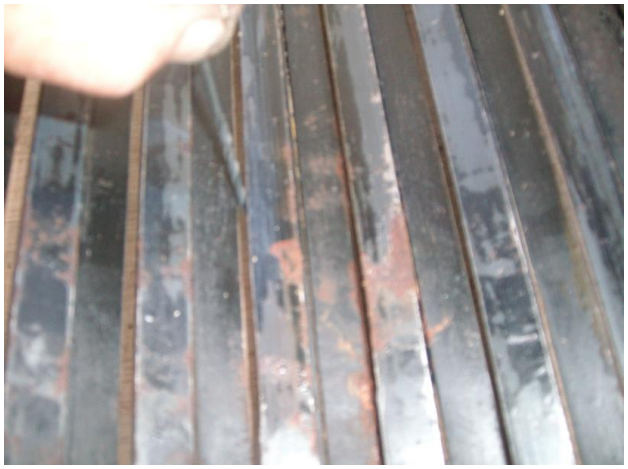
Mounting for feed shoot

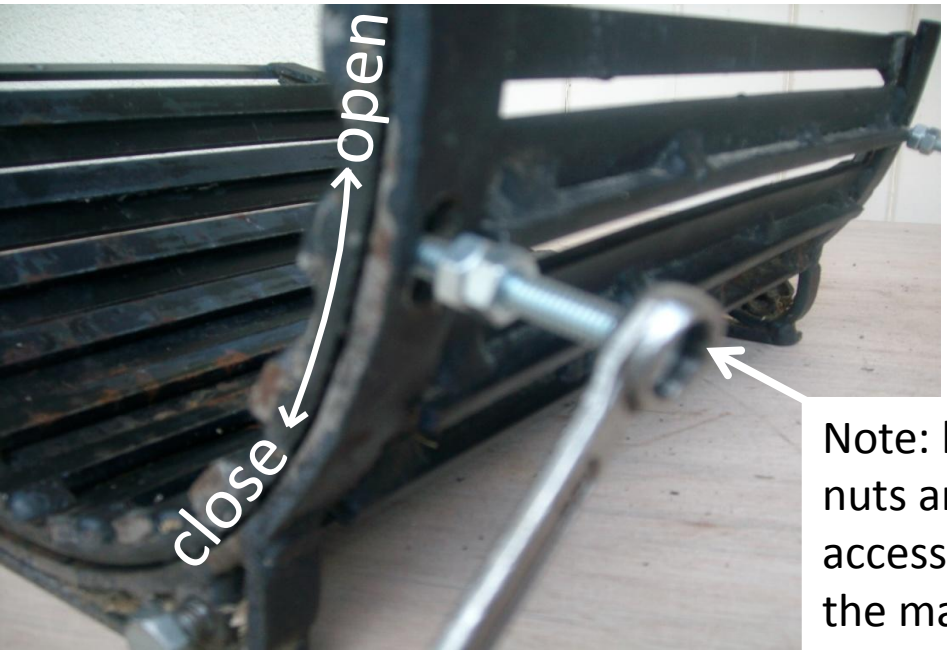
Mating surfaces cleaned up with a disk grinder so upper concave is free to slide/rotate back and forth

2.10. Concave opening

Concave fully open for peas or small beans

Concave open to 2-3 mm for small grains





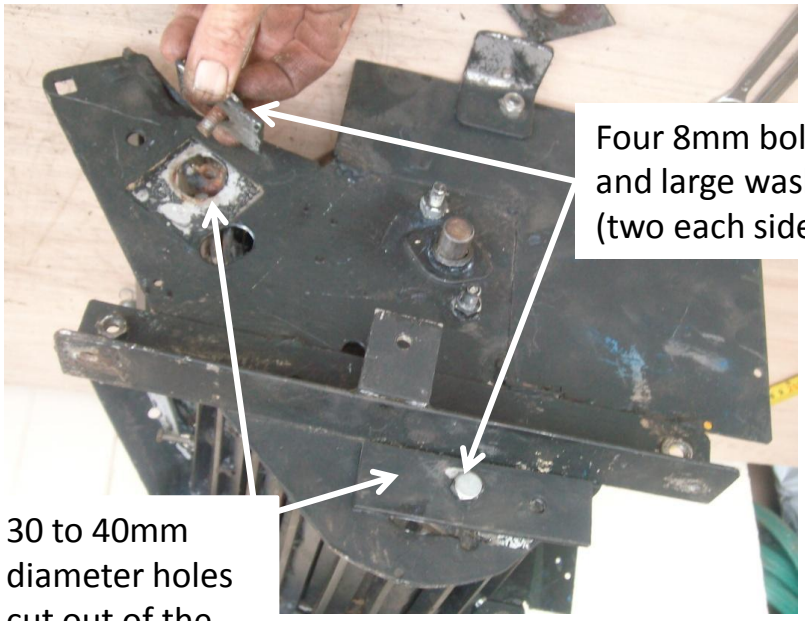
The degree of concave opening is locked in position by four 6 mm bolts

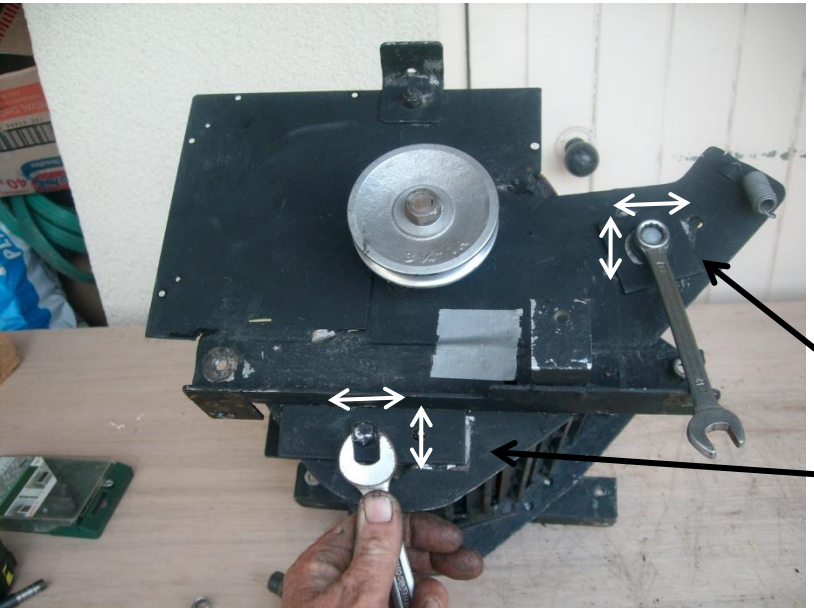
Note: long blots with two lock nuts are used to facilitate easy access when fully assembled on the machine

2.11. Drum clearance adjustment

Large clearance

Small clearance

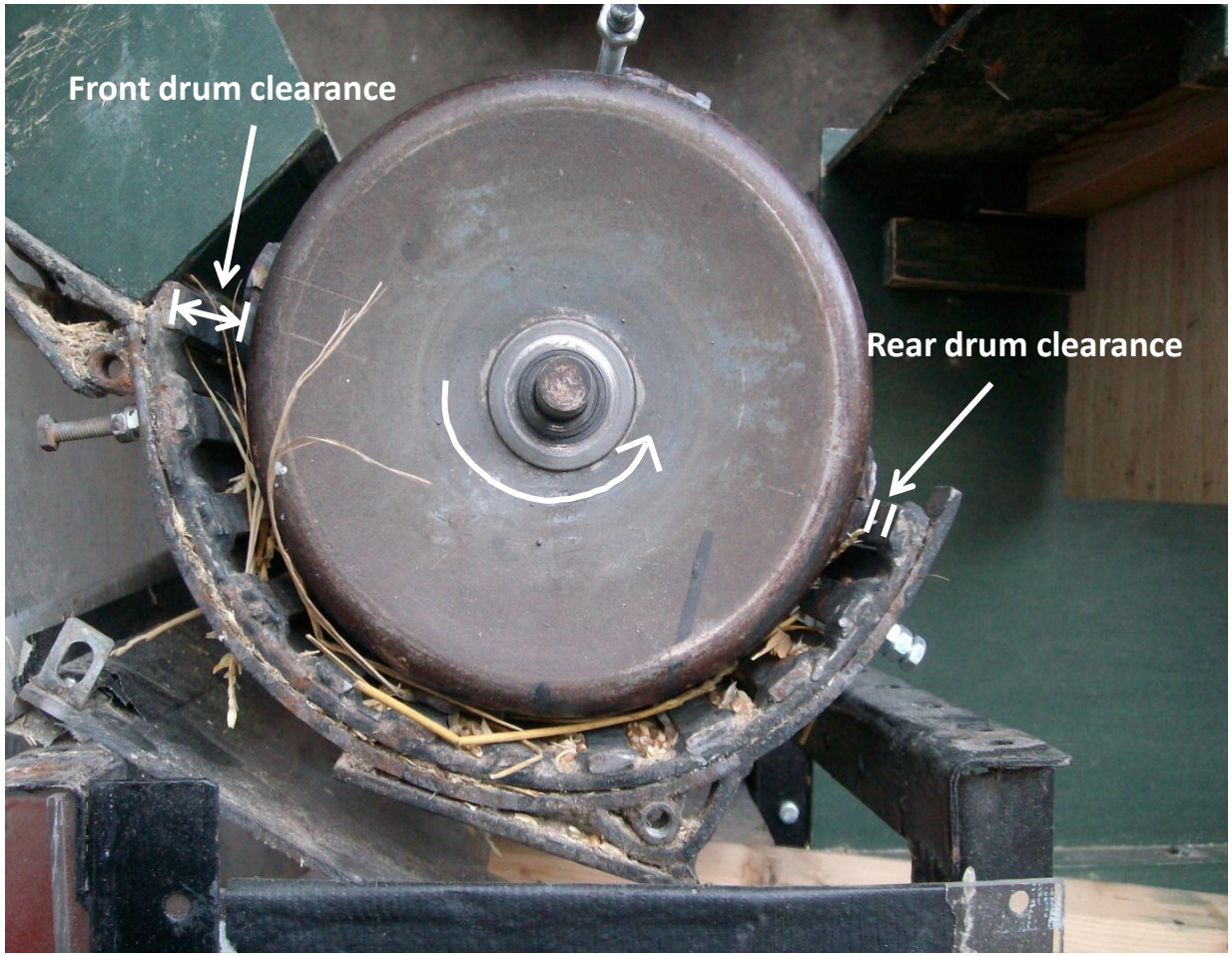




The drum clearance is adjusted by moving the concave up and down and/or forwards and backwards. The concave is locked into position by tightening the 8mm bolts. This adjustment is made after the drum and concave assembly is bolted in place on the machine.

2.12. Drum clearance adjustment continued

The front drum clearance is always set greater than the rear drum clearance. The smaller the drum clearance the more aggresive the threshing action and vice versa. Typical settings for wheat would be a front drum clearance of 15 to 20 mm and rear drum clearance in the order of 1 to 3 mm.



Note: side plate removed for clarity

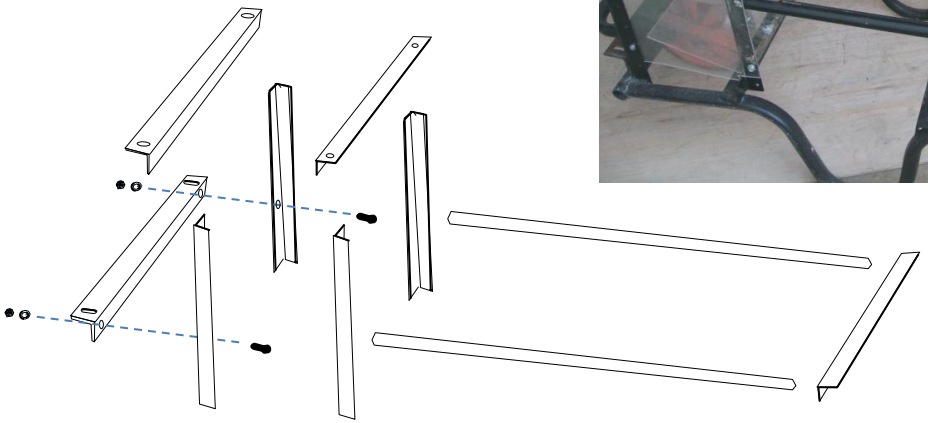
2.13. Mounting the drum and concave to the main frame

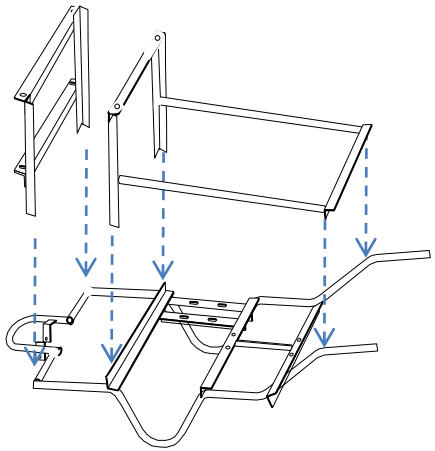
The oversized holes give a degree of adjustment to align the threshing drum pulley with the engine pulley

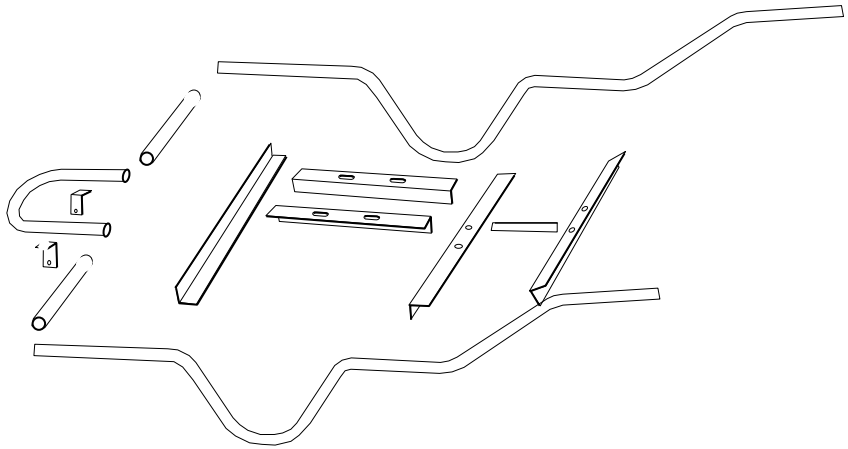
The threshing drum and concave assembly is bolted to the frame using four (8mm) bolts with spring washers or locknuts.

3. Main frame

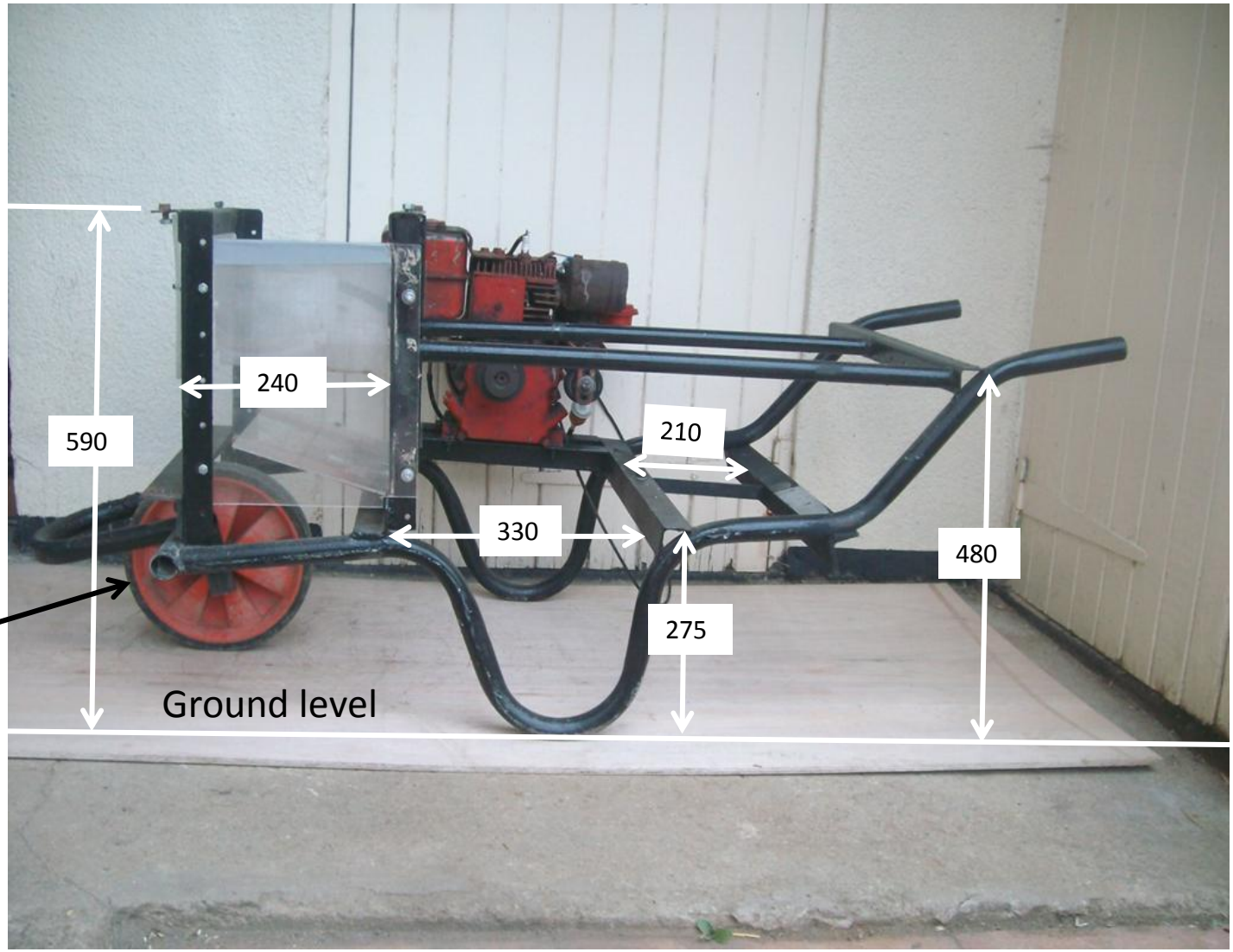
Fabricated from angle iron, steel pipe and a heavy duty wheelbarrow







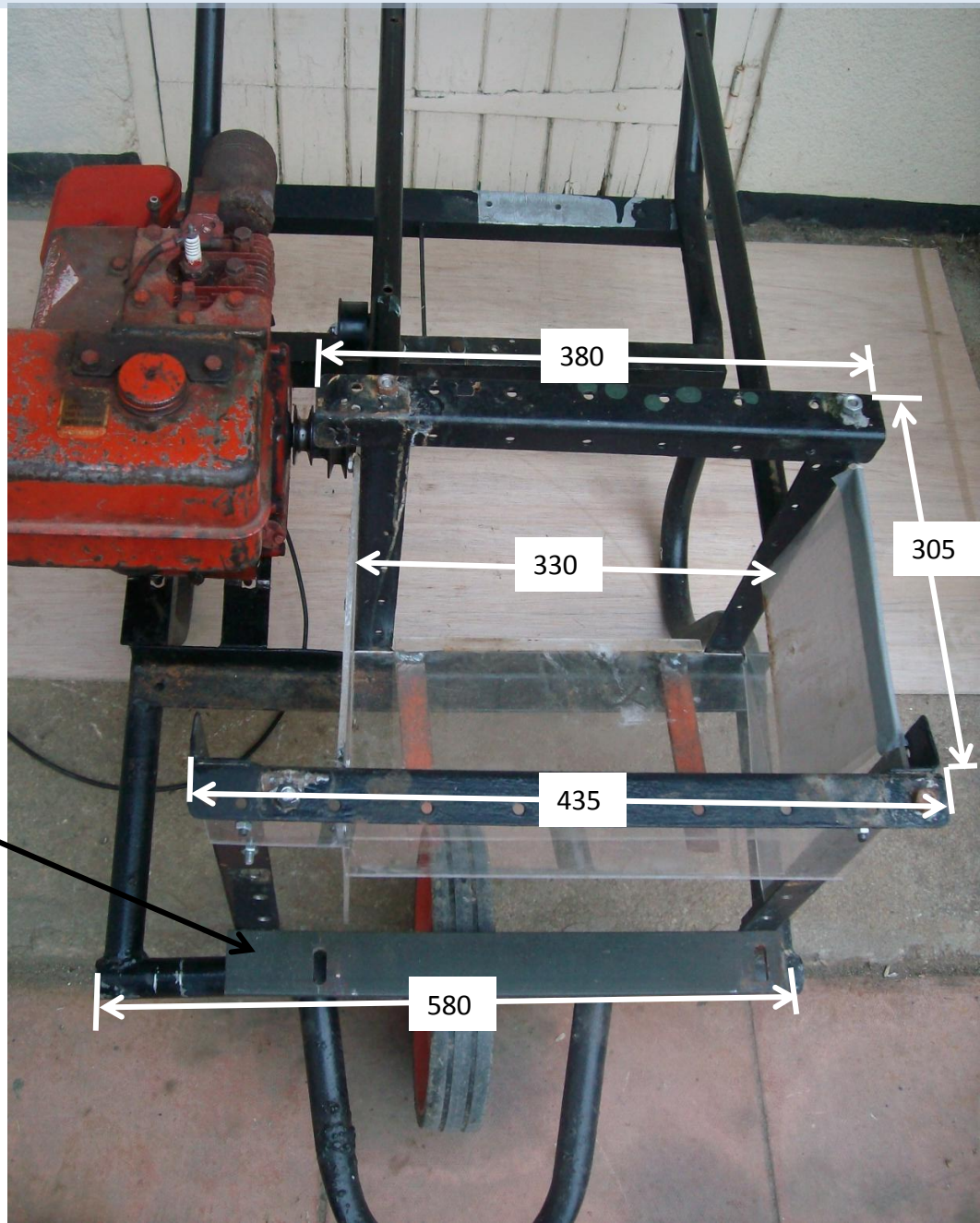
3. 1. Main frame dimensions (mm)



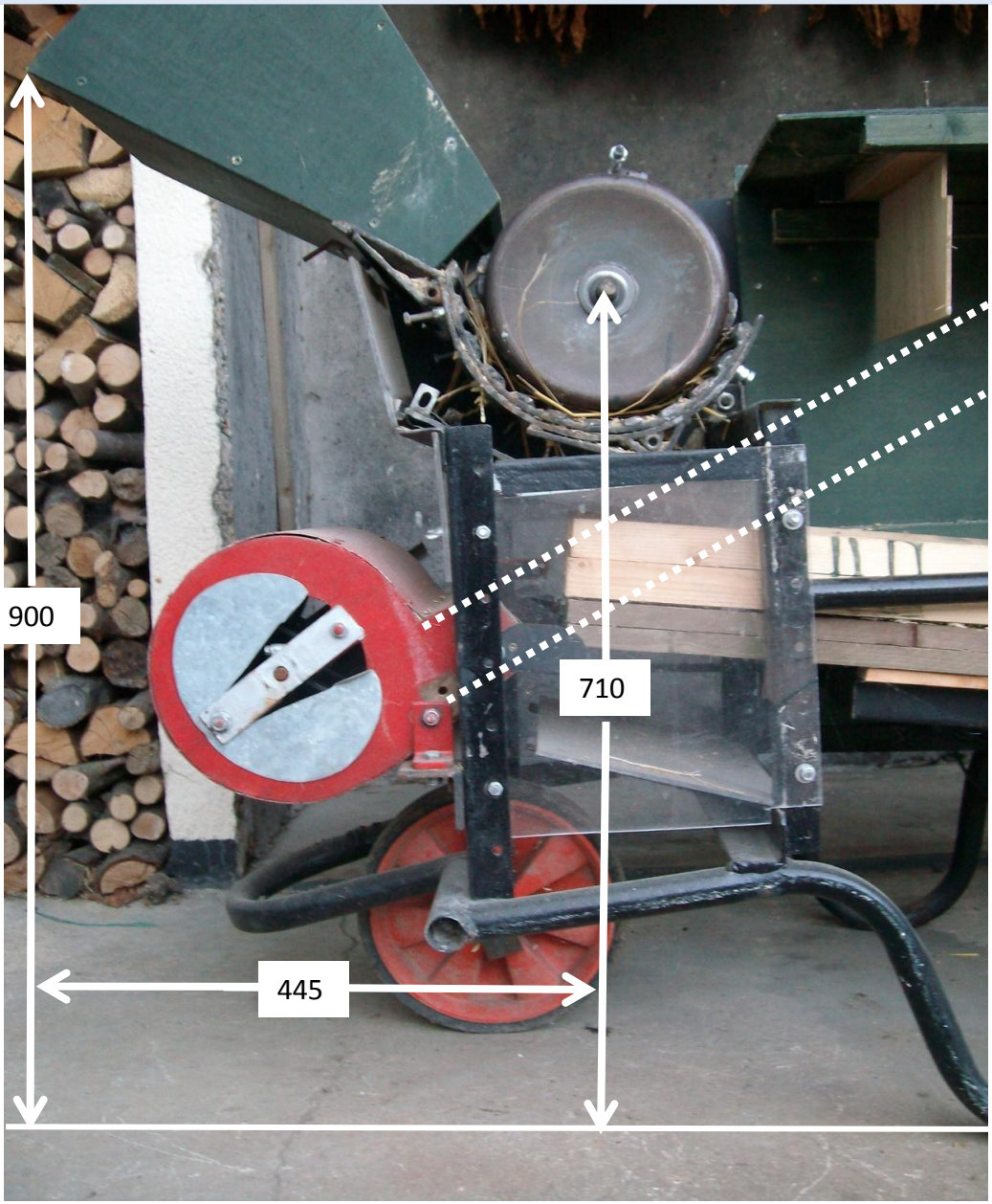
Smaller wheel used to give room for fan mounting

3. 2. Dimensions continued

50mmX50mmx6mm angle iron with 9mm elongated holes for fan mounting is bolted to the main frame with 8mm bolts

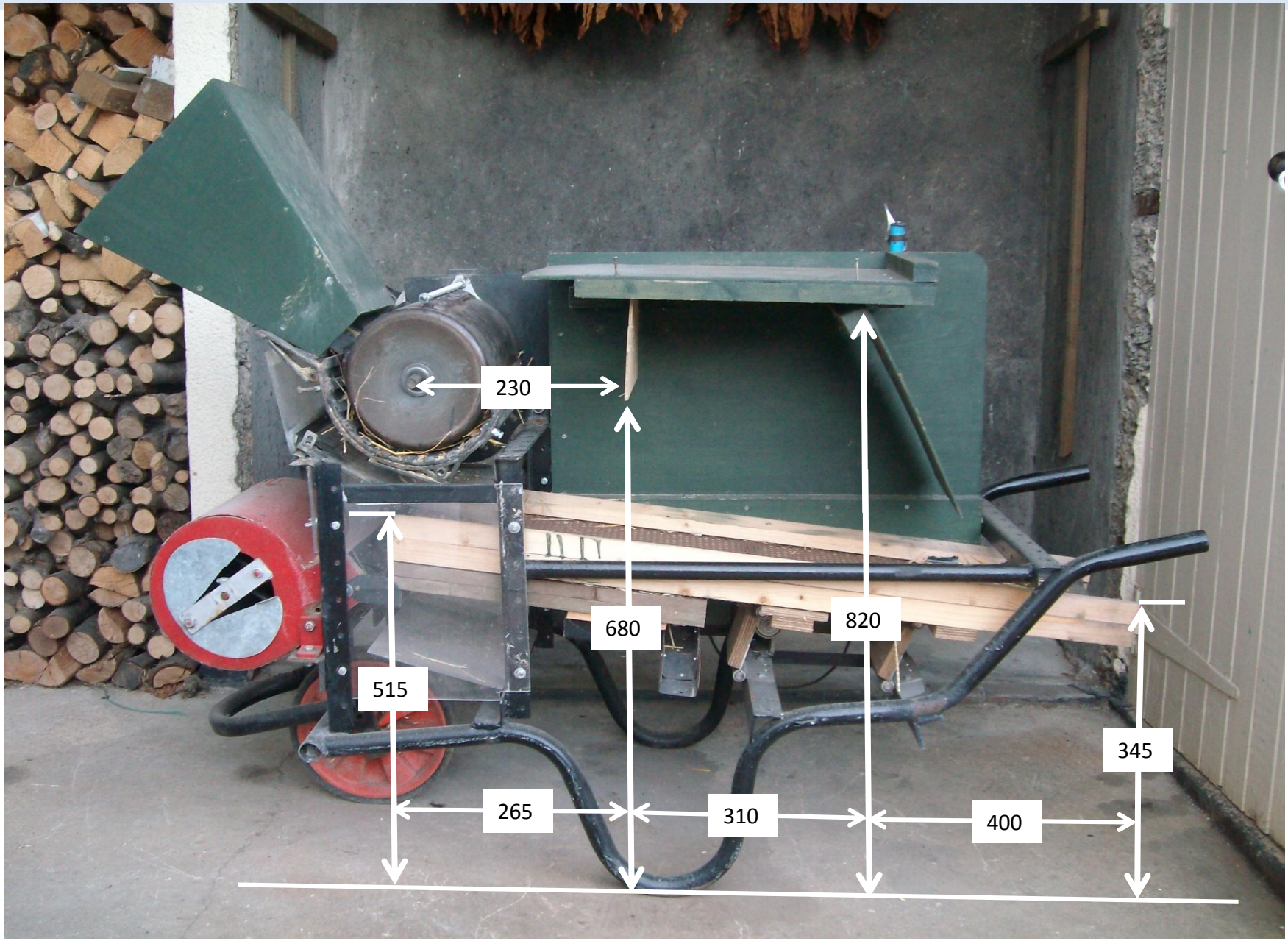


3. 3. Dimensions continued

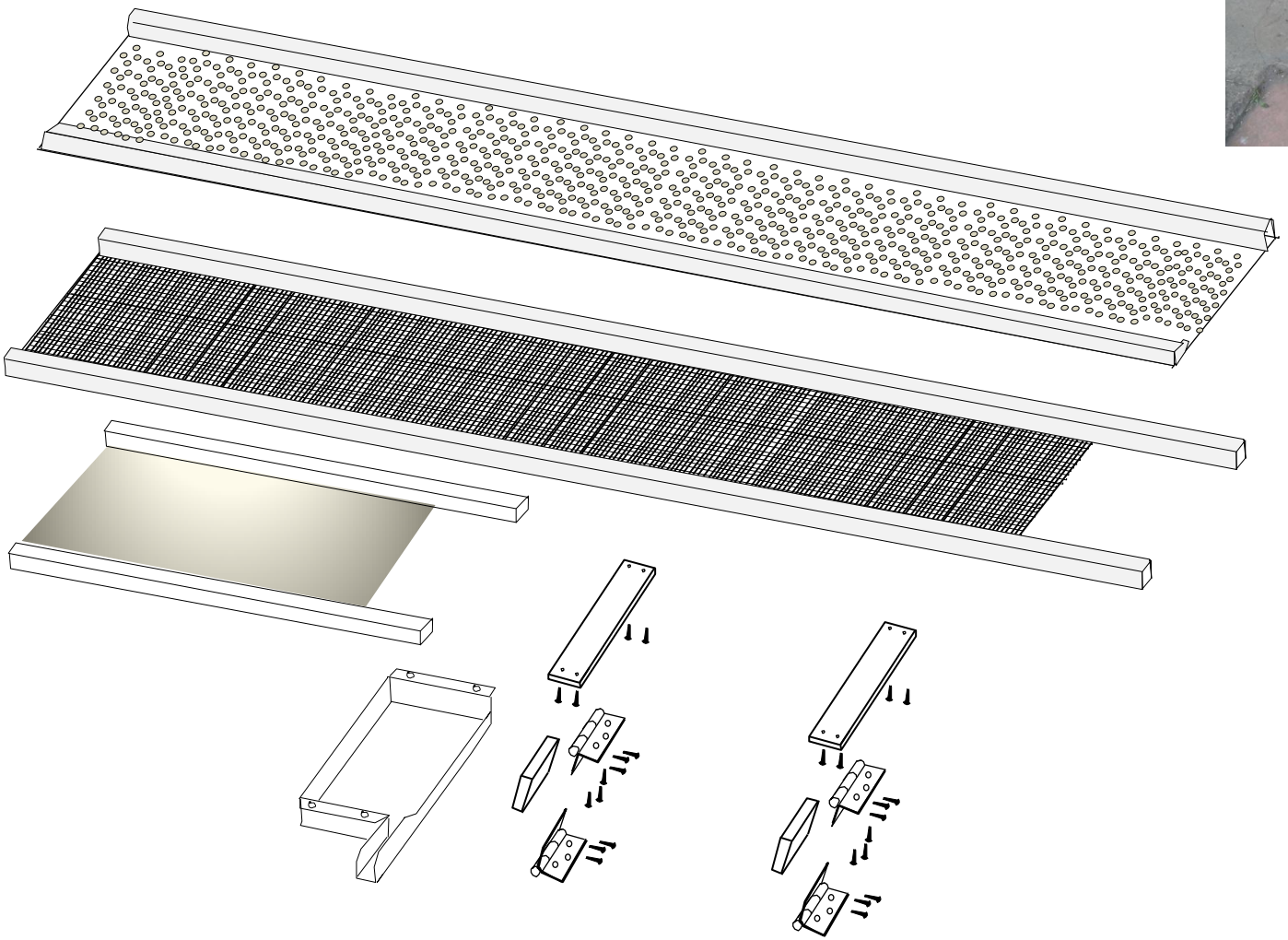


Angle of fan around
30 - 45 degrees

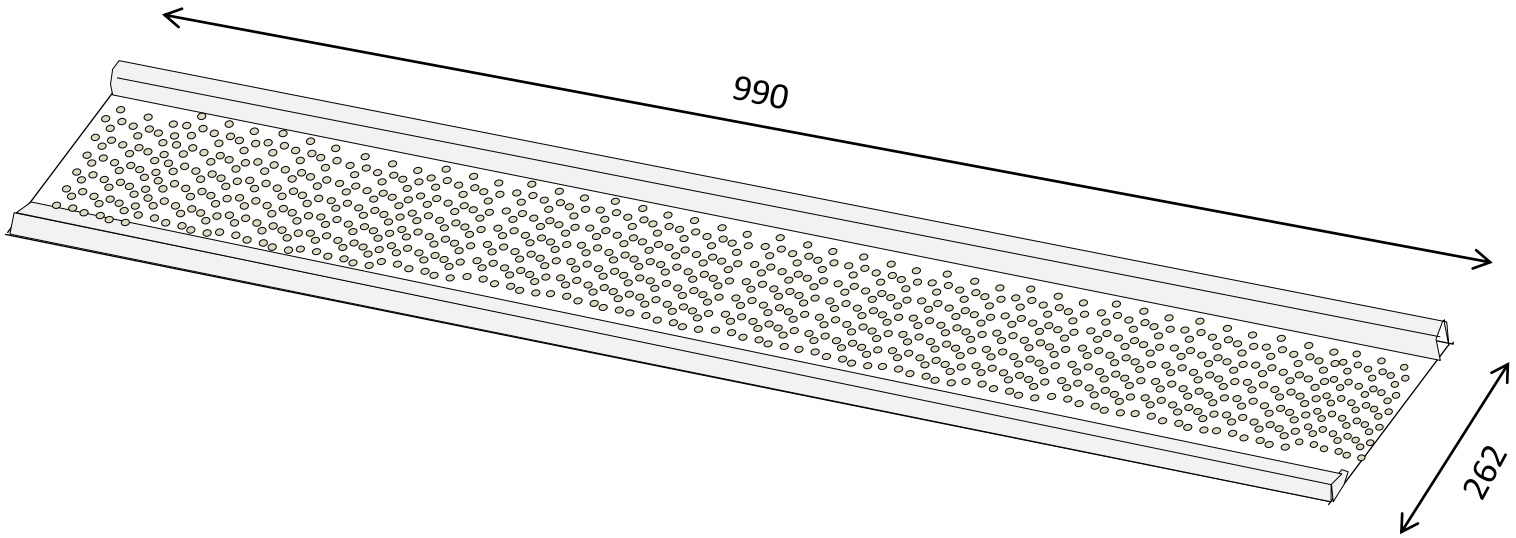
3. 4. Dimensions continued



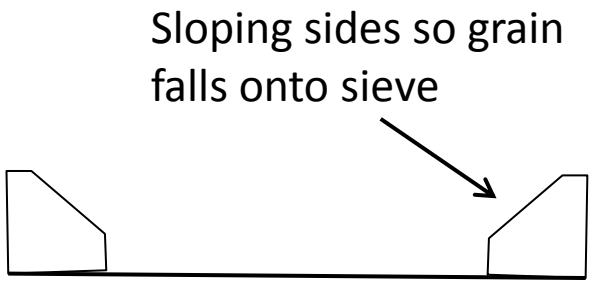
4. Oscillating sieve and camshaft



4.1. Top sieve

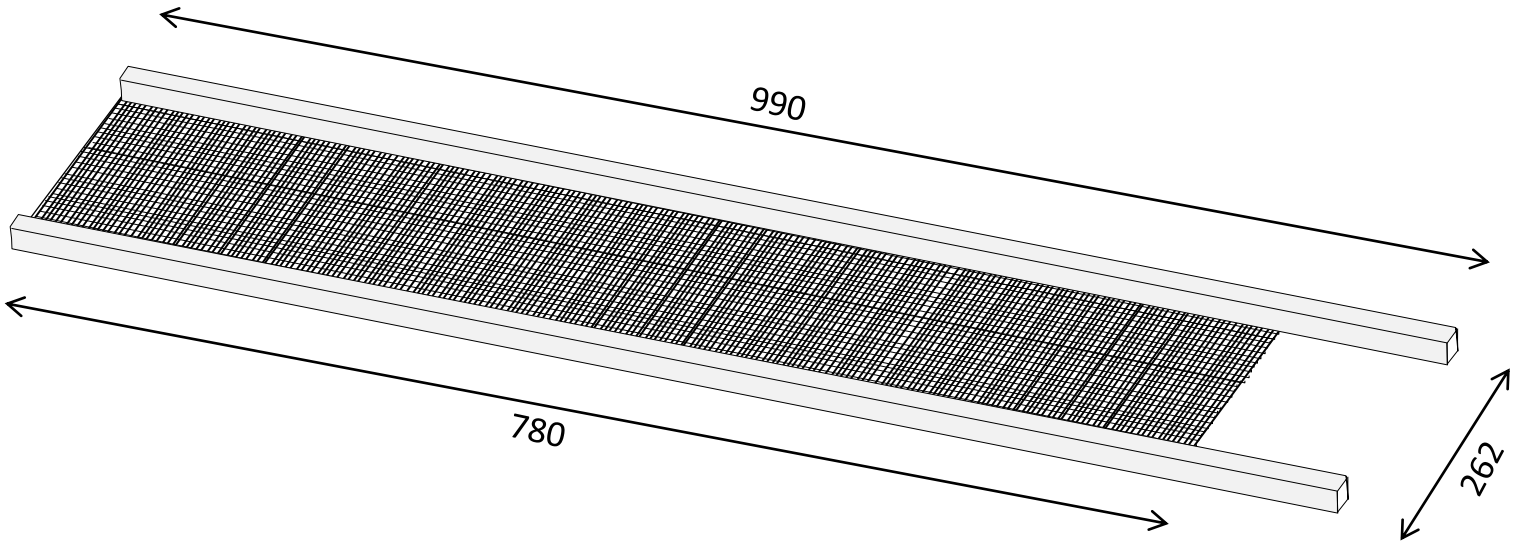


The top sieve is made from 8mm round perforated steel sheet screwed to 32mm x 32mm wooden batons. This size suits small grains such as wheat, barley etc. Other sizes will be required for different crops. If needed the effective length of the sieve can be reduced by sealing off the last part of the sieve with duct tape. If for example, all the grain has fallen through two thirds of the way along the sieve then the last third can be sealed up.



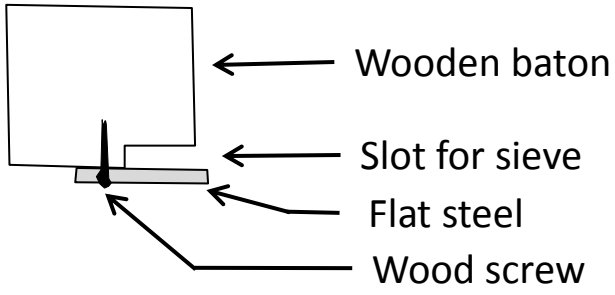
End elevation of sieve

4.2. Middle sieve



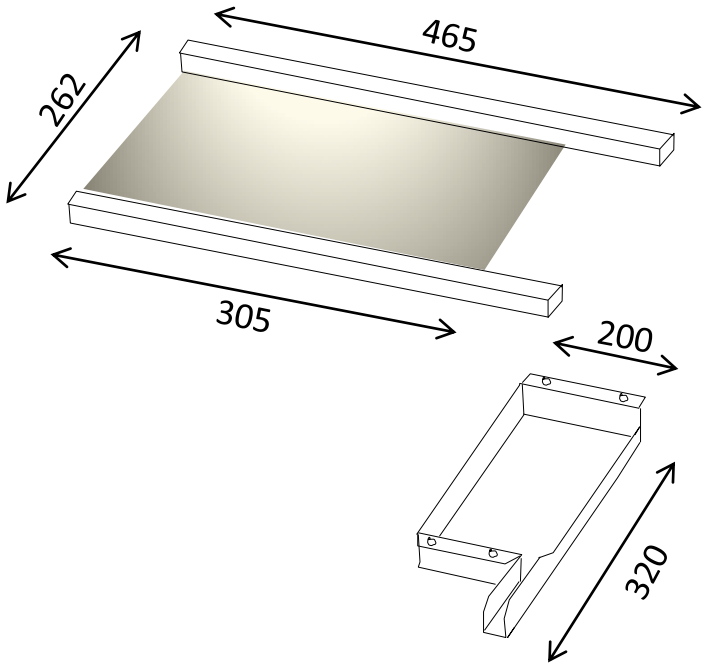
The middle sieve is constructed from 6mm square perforated steel sheet which is slotted into slots rebated into 32mm x 32mm wooden baton. The sieve is secured in place with two wood screws and can be easily withdrawn and replaced. The rebate is formed by planning a step on the wooden baton and then drilling and screwing a 780 mm length of 1 mm x 20 mm flat steel to the baton. This sieve size usually suits small grains such as wheat, barley etc. However other sizes maybe required depending on grain size.

Detail of slot for sieve



End elevation of sieve

4.3. Bottom sieve

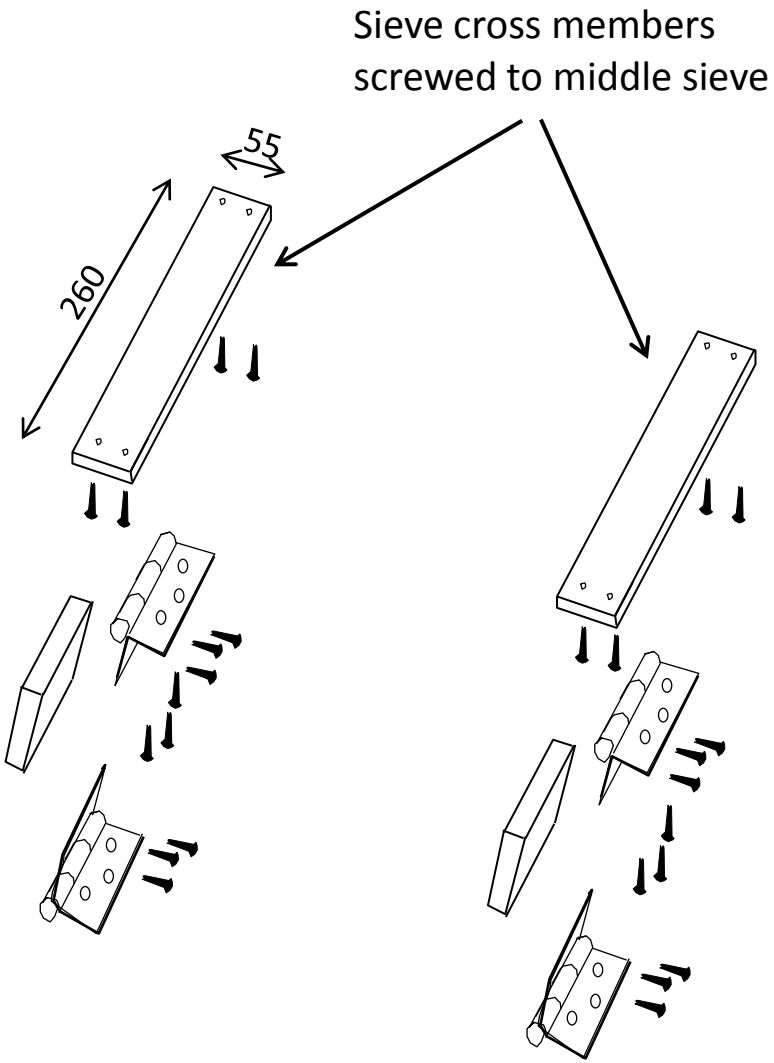


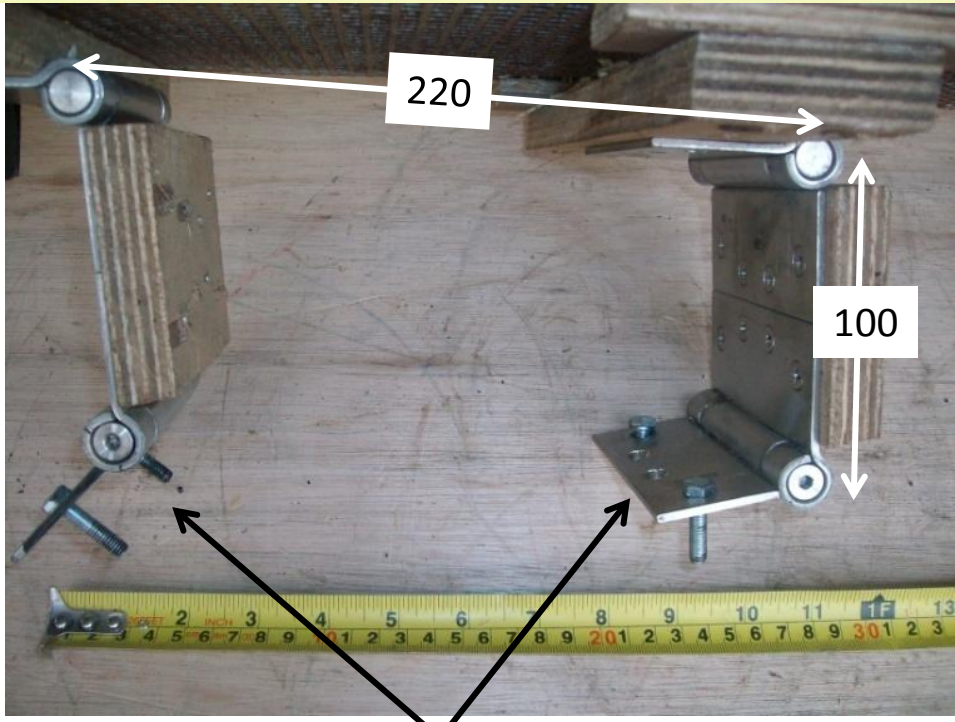
End elevation of sieve

The bottom sieve is made from wire mesh (1.5mm hole size) screwed to 32mm x 32mm wooden baton. The grain shoot is made from light gauge steel sheet, folded and riveted to form a collecting tray with shoot and screwed to the wooden batons (dimensions are not critical)

To assemble the sieves, screw the top and bottom sieve to the middle sieve. Then screw the sieve cross members (see next page) to the middle sieve. Pilot drill the screw holes so the screws do not snag on the metal sieves or flat steel strip.

4.4. Reciprocating arms

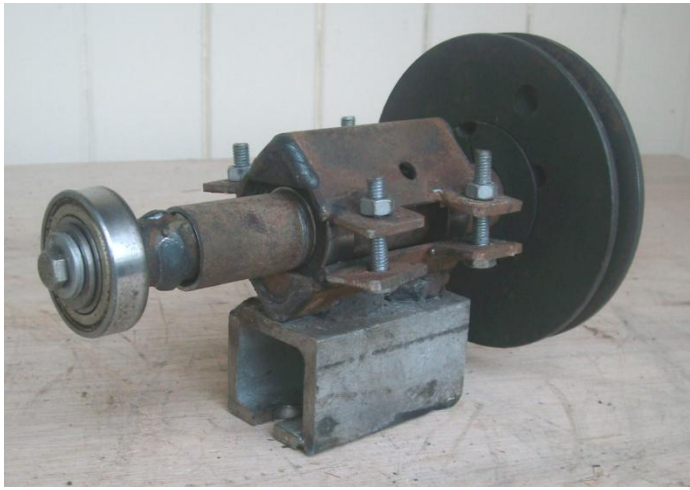




Self closing hinges

The sieve reciprocating arms are made from 18 mm plywood and four heavy duty hinges two of which are spring-loaded self-closing hinges. Do not use oil or grease on these hinges as this will accelerate wear in the dusty environment.

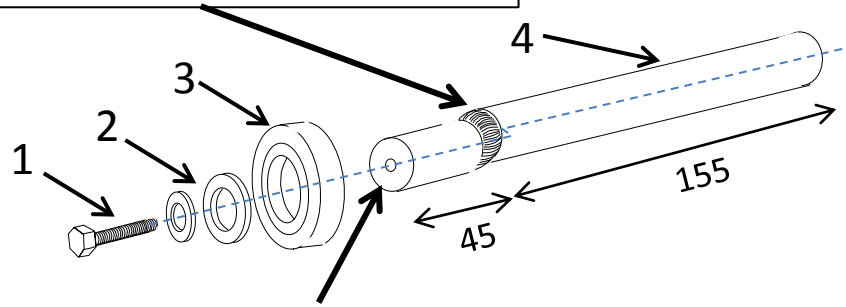
4.5. Camshaft assembly



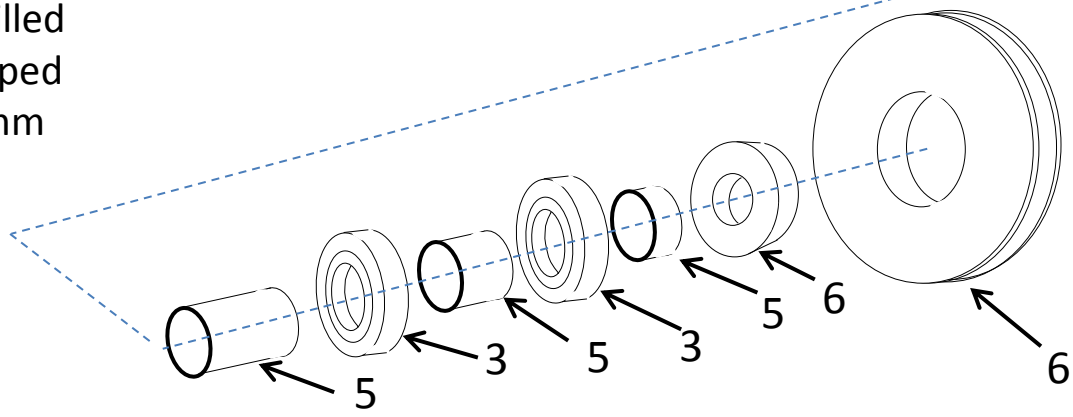
4.6. Camshaft

The shaft is cut and then weld it back together at/around 2 mm off-centre to give about 4 mm of cam travel. Note, if there is too much cam travel the reciprocating arms of the sieve cannot return fast enough and you get a condition similar to value bounce in an engine.

It is important to bevel the ends to be welded with a grinder to give a deep V shape (which is then filled in with several runs of weld) to produce a strong joint.



Hole drilled and tapped for a 6mm bolt



Camshaft components

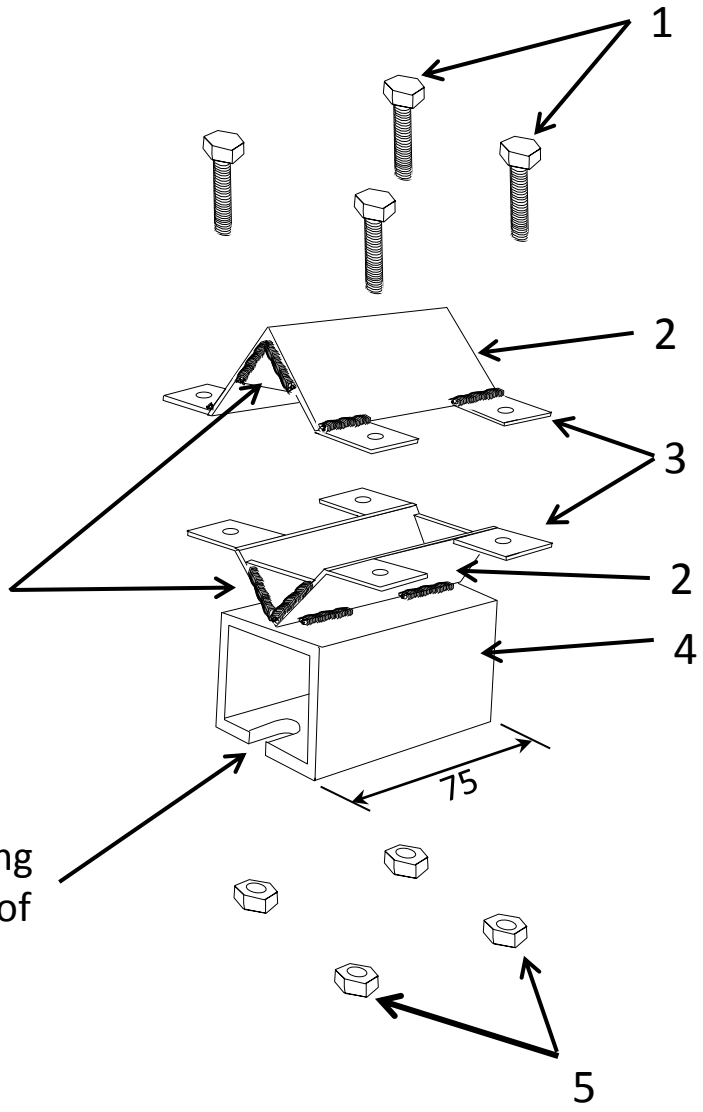
1) 6mm bolt
2) washers
3) sealed bearing for ¾" shaft
4) ¾" shaft
5) spacer cut from steel pipe
6) taper lock pulley 4 ¼ " A series

4.7. Bearing housing

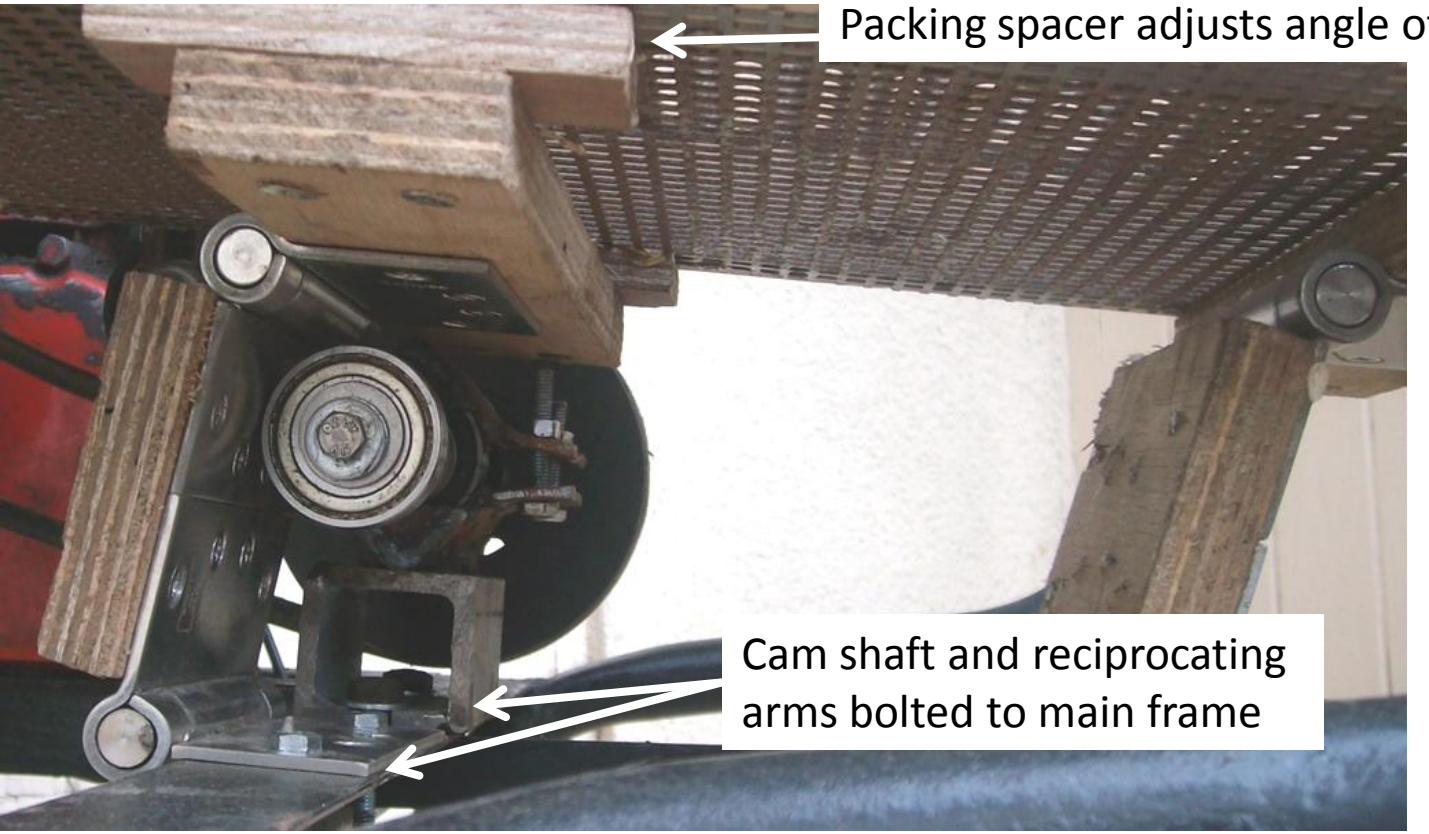
1). 6mm bolt
2). 40mm x 40mm x 3 mm angle iron
3). Tabs with 6 mm hole welded to angle iron
4). 40mm x 40mm x 4mm box section
5). 6 mm locknut

Triangular end stops welded to angle iron

8mm elongated mounting bolt holes give a degree of adjustment to align the camshaft pulley with the engine pulley



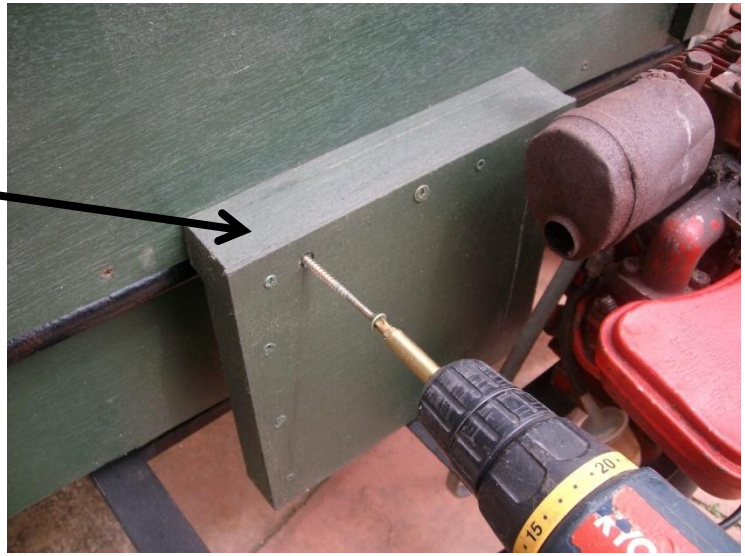
4.8. Mounting the camshaft and sieves to main frame



4.9. Camshaft drive belt and guarding

Belt tension adjusting pulley recycled from engine cam belt pulley

Appropriate guard made from wooden baton and plywood

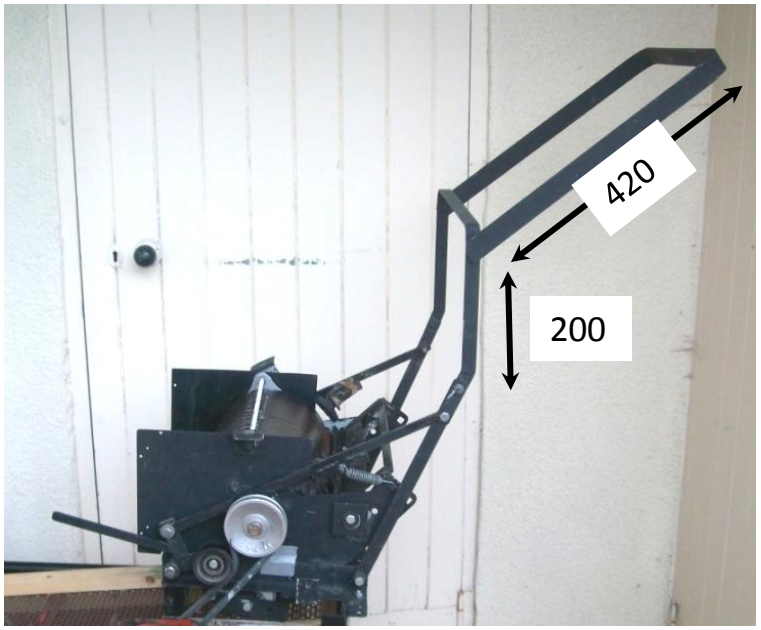


4. 10. Sieve cleaning

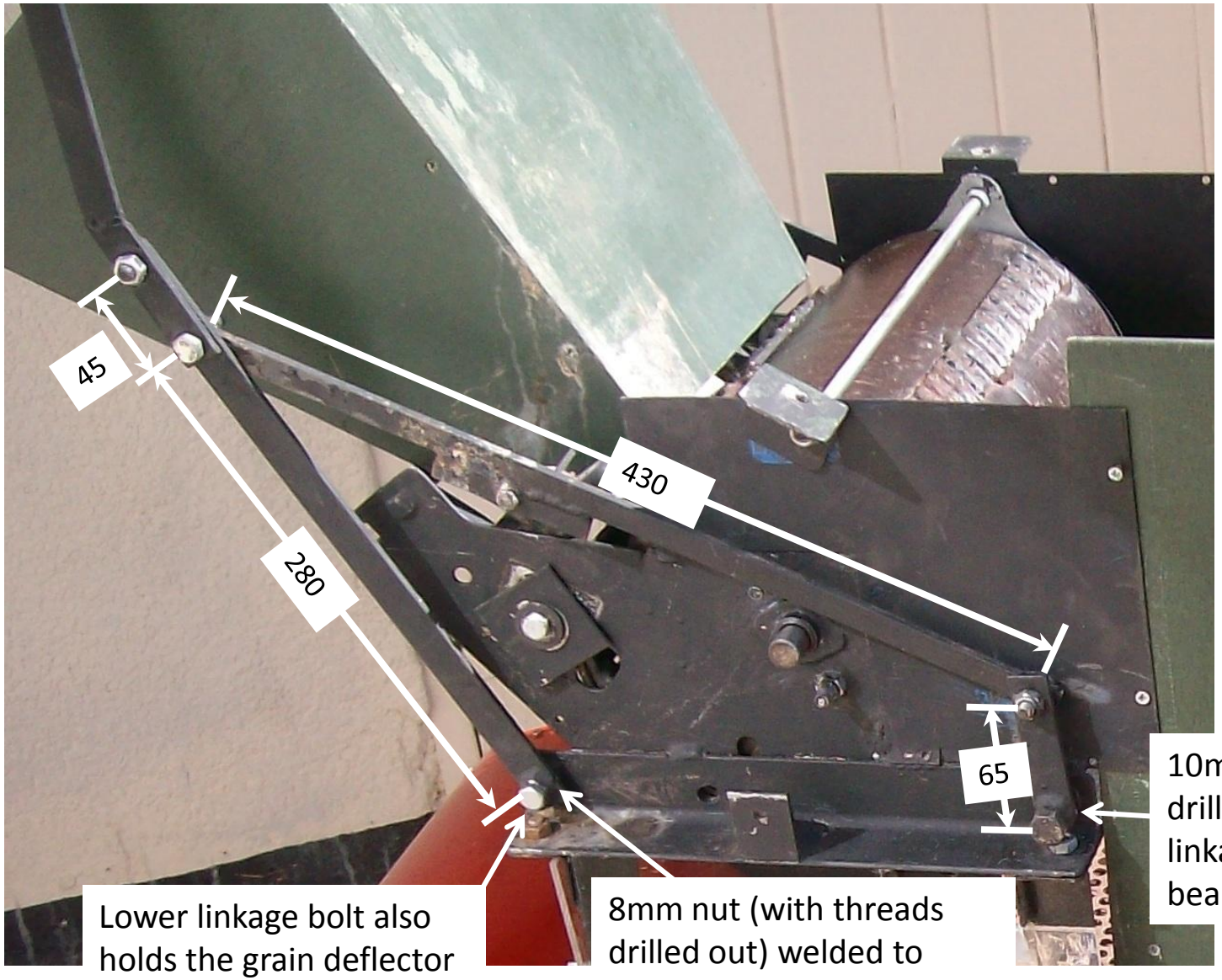
During operation the top and middle sieves will require periodic cleaning. This is best achieved with a specialist cleaning brush made from a wooden double-sided nail brush. Weld a 6mm bolt to a 1200mm length of 8mm round bar, drill a hole in the nail brush and secure it to the bar with a washer and locknut.

Slide the brush back and forth between the top sieve and the middle sieve to clean both sieves simultaneously.

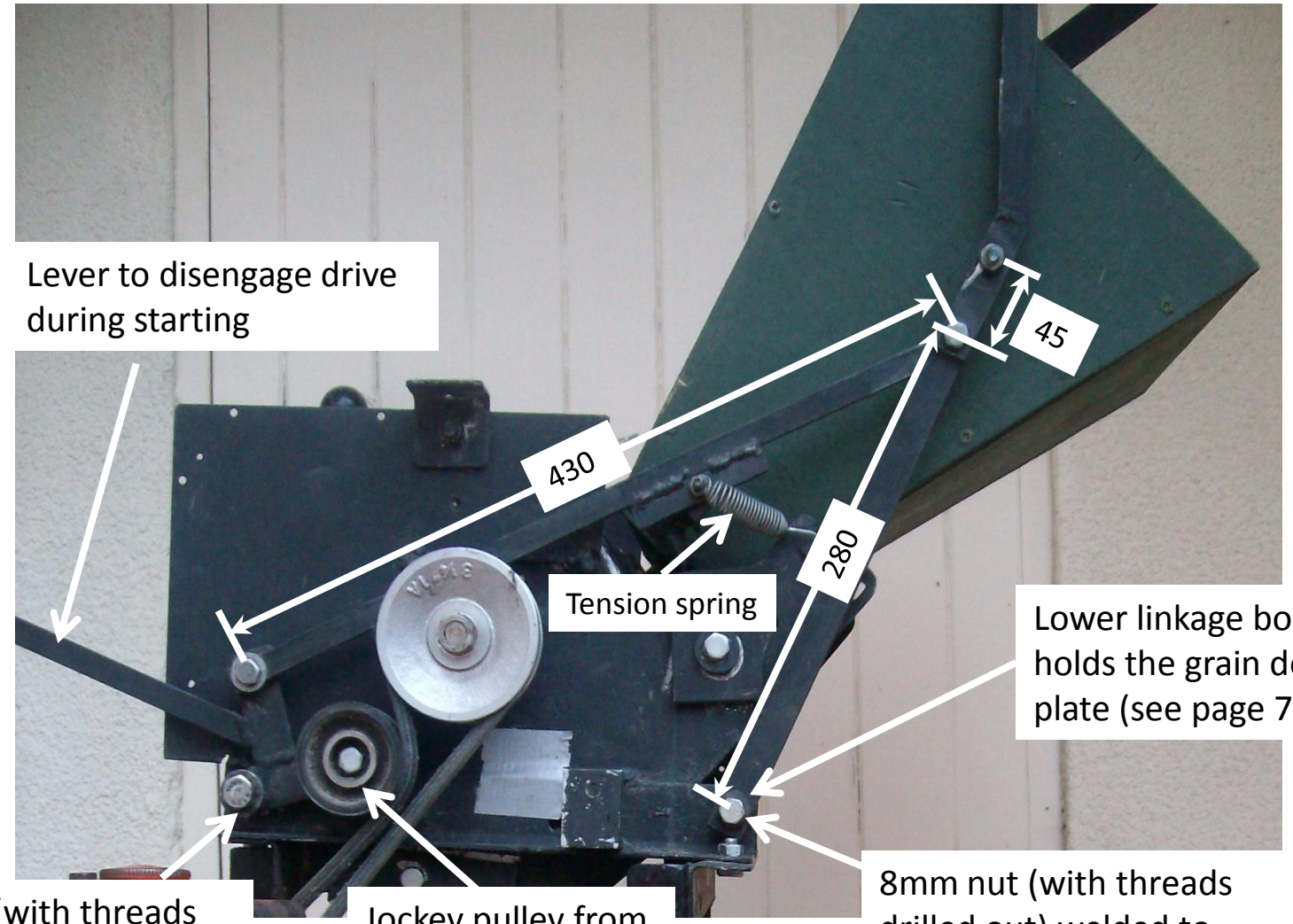
5. Clutch and emergency stop linkage



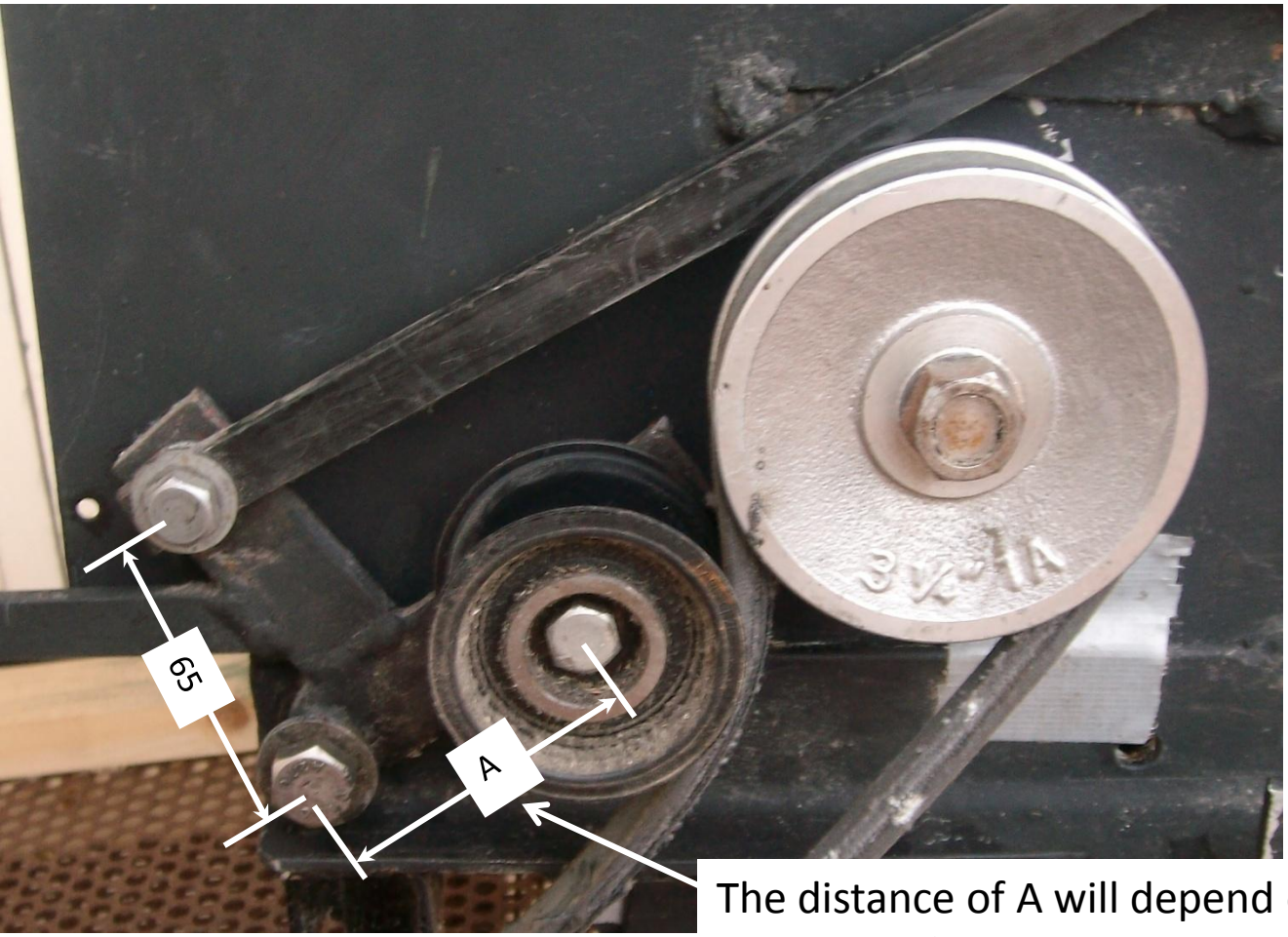
5. 1. Right hand linkage assembly



5. 2. Left hand linkage assembly



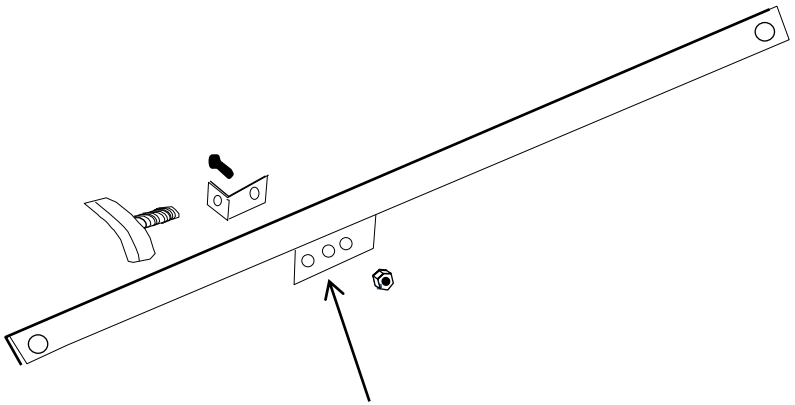
5. 3. Jockey pulley clutch



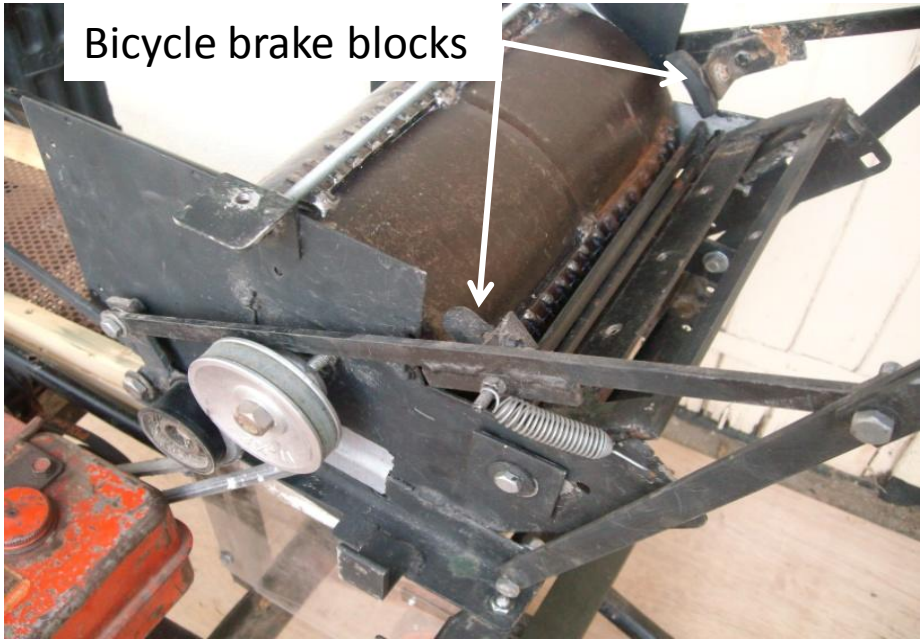
The distance of A will depend on the diameter of the jockey pulley used

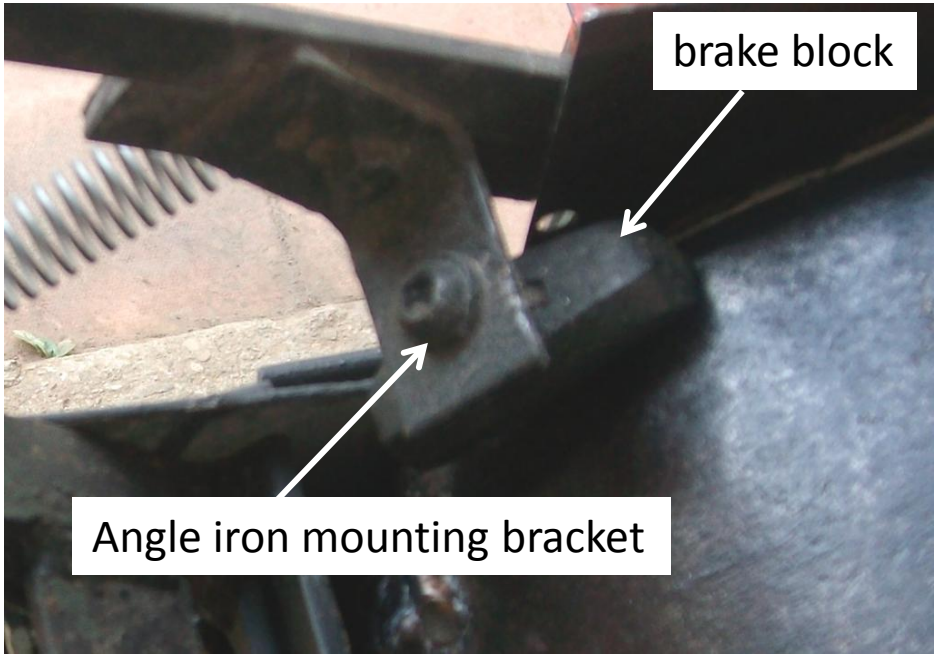
5. 4. Emergency stop system

The emergency stop activates if the operator gets too near the machine and pushes against the safety bar. This disengages the jockey pulley and the threshing drum is brought to a sudden stop by two bicycle brake blocks.
The brake blocks are bolted to the linkage so they touch the drum just after the jockey pulley is disengaged.



Holes for brake adjustment



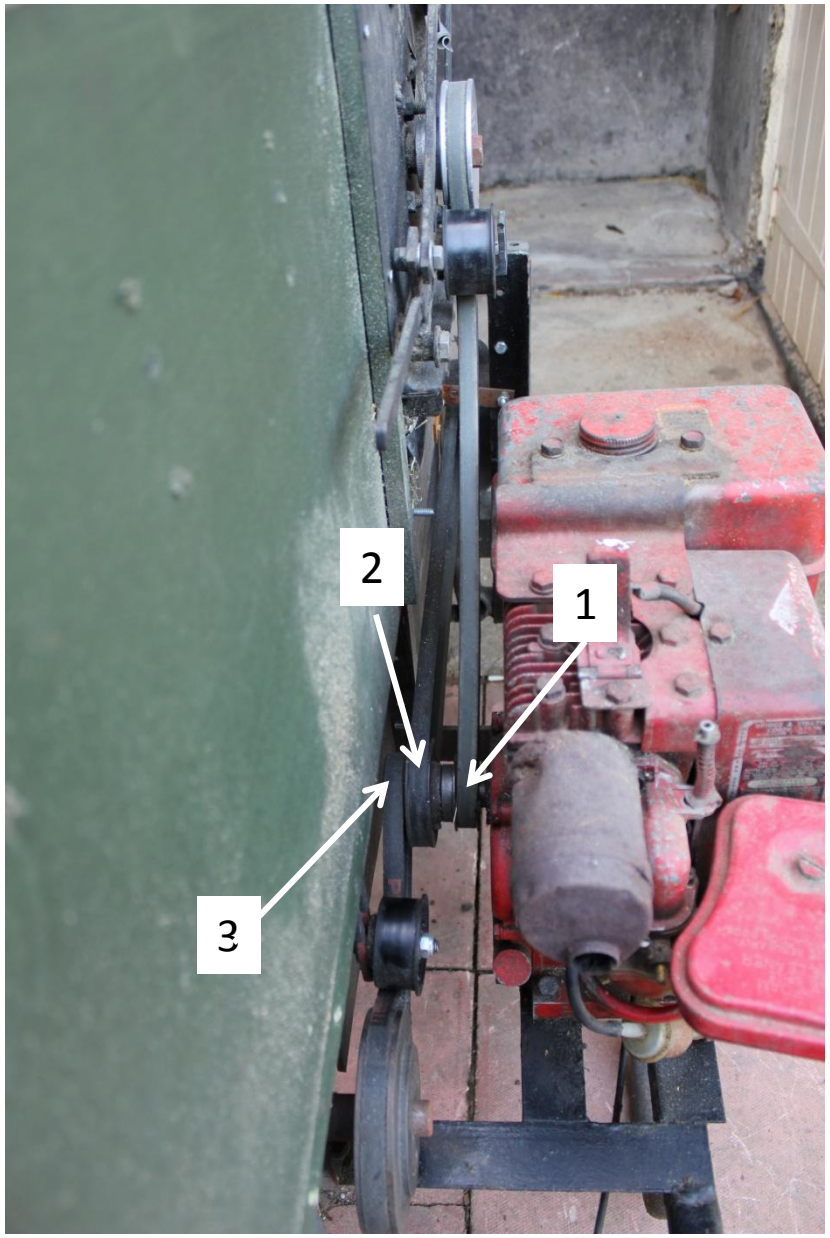


5. 5. Drive belts

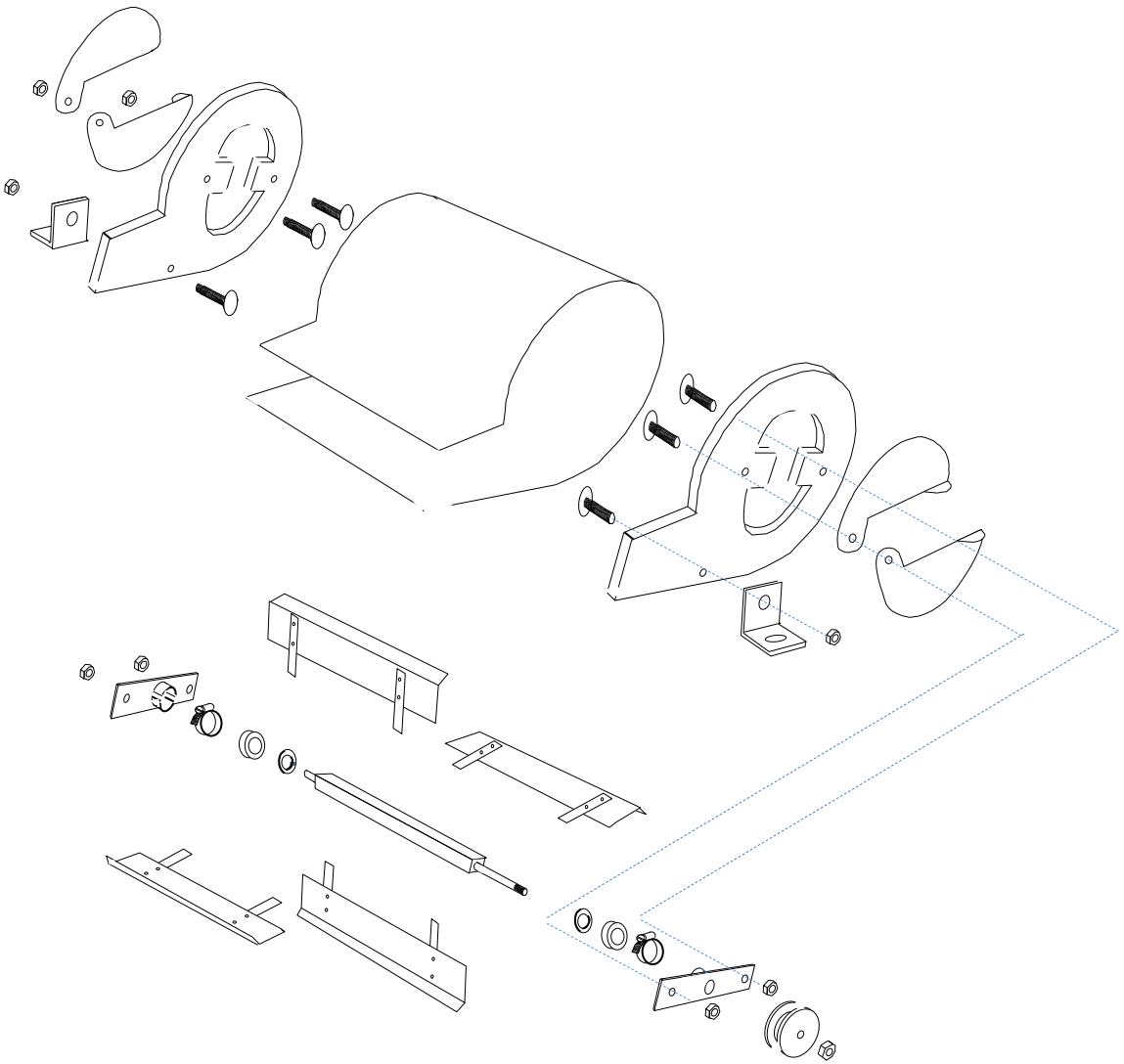
The engine crankshaft pulley sizes are as follows:

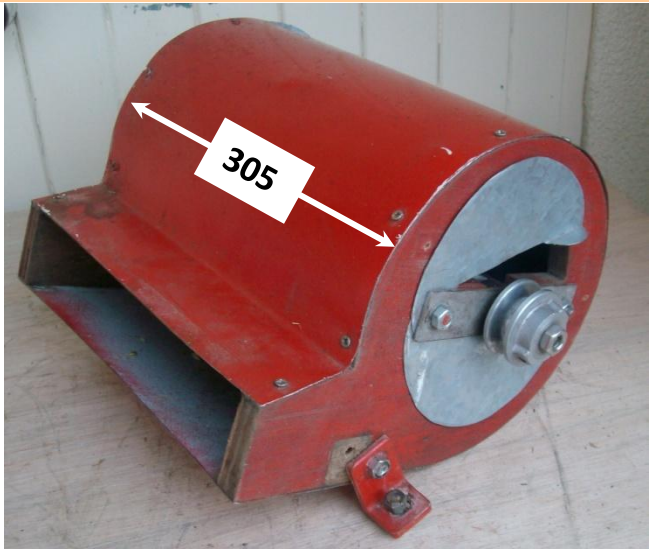
1) 1 ¾ ” A series drives the threshing drum
2) 2 ½ ” A series drives the fan
3) 1 ¾ ” A series drives the sieve camshaft

The V belt for the threshing drum must be a canvas coated belt to work with the jockey pulley clutch. The tension on this belt is adjusted by sliding the engine backwards or forwards, along elongated mounting bolt holes in the main frame. Belt tension for the fan is adjusted in the same manor by sliding the fan backwards or forwards. The camshaft belt is adjusted by lifting or lowering the tensioning pulley. All pulleys must be in correct alignment and it is important not to over tension the belts as this will cause premature bearing failure.

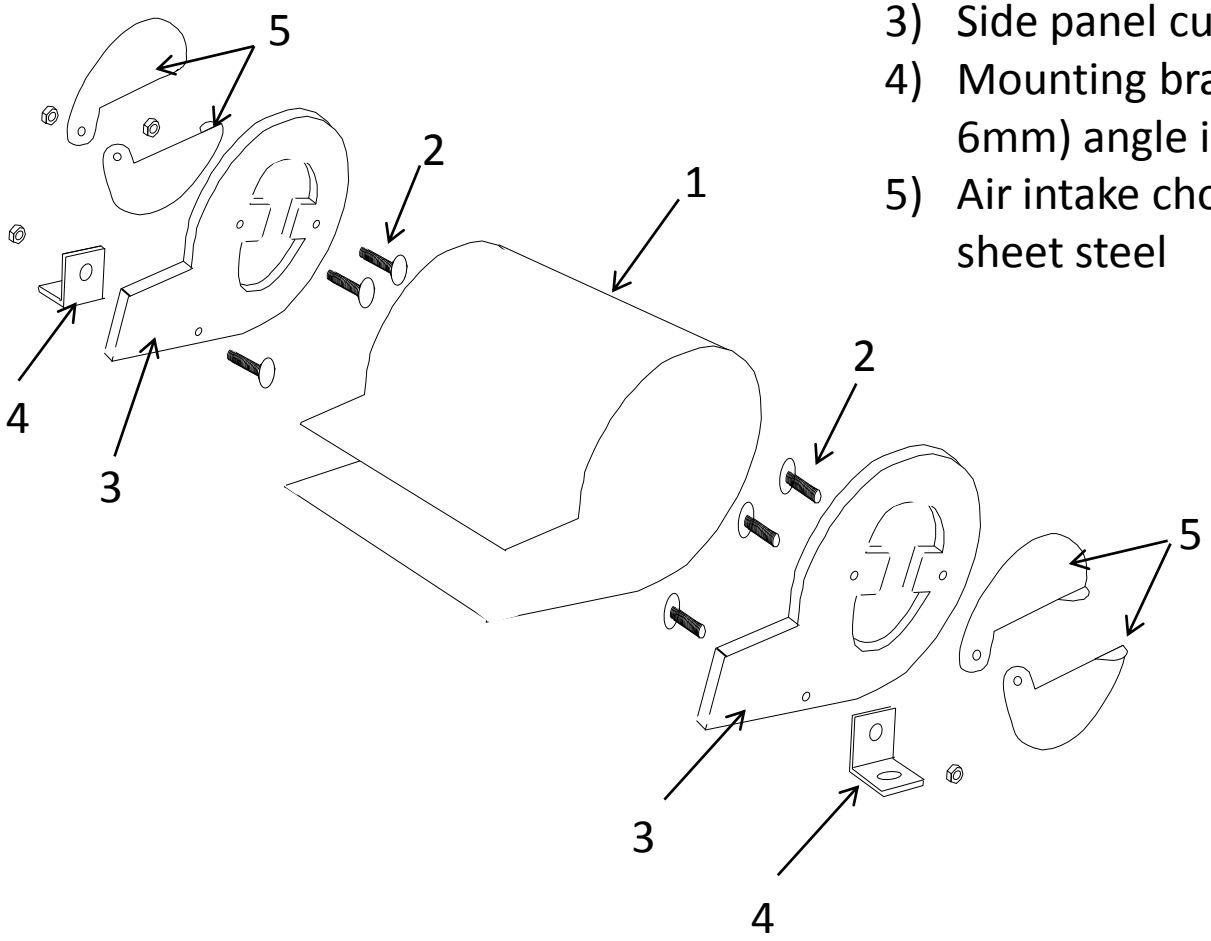


6. Fan assembly



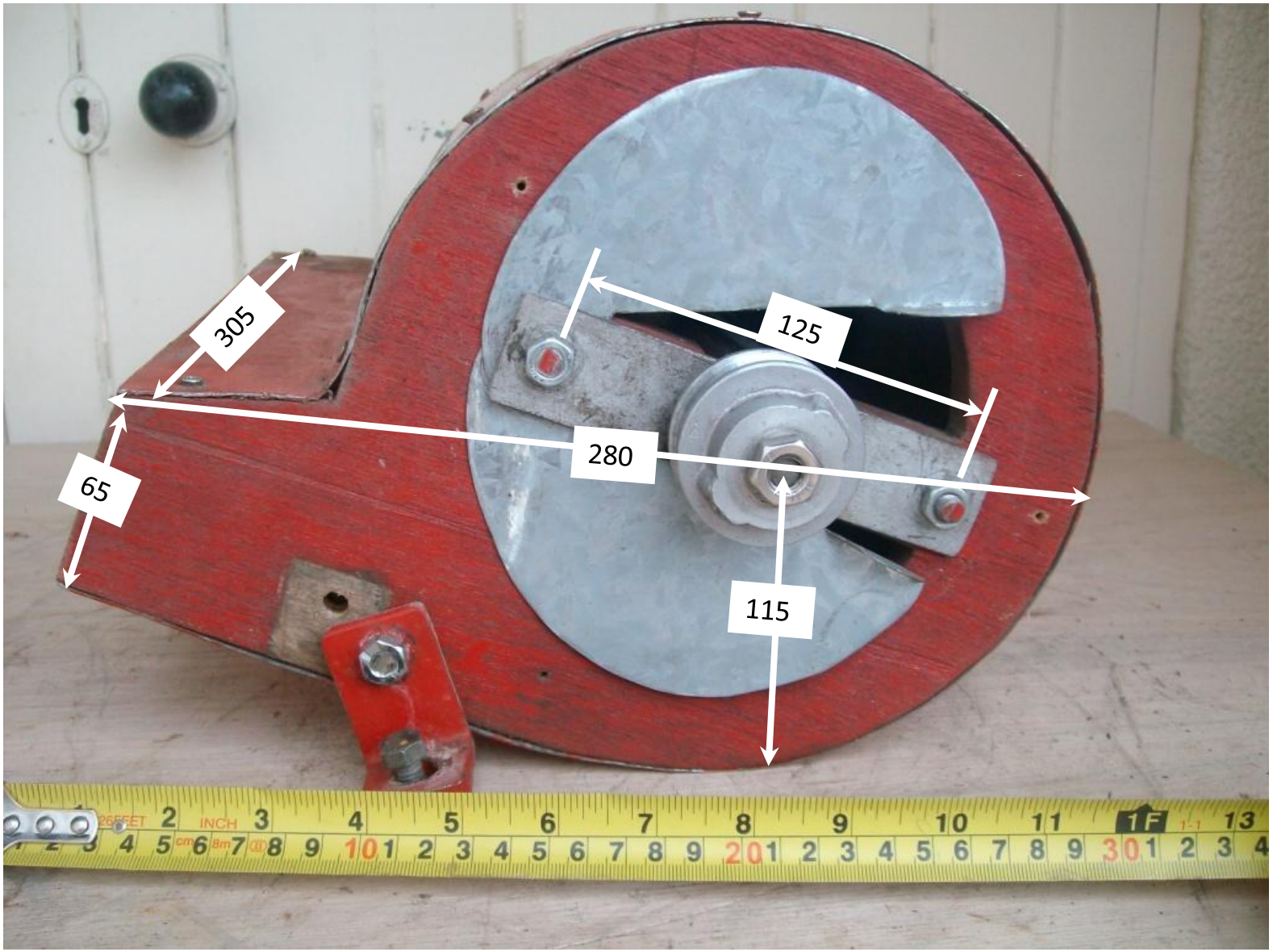


6. 1. Fan body components

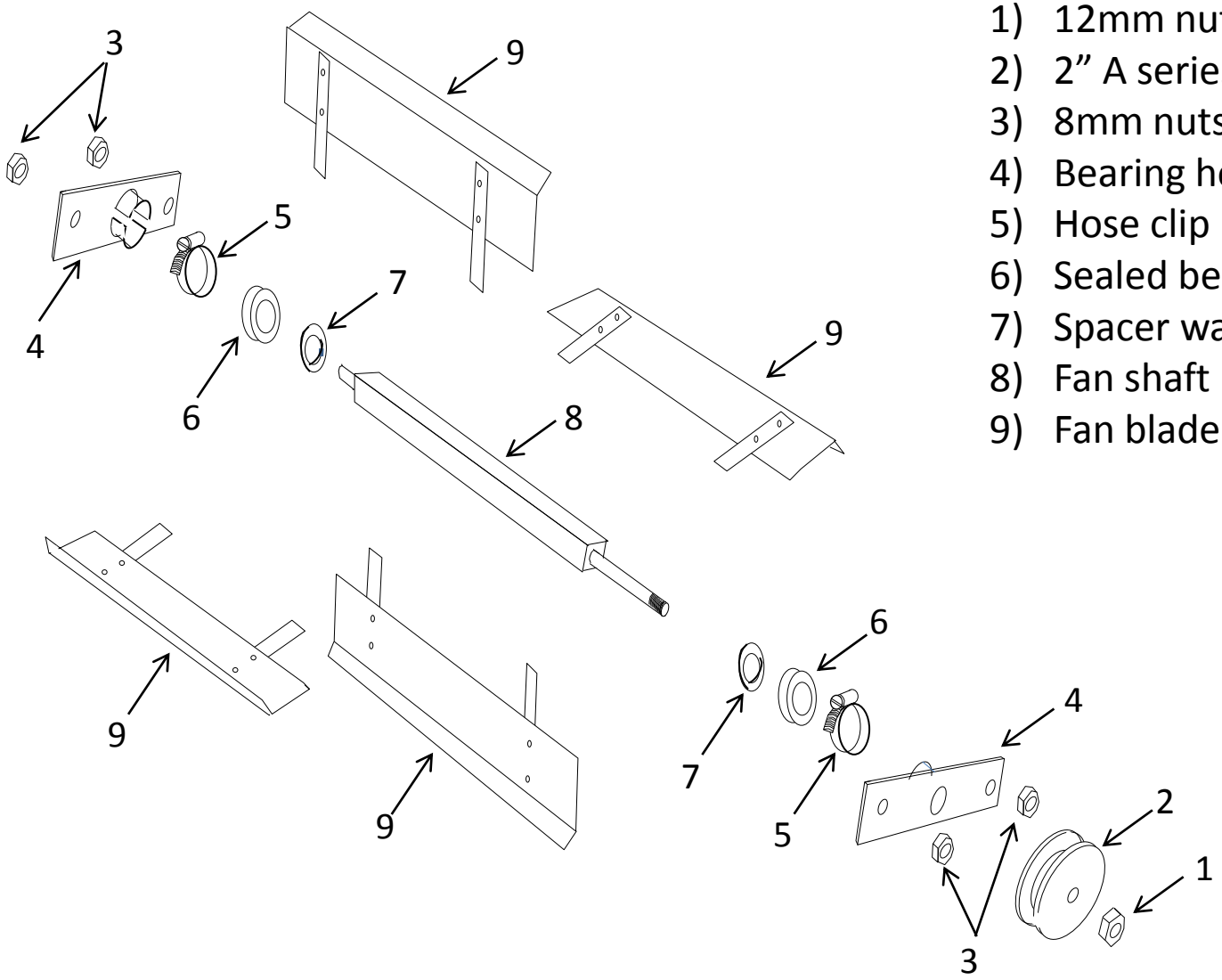


1) Light gauge sheet steel drilled and screwed to side panels
2) 8mm bolts
3) Side panel cut from 18 mm plywood
4) Mounting bracket (50mm x 50mm x 6mm) angle iron with 9mm holes
5) Air intake choke cut from light gauge sheet steel

6. 2. Fan body dimensions

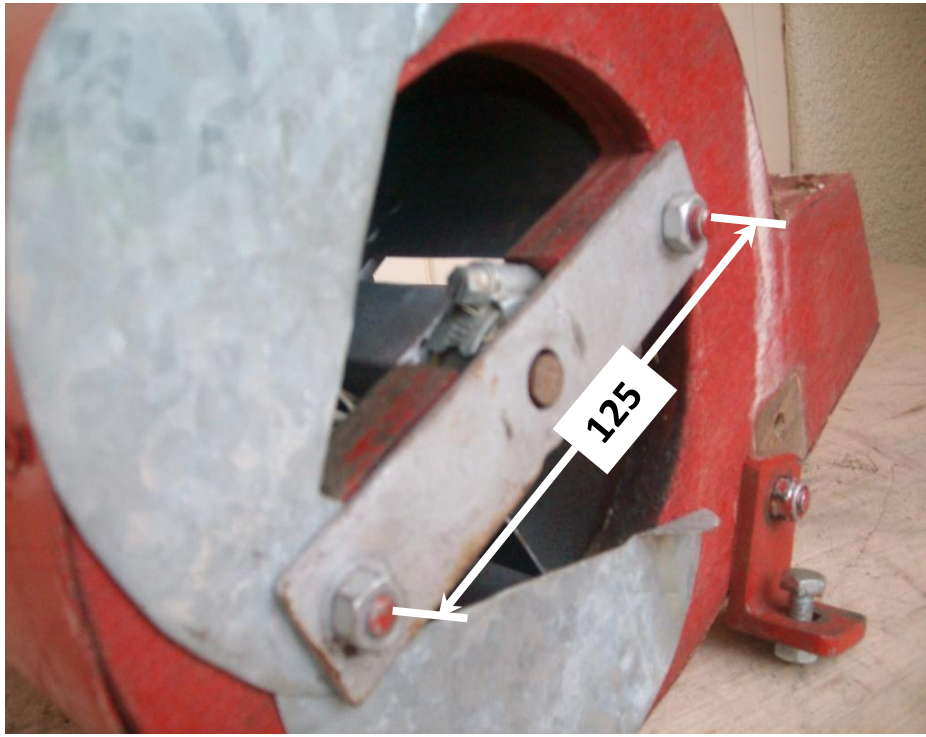


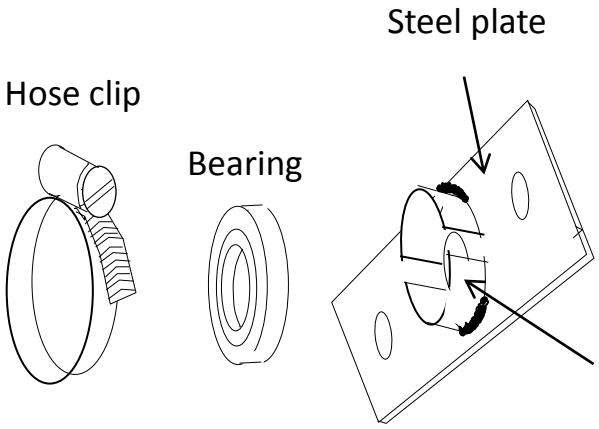
6. 3. Fan components



1) 12mm nut
2) 2” A series pulley
3) 8mm nuts
4) Bearing housing
5) Hose clip
6) Sealed bearing for 12mm shaft
7) Spacer washer
8) Fan shaft
9) Fan blade

6. 4. Fan bearing housing

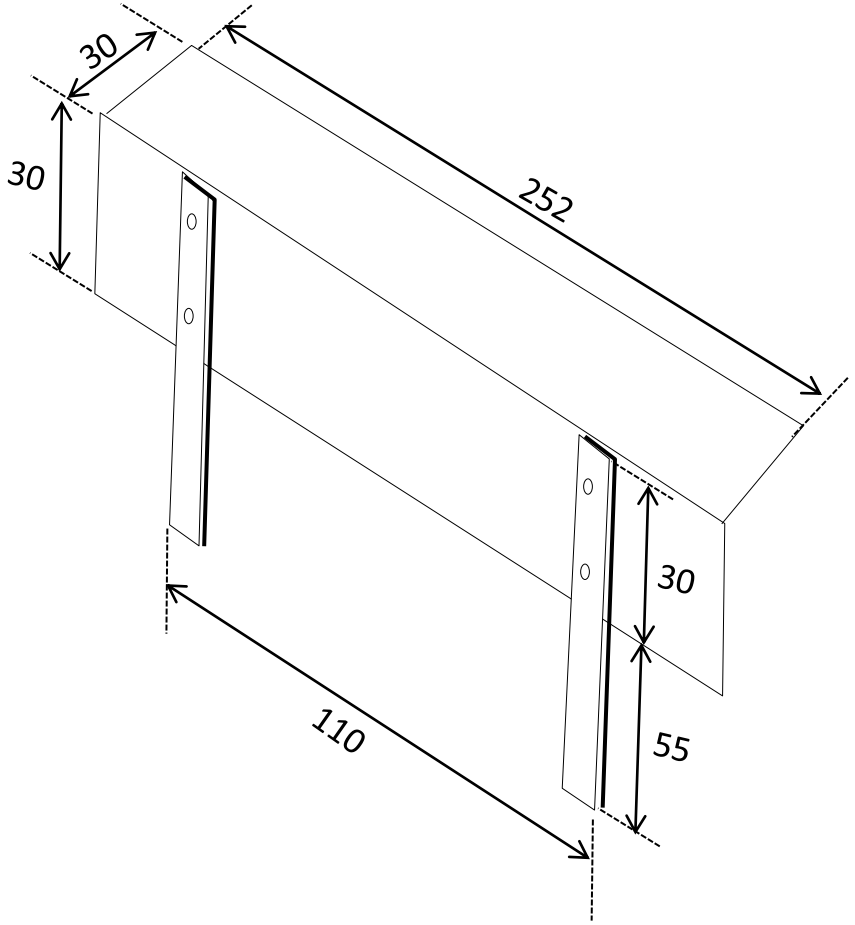




Steel pipe cut and welded to plate. The bearing is clamped in position by the hose clip

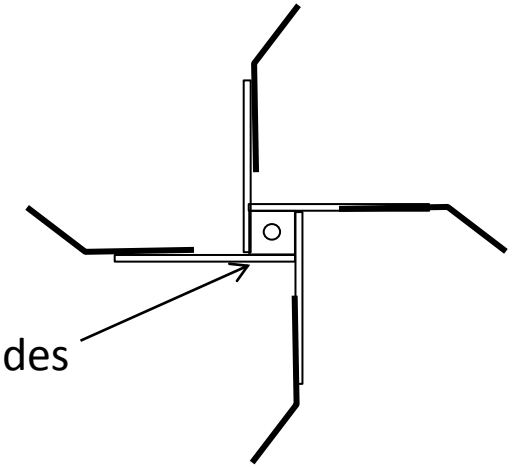
6. 5. Fan blades

The fan blades are drilled and pop riveted to arms made from 14mm x 3mm flat steel. All four finished blades should be the same weight. The angle of the blade tip is not critical (flat blades will work as well).

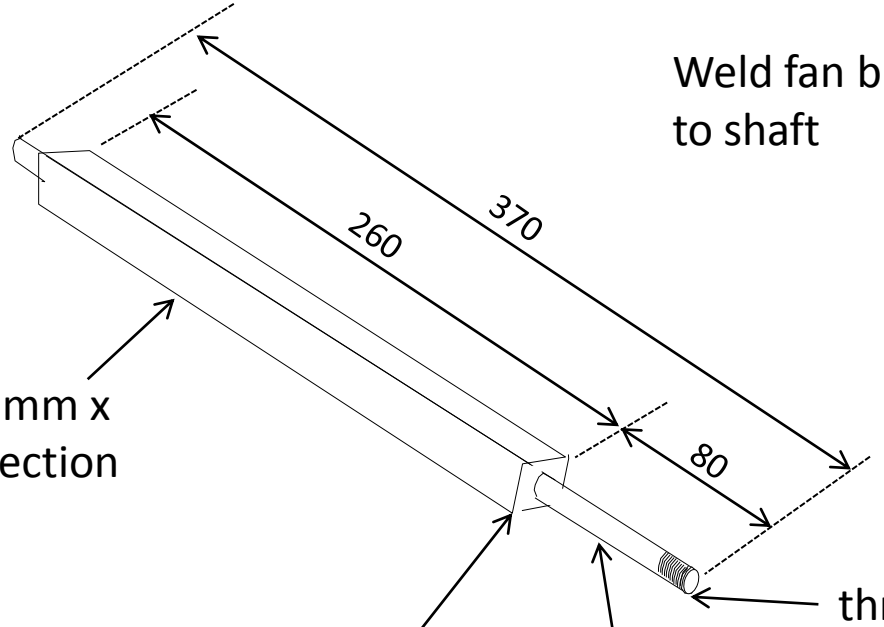


6. 6. Fan shaft

The pulley is attached to the shaft with the pulley grub screw tightened against a pilot drilling on the shaft and locked with the 12mm nut. Once assembled the fan will need to be balanced (see page 8).



End elevation



25mm x 25mm x 2mm box section

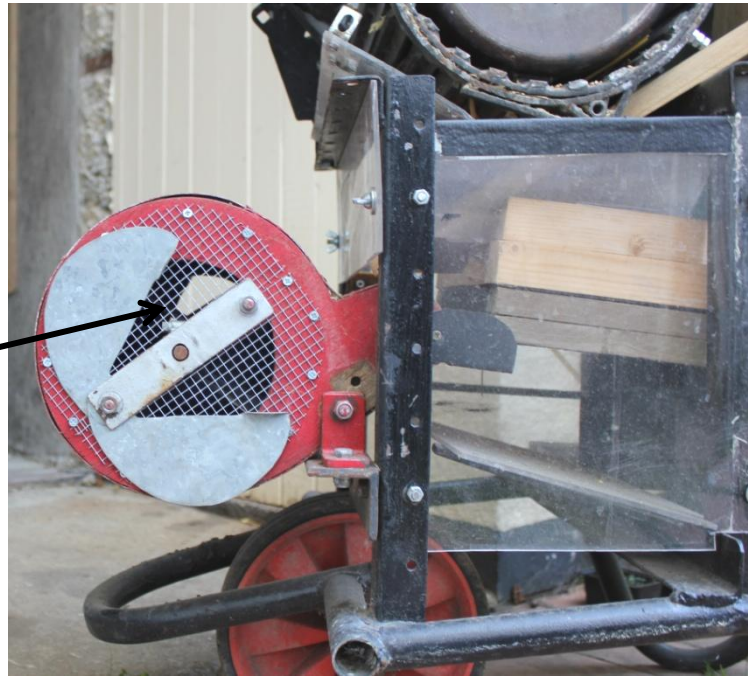
thread cut on 12mm shaft

End cap with 12mm hole drilled exactly centre is welded to box section

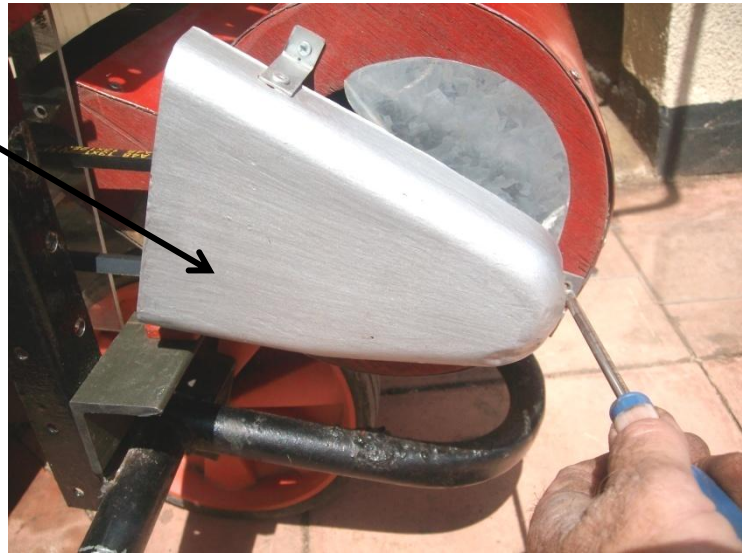
12mm shaft welded to end cap

6. 3. Fan guarding

Wire mesh guard over air intake.



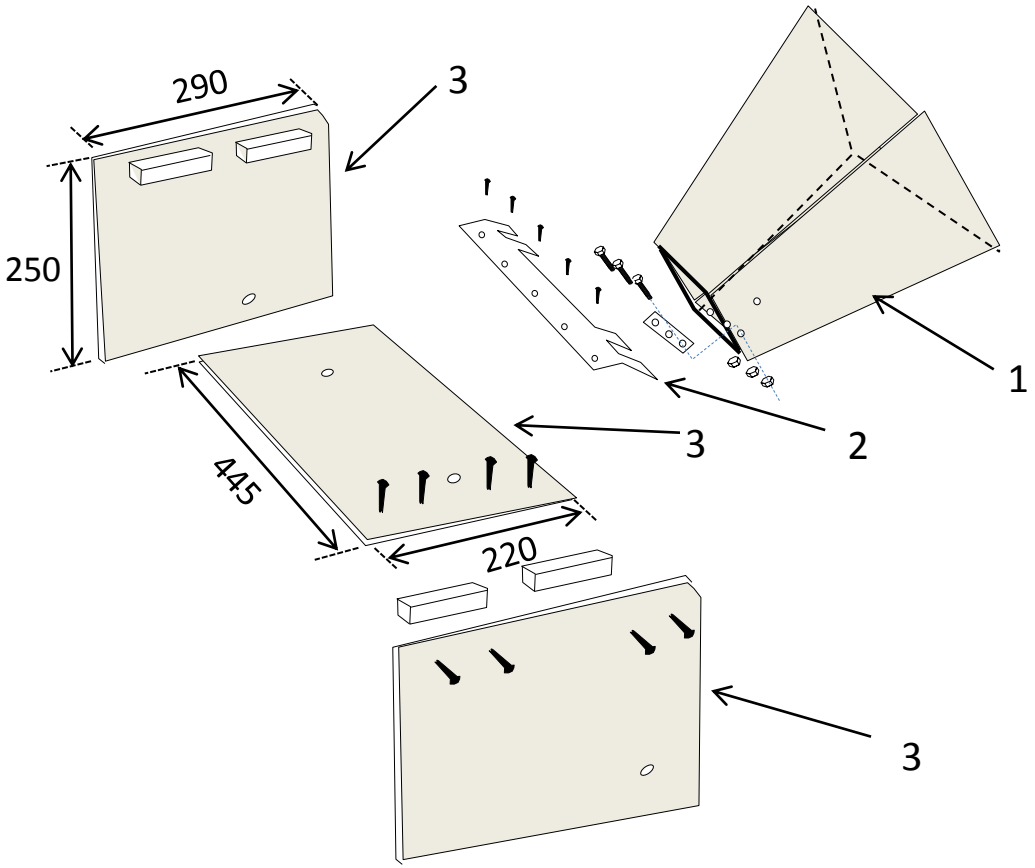
Drive belt guard made from recycled components. Suitable brackets pop riveted to the metal guard and screwed to the plywood side panel of the fan.



7. Panels

Feed shoot and threshing drum guard

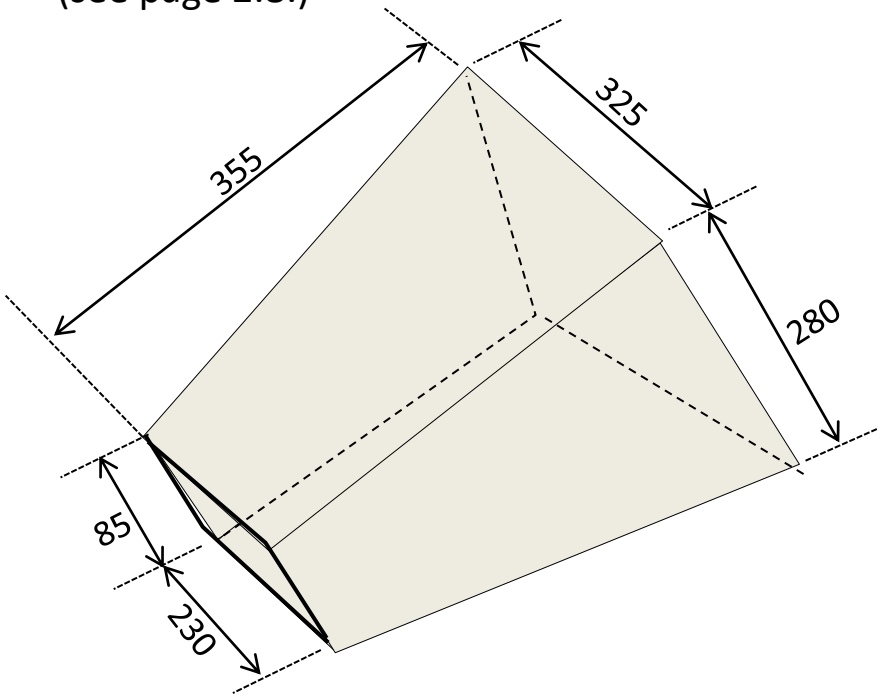
1) Feed shoot
2) Guard strip
3) Threshing drum guard



The feed shoot and threshing drum guard are constructed from 12mm plywood. The threshing drum guard is bolted to mounting brackets on the threshing drum assembly with 8mm blots (see page 2.1.). A guard strip cut from light gauge sheet steel seals the gap between threshing drum guard and feed shoot.

7. 1. Attaching the feed shoot

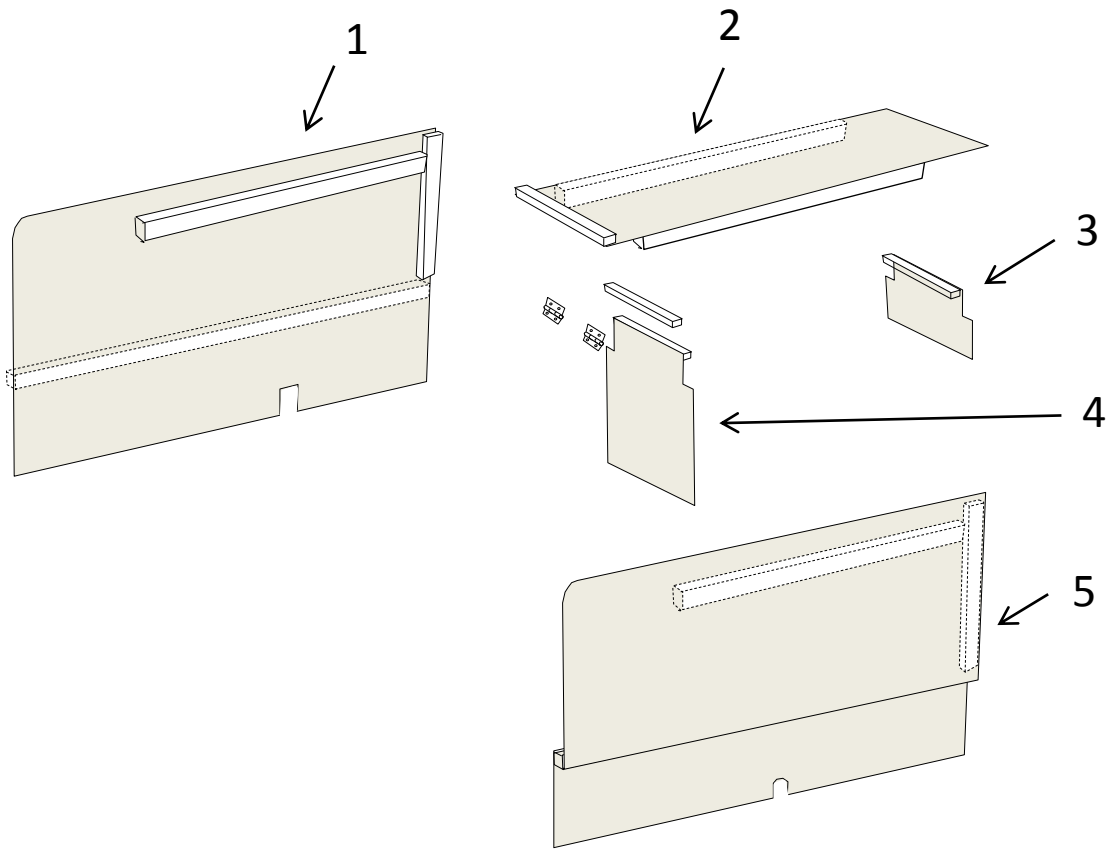
The feed shoot is bolted to the mounting plate on the concave using 6mm bolts (see page 2.8.)



Note: Adjustment of the drum clearance will alter the position of the feed shoot. To compensate for this the guard strip can be repositioned, or alternatively, the gap between the feed shoot and guard strip can be sealed with duct tape.

7. 2. Baffle plates & side panels

Made from 3mm plywood sheet and wooden baton

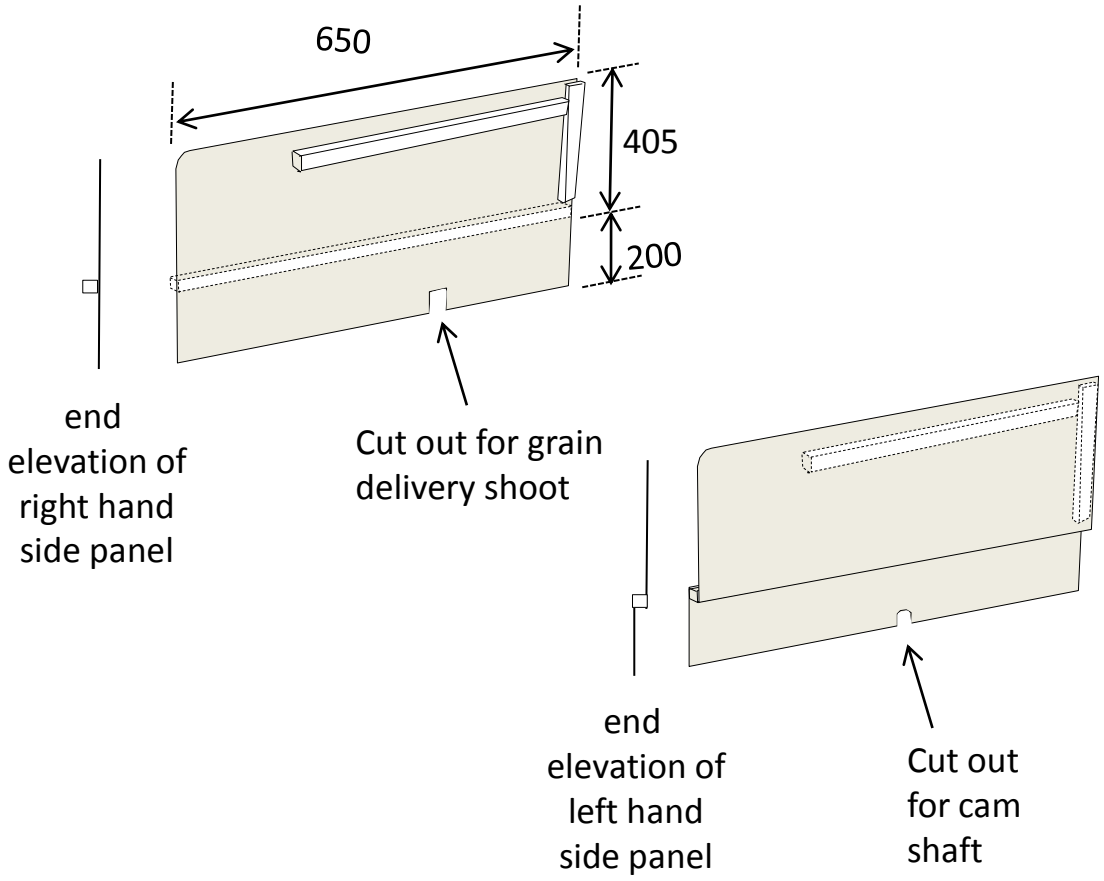


Components

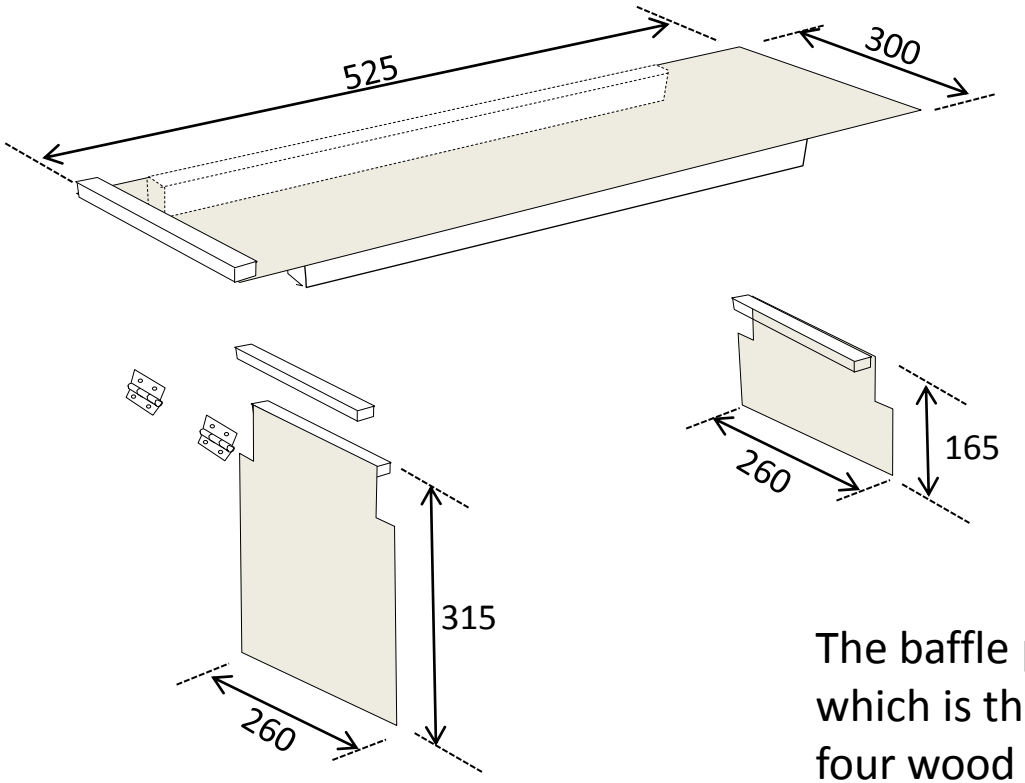
1) Right hand side panel
2) Top panel
3) Fixed baffle plate
4) Hinged baffle plate
5) Left hand side panel

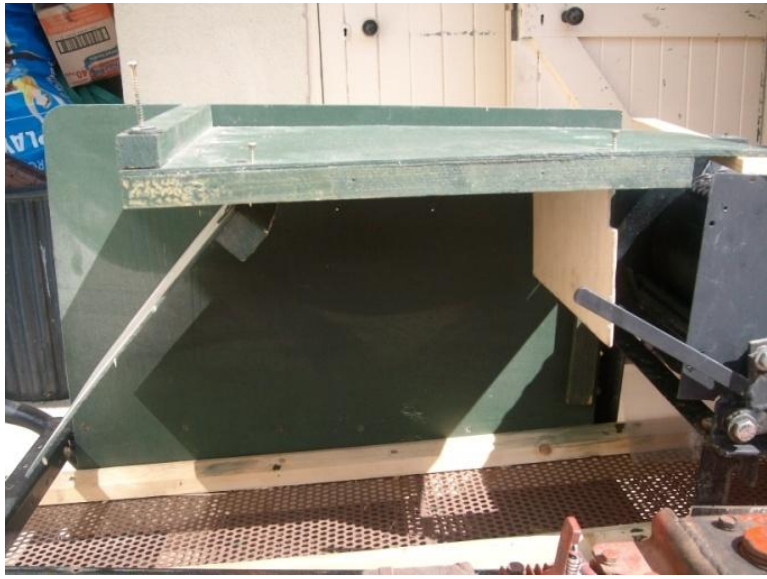
7. 3. Side panels

The side panels are screwed to the threshing drum side plates with No 6 wood screws and bolted to the main frame with four 6mm bolts.



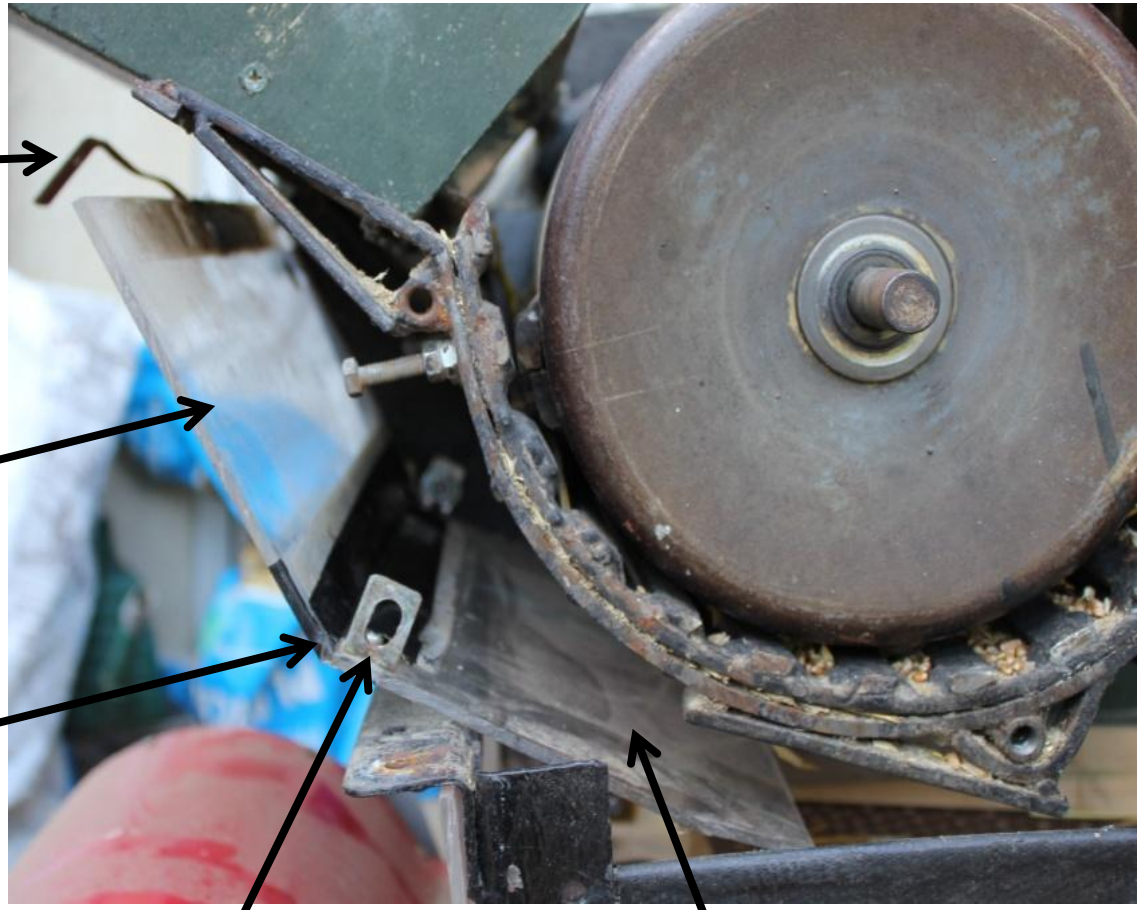
7. 4. Baffle plates





The baffle plates are screwed to the top panel, which is then attached to the side panels with four wood screws. The fixed baffle plate forces any grain and chaff thrown out by the threshing drum to fall into the air stream of the fan. The hinged baffle plate (when lowered) concentrates air flow over the sieves to improve sieve cleaning.

7. 5. Perspex grain deflector



Bracket pop riveted to access panel and screwed to plywood feed shoot

Access panel hinged to the grain deflector plate

Hinge made from two strips of duct tape

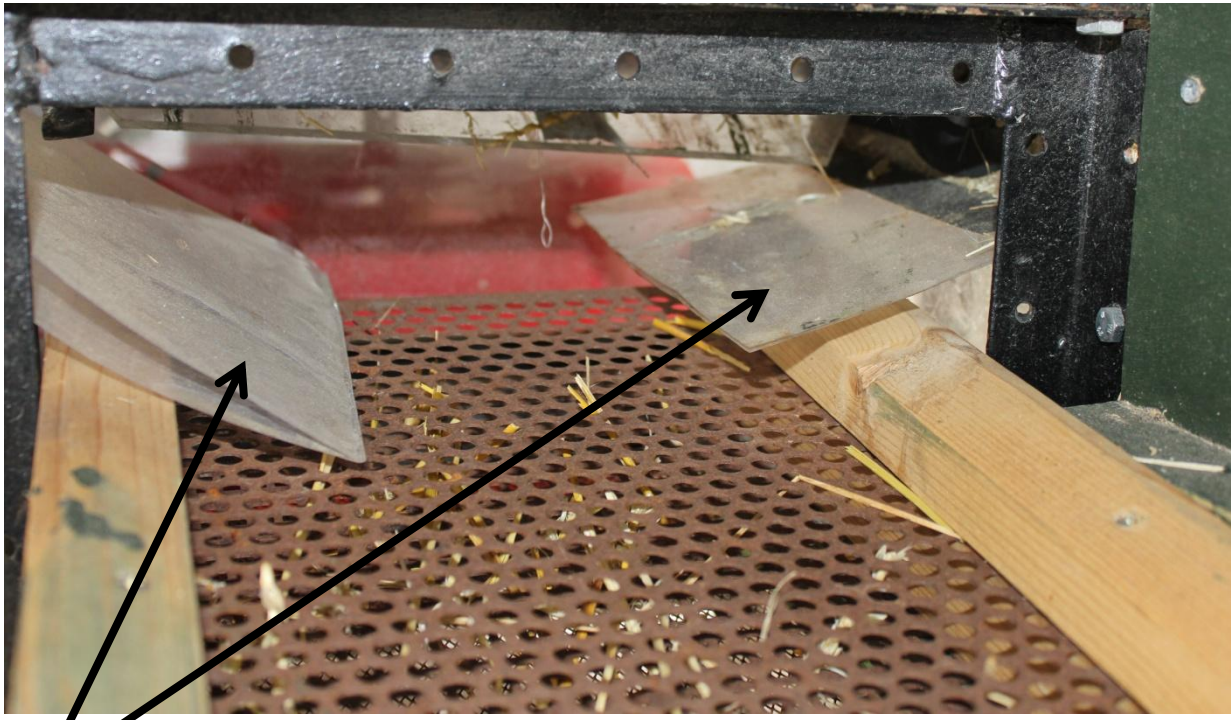
Bracket pop riveted to deflector plate and attached to the threshing drum side plate via lower linkage bolt, (see page 5.1.).

Grain deflector plate directs grain falling though the concave onto the sieves

7. 6. Perspex shielding

Perspex sheet bolted to the main frame. To prevent loss of grain and air flow from the fan seal any gaps with duct tape.

7. 7. Plastic cover strips



Two cover strips cut from strong plastic sheet (such as a document holder) are secured to the Perspex sides with duct tape. This ensures all grain is deflected on to the sieves.

8. Notes and trouble shooting guide

Balancing the threshing drum

Mount the threshing drum on the main frame with drive belt and concave removed. Spin the drum by hand as fast as possible and allow it to come to a stop on it's own. Mark the bottom of the drum with caulk. Repeat this procedure several times, each time marking the bottom side of the drum when it stops. If the drum always stops in the same place, it is out of balance. The caulk marks show that this side of the drum is too heavy. To correct this you can either reduce the weight, for example, by grinding away some of the rasp bar or, add more weight 180 degrees from the caulk marks on the other side of the drum by laying runs of weld. Continue spinning the drum to check the balance and then adding or removing progressively smaller amounts of metal until the drum comes to a stop randomly in different places. At this point the drum is balanced.

Balancing the fan

First make up a temporary wooden frame to mount the fan and it's bearings on. Then proceed to balance the fan in the same way as the threshing drum. To reduce weight it is often easier to drill a small hole in the fan blade. If you need to add a large amount of weight, drill a hole and add a small pop rivet or 2mm nut and bolt. (If you use a nut and bolt as a weight, rivet over the thread so the nut cannot work lose)

8. 1. Safety considerations during operation

1) The operator should not wear lose clothing and long hair **must** be tied back and secured so it cannot get entangled in the machine.
2) Wear appropriate eye protection.
3) Before operation check the emergency stop system is working correctly.
4) Always stand behind the safety bar when working, do not feed the crop in from the side of the machine.
5) Always stop the engine and disconnect the plug lead when making adjustments.
6) Do not operate the machine with the safety bar or guards removed.
7) Keep young children away from the work area or erect a safety fence.
8) Operate the machine outdoors or in a very well ventilated area. (In confined spaces dust is potentially explosive)

8. 2. Trouble shooting guide

Problem	Possible cause(s)
Incomplete threshing (high number of un threshed heads)	1) Drum clearance too wide 2) Concave opening too wide 3) Threshing drum speed too low 4) Crop not dry enough
High number of cracked and broken grains	1) Drum clearance too narrow 2) Concave opening too narrow 3) Threshing drum speed too high (pulse crops –peas etc- require a lower drum speed)
Too much grain thrown out the back of the machine along with the chaff	1) Air flow too high 2) Angle of sieves too steep (lift the end of machine up on blocks to alter the angle) 3) Angle of fan less than 30 degrees 4) Sieve hole size too small
Sieves block up with straw and chaff	1) Air flow too low 2) Hinged baffle plate not lowered 3) Angle of fan more than 45 degrees 4) Sieves not brushed clean periodically
Drive belt keeps jumping of the pulley	Incorrect pulley alignment, the pulleys must be inline and the shafts must also be parallel to each other (parallel when viewed from the plan view and the end elevation view).
Threshing drum continues to turn even though the jockey pulley is disengaged	1) Incorrect drive belt used, the belt must be a canvas coated belt. 2) Brake blocks not adjusted correctly

Note: A problem is often caused by a combination of factors and the goal when making adjustments is to achieve a best compromise.

8. 3. Pedal powered thresher

The ultimate goal is to develop an efficient pedal powered thresher. The following notes are provided for those who wish to explore this challenge further.

The average continuous power output for a human pedalling is around 100 watts. To operate the threshing machine will require something like 500 watts (this estimate needs to be verified) . It is proposed to use a human powered flywheel motor to store up the power from pedalling (i.e. the 100 watts from continuous pedalling) so that it can be delivered in short bursts of power at about 500 watts. The thresher would be operated by two people, one pedalling and one feeding the crop into the machine.

This method suits the threshing machine because it is only under load when each individual crop bundle is being threshed. The flywheel is recharged with power during the period of time it takes to, discard a threshed bundle and prepare a new bundle for threshing.

The design proposed would incorporate a safety bar, clutch and emergency stop system to give operator safety. Designs using the threshing drum itself as a flywheel are simple, but potentially very dangerous to the operator.

Friction losses can be reduced by replacing drive belts and pulleys with chains a sprockets. Power requirements can be reduced further by splitting the machine in to two units, one for threshing only, and one for grain cleaning. Alternatively the grain could be cleaned using traditional winnowing methods (threshing is by far the most arduous and time consuming of the two operations).