

A D.I.Y Power Hacksaw--



--Using Washing Machine Bits

I needed a power hacksaw for my work making tubular chairs. Here is my design which is cheap to run and easy to build.



Disclaimer

The author cannot accept any responsibility for injuries arising from the construction and/or use of the equipment described in this handbook. Individuals using these instructions should make sure they have the necessary skills in both mechanical and electrical engineering before starting the project.

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The design—main parameters

1. Should use 12 inch standard hacksaw blades, these are cheap at 50p each.
2. Table model with minimum weight consistent with rigidity so that it can be transported easily and repositioned for angled cuts etc.
3. As far as possible use proper bearings for longevity.
4. To be able to move the vice to cut at an angle of up to 45 deg.
5. To use readily available materials.

1. The bits you will need

From the washing machine, you will need.

1. The motor. It's important to use the variable speed brush variety (some machines use synchronous motors). Leave 50cm wire on motor connector.
2. The ON/OFF switch (nice push button)
3. The control board (from which to extract the triac)
4. The drive belt (which you will shorten)
5. The drum (from which you will extract the large pulley and bearing assembly)
6. The casing which is used to guard all the moving internals of the completed saw. (this sheet metal, can also be welded to cars)
7. The input mains filter. (an aluminum cylinder with 4 terminals)
8. Wires with the original spade connectors attached.

Salvaging the drum bearing and pulley

The bearing was embedded in a fairly heavy plastic surround at the back of the drum and required some work with a hand saw around the outside of the drum (cut A). Then a jig saw was used to trim around the outside of the pulley at cut B.

The spindle can usually be removed through the front of the drum once the big nut holding the pulley has been loosened .It comes out complete with the spider which is fixed to the inner drum. Take care not to loose any bearings.

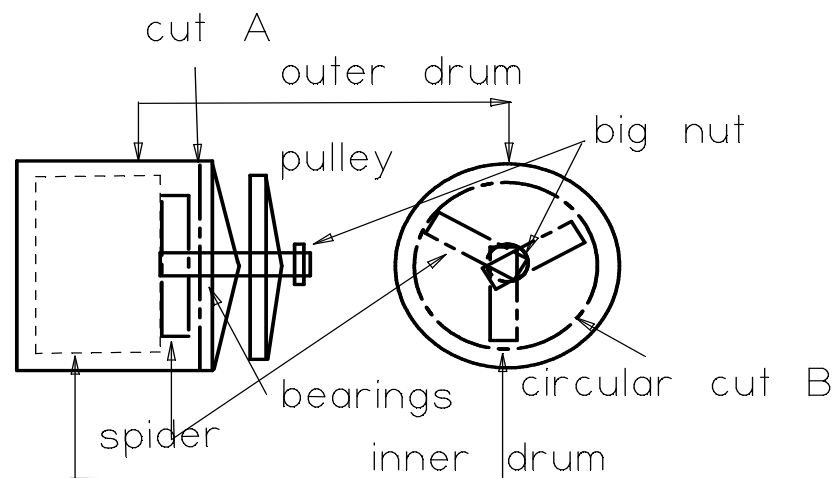


FIG 2 Washing machine drum assembly

The inner drum was easily detached from the “spider” resilient mounts. The three legged “spider” is made of aluminum molded over the pulley shaft. This shaft was carefully recovered by cutting into the aluminum parallel to its sides. These cuts were opened up with a flat chisel and the aluminum was split away. Soft vice jaws were used to avoid damaging the shaft bearing surfaces. Inside the aluminum molding was a nice round shaft with a flat to grip the spider better.

Other bits required

A pair of pedals and cranks from an old pushbike, preferably steel ones. These provide good crank bearings.

Most of the static frame is made from old bed iron

For the moving frame of the saw you will need approx 10 feet of 25mm square steel tube.

You also need about 5 feet of 1 inch 3mm bar.

A small quantity of 30mm angle iron is needed for the sliding blade carrier. (12 inches)

For the saw table (to which the vice is bolted) some 5mm x 350x110mm plate is required. Some conveniently available building angle was slit and welded together for this purpose.

Since the saw blade is so high an ordinary record number 1 vice was used to hold the work.

Two 9mm x 11inch coach bolts needed to act as swinging arm pivots

A length of 12mm studding (220mm) and 3 12mm nuts is needed for adjustable crank rod.

Approximately 5 inches of 30mm square section tube is needed for the crank joints.

Various 8mm nuts and bolts

One Radio Spares 8mm knob (for blade tensioner)

Number 1 Record metalwork vice

Three 10mm bolts and nuts for vice

A car timing belt idler wheel to catch the saw when it cuts through the work. (maybe you have changed this yourself it's a 60k service, garages throw them out).

Control IC TDA1085 available from Radio Spares.

2. Constructing the bedplate framework

Welding capability

This is quite an advanced project; a large amount of stick welding is required. Always tack things together initially, and then when you are sure they are in the right place you can make a “tight” weld. The author has lost count of the number of times he has welded something into the wrong place. You then have to slit it with the angle grinder, sometimes in difficult places, so be warned. Do your final welding when the machine is almost finished!

Welding distortion

This occurs because the metal expands when it is hot and then the joint cools and everything pulls together. It’s a very difficult problem in many industries. Problems like banana shaped boats and submarines can occur unless special measures are taken.

Example

Welding strips of steel together

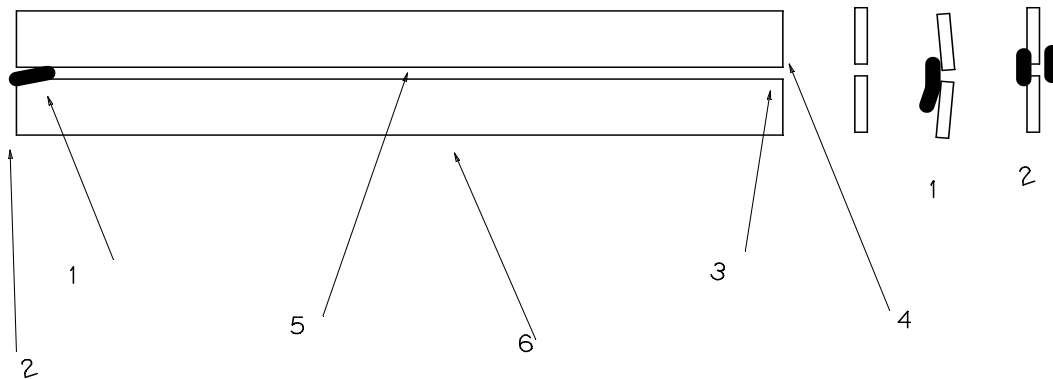


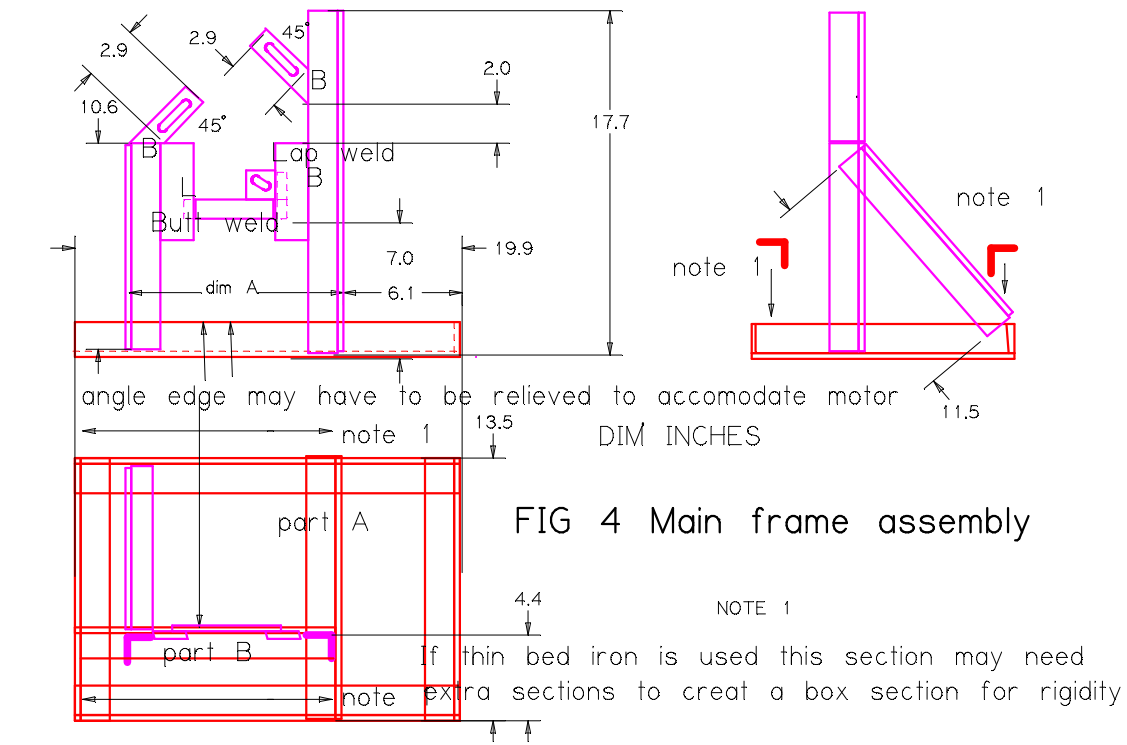
FIG 3 Welding capability

The illustration shows what happens even when two strips of metal are only tacked together on one side. When a tack is made on the other side it evens up. The opposite ends should then be tacked in the order shown. Six tacks should be sufficient for a short distance. Even when it is decided to make a run it’s a good idea to do half of one side then half of the other. The result is less neat than a continuous run but there is less danger of distortion.

This is probably the most difficult piece of work to get right but it does bring home the point.

I would also steer clear of continuous “runs” unless it is completely necessary.

Constructing the bedplate framework



Part A is the front cross beam which divides the front saw table from the rest of the saw.

Part B is set to give enough clearance from the side of the case to the cone shaped pulley. The front vertical spar is welded into the corner formed by joint between parts A and B.

Dimension A, between the two upright spars is set to accommodate different sized bearing plates from the donor washing machine.

A plate was butt welded to the top of each vertical spar to spread the load and give more flexibility to the bearing plate fixing bolt position.

These fixing plates were tied together with a 1 inch bar welded as shown. The pulley must rest against the flat surface formed by the inside of the vertical spars. Butt welds are used where flat mounting surfaces must be preserved.

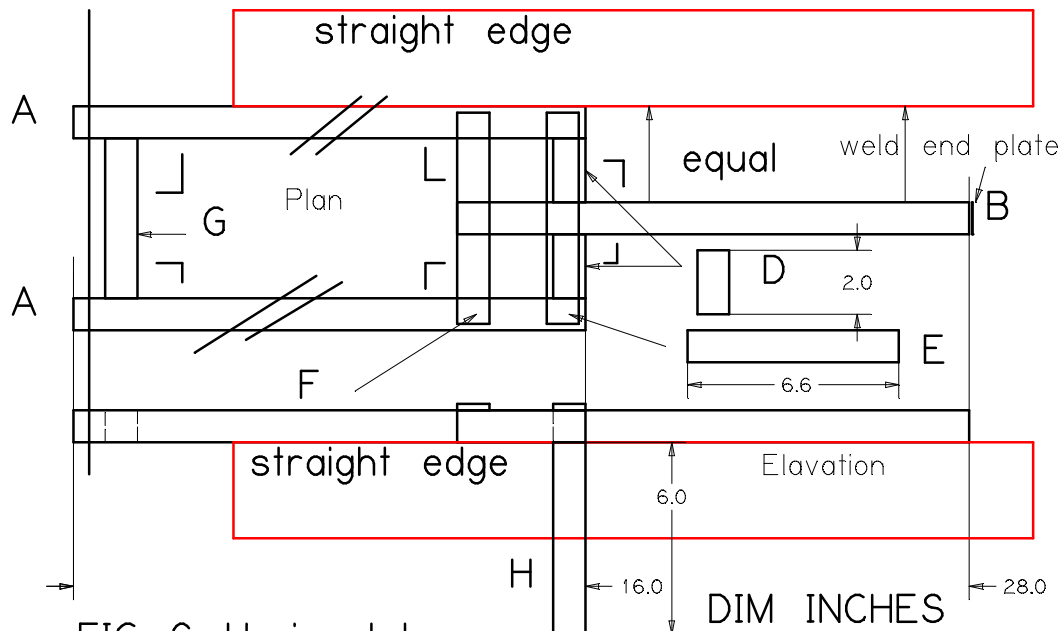
The prototype bedplate was made from 1.5 inch wide bed iron, this proved to be a bit thin and there was appreciable flexing when the crank rotated. However thicker material may prove satisfactory. In this case the frame was reinforced by welding in extra sections to create box sections as shown in fig 4 note 1.

The back vertical spar was also reinforced with a diagonal brace.

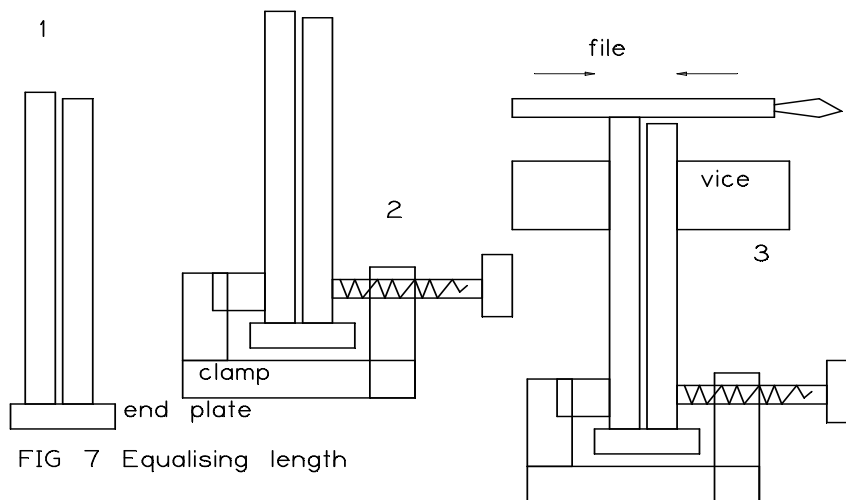
3 Constructing the saw swinging arm

Getting this item right will mean that the saw will cut in a straight line through the work without wandering off at an angle.

Before this was started all the factors which might cause the saw to wander were listed. All considered the method and order of making up the components to take advantage of the uniformity of the materials turned out to be important. The saw frame and arm were fabricated first.



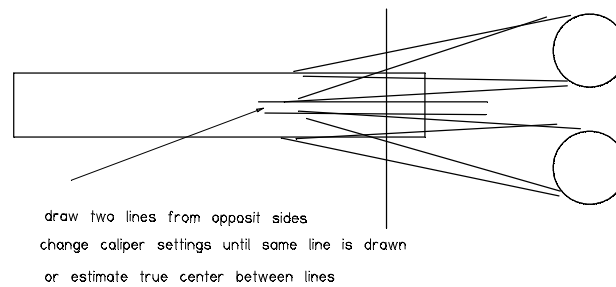
Parts A were cut to size from 25 mm square tube and were equalized by filing whilst clamped together side-by-side in the vice as shown in fig 7. The opposite ends were squared up by inverting and repeating the process.



Top pivots

Referring to fig 6 tubes part A were center punched 0.5 inch from each end along the center line and drilled with a 3mm pilot hole on a drill press. The center line can easily be estimated by using odd leg calipers or dividers (my son made several during his apprenticeship.)

FIG 8 Centering up using calipers.



The 9 mm shank bolts used for the pivots had rolled on 10mm threads at one end. These threads were therefore bigger than the shaft and would not pass through a 9 mm bearing hole. The solution was to grind these threads off with the bench grinder. An 8 mm thread was then cut with a die when the diameter had been reduced sufficiently.

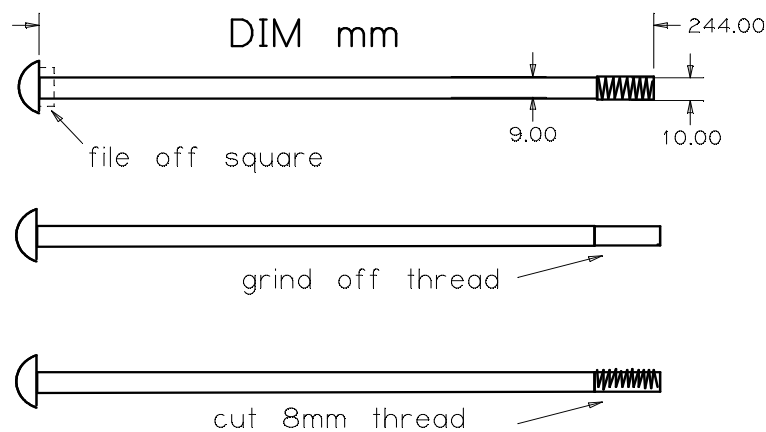


FIG 9 Threading the bolts.

In-line reaming

The pilot holes can be enlarged with a larger drill to just smaller than 9mm. This allows the holes in each to be lined up side-by-side in a vice and reamed out to fit the 9mm bolt. It turns out that a standard 11.25 inch rat tailed file was ideal for the purpose giving a 9mm hole when it slips through completely. Squareness and equality of position is guaranteed by this process. The diagram also shows clamping in the fore and aft direction aligning the components in two planes.

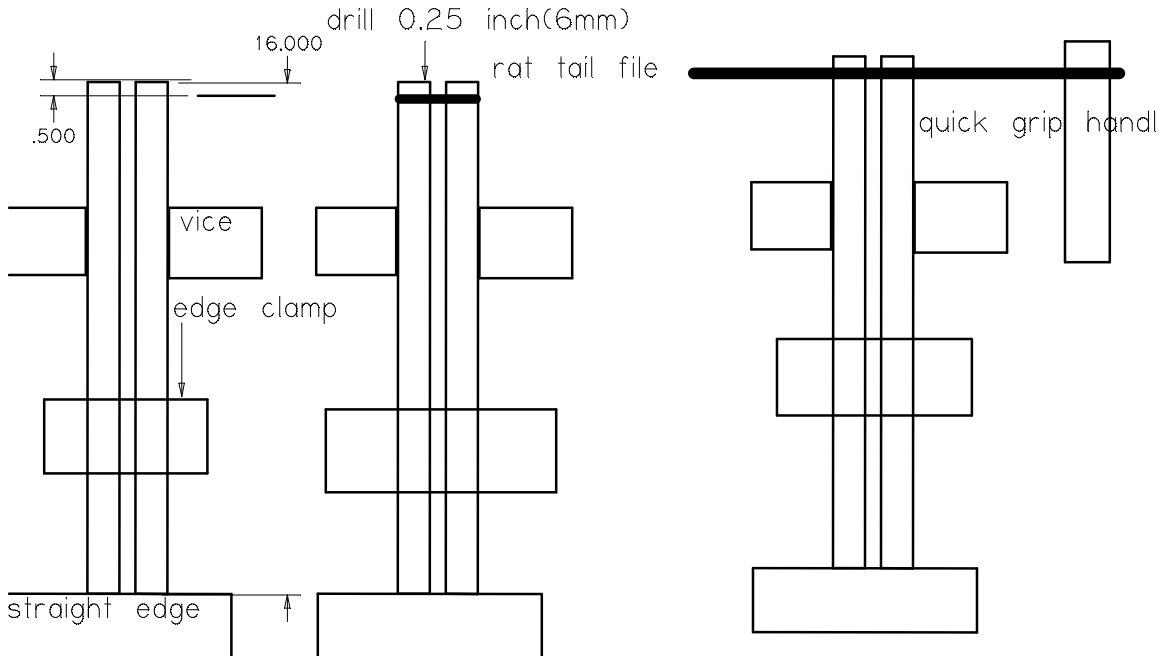


FIG 11 Pivot hole reaming.

The handle of the rat tailed file was removed and a pair of vice grips used to twist it in the manner of a reamer to enlarge the hole. It is possible the constructor may not be able to obtain the same sized file. It will be satisfactory as long as it is approximately the same. Experimenting with bolt insertion will verify how much work is needed. A tight mobile fit is required. A bolt was inserted into the first set of pivot holes prior to reaming the opposite end, to ensure perfect alignment.

The bearing is mild steel to mild steel, not ideal, but there is nothing to stop the end of the square section from being filled up with bronze or white metal at some future time to give better wear resistance (soft-to-hard metal).

Referring to fig 6 at the start of the section we now need parts B through G, be sure to make parts D equal using the methods already described.

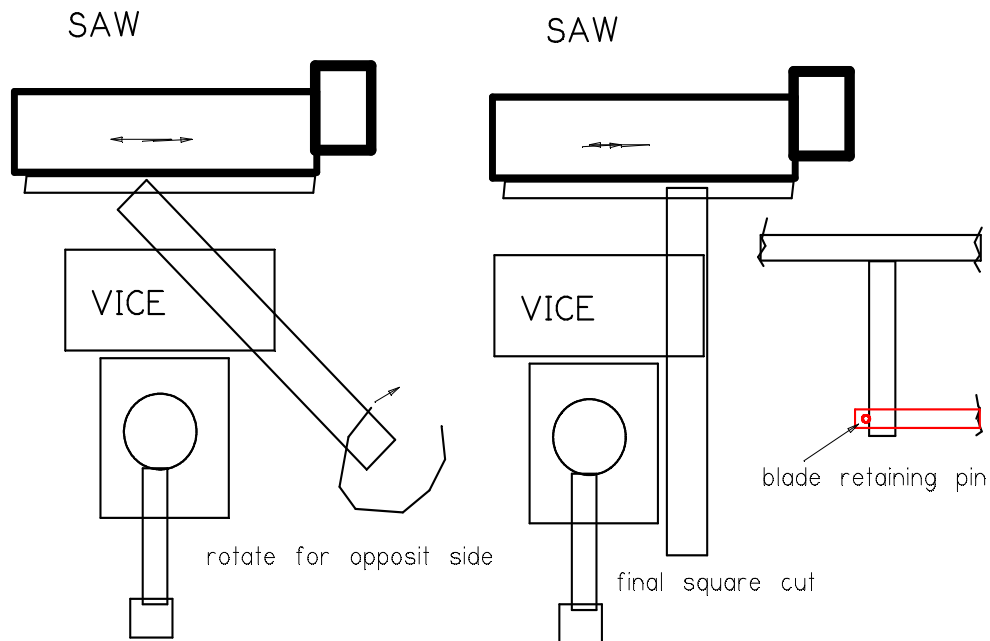
Part G was tacked into position when parts A were held in position threaded by a pivot bolt and part F clamped with two “G” clamps. Part B was also clamped into position with spacers D. Just to make doubly sure measurements of squareness were taken and a straight edge used. When satisfied G, F and E were tacked into position. The top swinging arm should be true due to the squareness and uniformity tube components used.

Blade holder

As shown in fig 6 part H was slit down the center line at one end by 0.5 inches to take the hacksaw blade. Its center line should be determined on both sides by using caliper method described earlier.

Using the hacksaw a cut was made holding the part in the vice at 45 degrees. This allowed the best control of the operation. Then the work was turned over and another cut made at 45 degrees. The cut was squared up when both sides have been done.

FIG 10 Slitting the blade holder.



If the slit is not parallel with the sides of part H then the saw will deviate from the vertical. Part H itself must also be vertical.

The blade is retained in this slit by a pin made from a piece of welding rod.

Referring to fig 6 part H was tacked onto part B square with parts D.

These tacks were made deliberately light on one side at first.

Then the part can be slightly adjusted with a hammer then tacked on the other side. It should not be welded up solid until it has been tacked on all sides and thoroughly checked for squareness.

Vertical swinging arm

The horizontal section of the frame hangs from the rear vertical sections and it is important that the parts C of this section are the same length. The method given in fig7 was again used.

This time there are two sets of pivot holes to line up. A and B. Pilot holes were drilled using the drill press, this gives approximate accuracy and squareness.

Then one set of holes were enlarged using the process already described with the rat-tailed file. Finally the bolt is inserted to align this end and the other set of holes at the opposite end are enlarged.

Again this process encourages equality and when parts C are separated and parallel the bearings should run true.

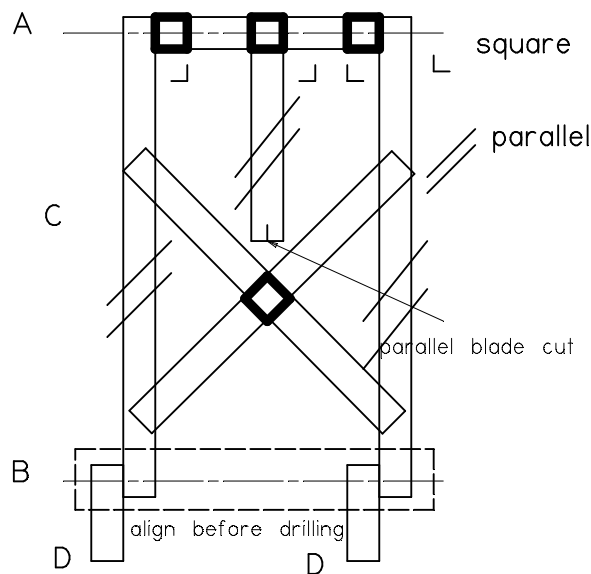


FIG 12 Swinging arm vertical section.

With parts C joined to the top swinging arm using the 9mm bolt the cross braces were clamped onto opposite sides of the square section.

These were welded on squarely when Parts C were made parallel by equalizing distances A and B.

Cross braces were welded onto opposite sides of parts C and are connected at the center with a small piece of 25 mm square tube.

The holes for pivot B which go through supports D should also be aligned before drilling either by clamping a steel plate to both square sections or by clamping both in the vice.

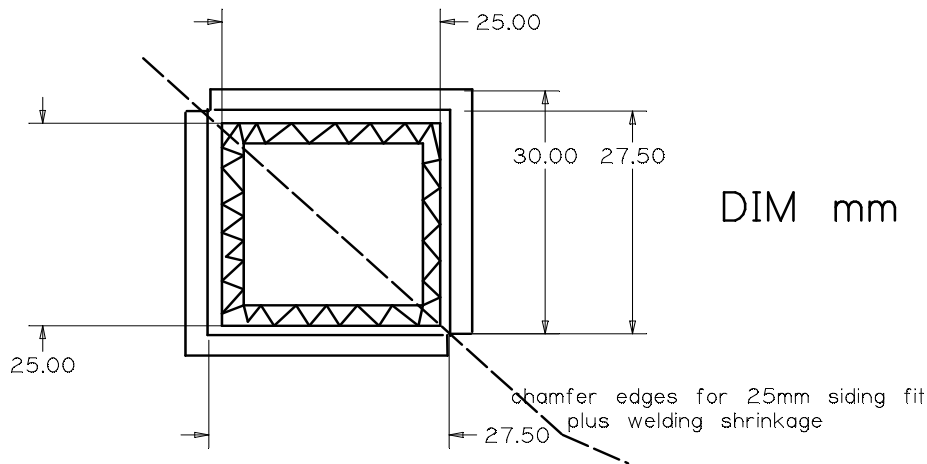
Otherwise twisting could occur when supports D are fixed to the back of the base plate which will tighten the bearing surface.

Blade tensioner

The blade tensioner is made from a piece of tubing which is a sliding fit on the outside of the saw arm 25 mm square section tube. This tube was fabricated from suitably chamfered 30 mm angle section.

The author uses a large amount of this tubing for other projects and has designed a grinding machine to simplify this task. For a “one off” job it’s probably easier to clamp the angle section in the vice and shave the edges down at 45 degrees with an angle grinder. Welding shrinkage has to be allowed for; the aim is for a sliding fit with as little “slap” as possible.

FIG 13 Sliding joint fabrication.



Another vertical spar which carries a slit for the blade was welded to the fabricated section. A straight edge was used to check for squareness.

The 8 mm nut welded to the end cap allows a “radio spares” 8 mm stud knob to be used to tension the blade. This bears against a blanking plate welded to the end of part B.

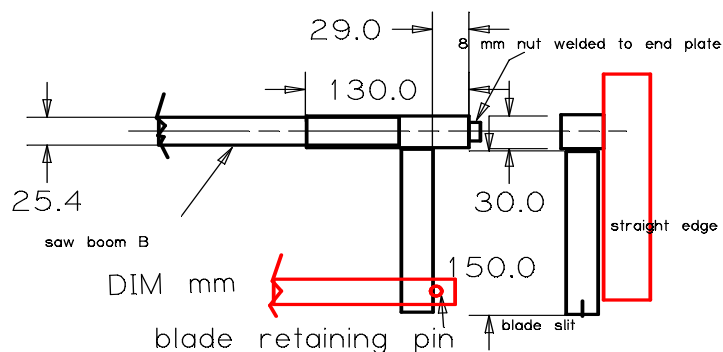


FIG 14 The blade tensioner.

4 Crank fabrication

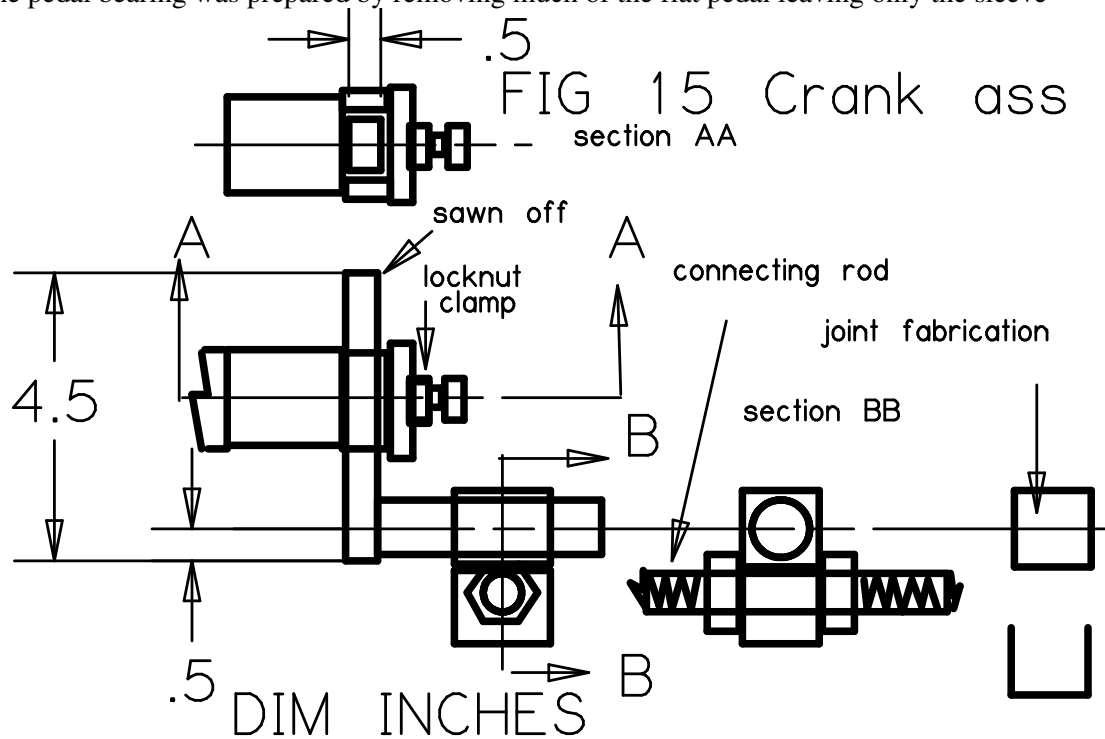
Having used the robust washing machine drum bearings it's fitting that the crank assembly is hard wearing too. Cycle pedals were the obvious choice.

There were a lot of unknowns here so it was decided to make everything as adjustable as possible.

A clamp was fabricated on the flat end of the drum shaft left when the "spider" was broken off. . Be sure to remove the shaft from the bearing before any welding, the grease will fry and plastic may melt.

The shaft of the sawn-off pedal is held in a square hole by a set screw. This allows the crank "throw" to be adjusted.

The pedal bearing was prepared by removing much of the flat pedal leaving only the sleeve



Note how the connecting rod consists of a 12mm threaded rod passing through a c shaped piece made from a piece of 30mm square section tube.

This section is welded to a complete tube which surrounds the pedal bearing. The hole for the 12 mm studding was drilled so that the studding is in contact with the side of the tube.

Two 12 mm nuts retain this connecting rod and also enable adjustment. A jubilee clip may be required to retain the connecting rod end on the pedal sleeve.

Adjustment of the 12mm nuts allows the saw arm position in relation to the crank to be changed. .The remaining pedal sleeve was used as a swinging arm connecting rod bearing.

Its threaded end was ground smooth which pushed into a suitable bracket.

The bearing retainer nut was used in conjunction with another bracket for a more positive fixing.

Again the pedal sleeve was surrounded by a piece of 30mm square tubing.

A 12mm nut was welded to this tubing to permit linking with the 12 mm studding used for the connecting rod.

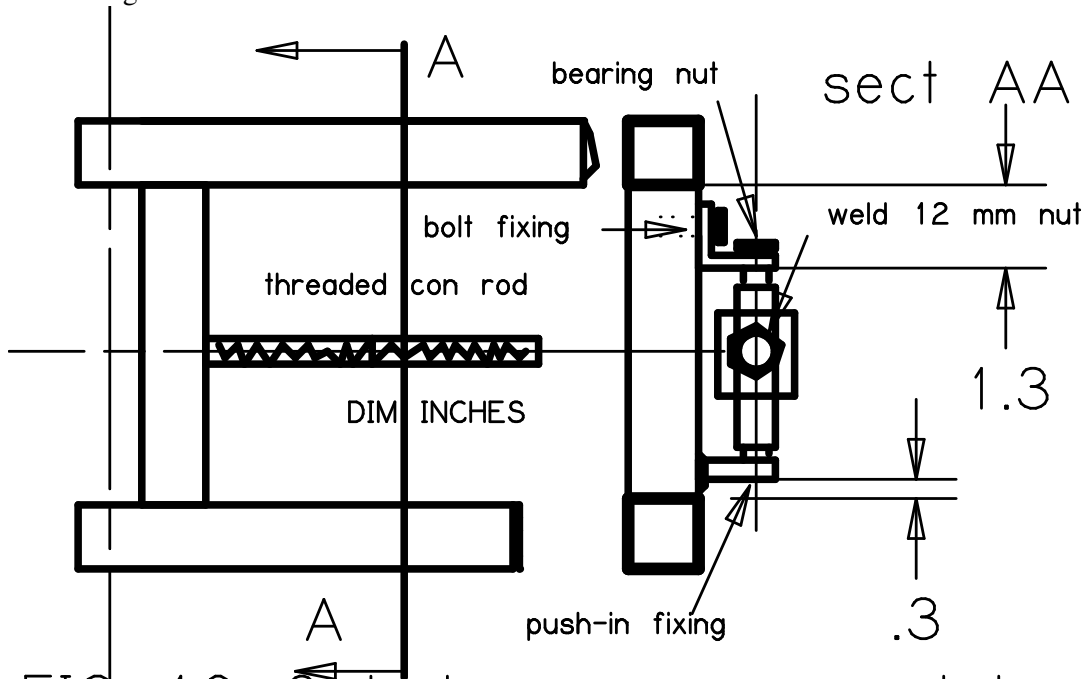
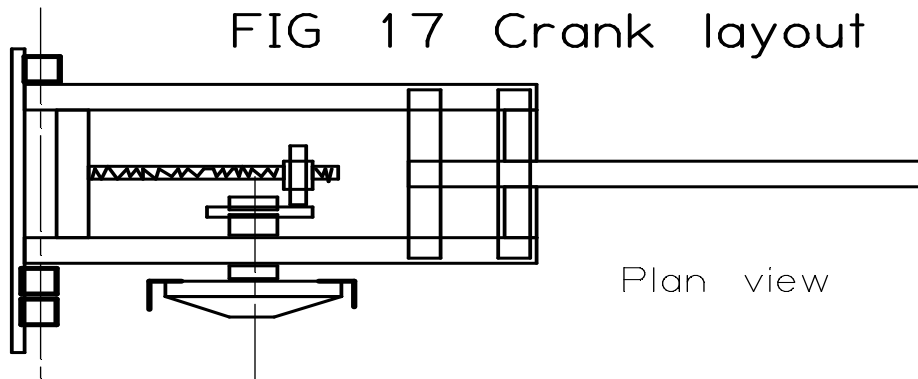


FIG 16 Swinging arm con rod bearing

The above diagram shows underneath the back of the top swinging arm of the saw. Dimensions may be varied to suit the pedals available.



5 Motor and drive belt

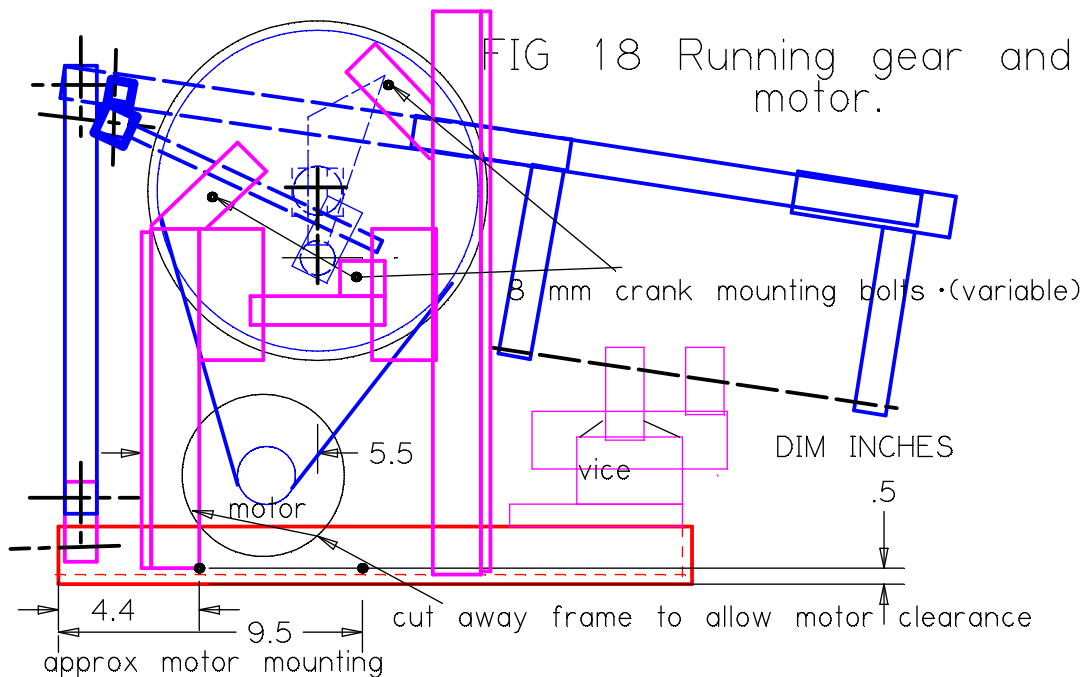
The motor is mounted on the piece of angle section beneath the verticals on which the drum bearing is mounted.

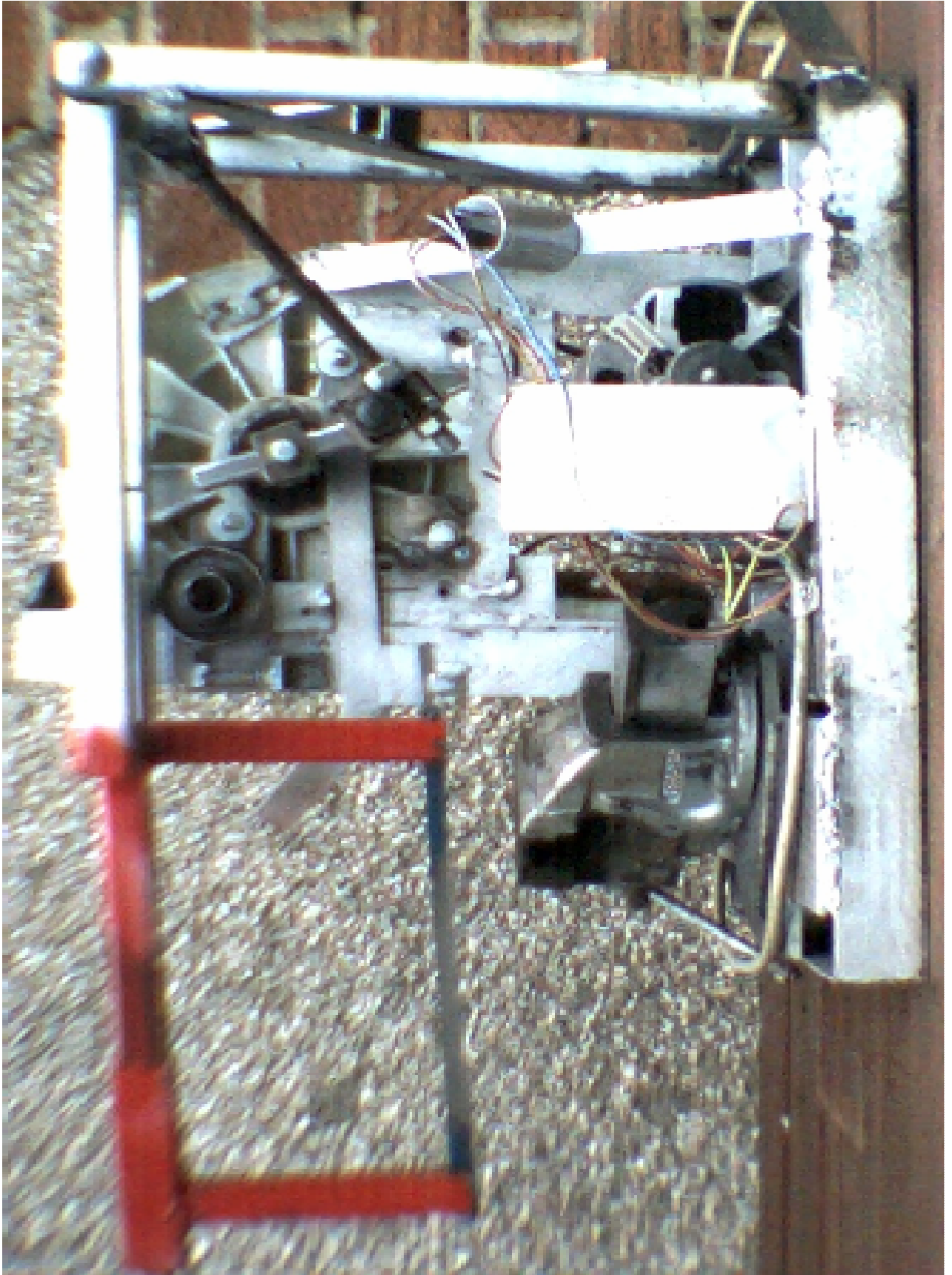
On the prototype the two motor mountings on the face were bolted to the base angle section which had to be cut away to give clearance so that the belt would run parallel and stay on the pulley.

The drum bearing backing plate was clamped into an approximate position and the three mounting holes drilled. Elongated holes in the metal brackets allow further adjustment to suit the belt used.

Care is needed so that the large pulley does not foul the inside of front vertical 45 deg guard.

The length of the existing belt can be shortened once the motor has been mounted and the approximate position of the drum bearing is known.





Shortening the belt

The belt furnished with washing machine is very much longer than is needed. A belt of approx one meter is needed for the machine.

Custom made belts are likely to be expensive in small quantities. Fortunately these belts can be shortened.

It's quite surprising but an overlap joint made with super-glue will actually hold. The joint should be 0.5 inch with the edges beveled on a bench grinder.

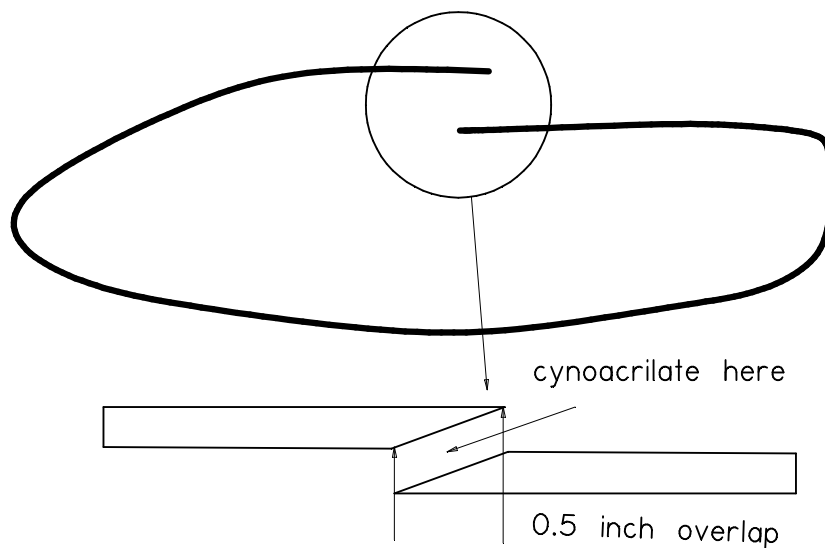


FIG 19 Method of joining the belt

According to the manufacturers instructions the glue should be applied to one surface then the joint should be clamped for a few minutes in a vice.

The belt was modified when both motor and drum bearing plate had been mounted so that its approximate length could be determined.

Then using the elongated holes the belt tension was set just enough to prevent slippage.

Setting the belt onto the inner grooves on the motor pulley will pull the belt into the large pulley.

These adjustments were made so that that belt just stayed on the large pulley as both were turned by hand.

This ensures wear free running of the flat grooved belt.

6. Saw stop, blade lifting device.

To stop the blade from dropping too far it's necessary to limit its travel (some saws actually switch off when they get through the work piece).

The blade also needs to be lifted out of the way when releasing the vice. Here these functions are combined in one.

A car timing belt tensioner is ideal for this purpose, having a heavy duty bearing incorporated.

Its wheel runs against the left hand square section swinging arm member when the saw cuts through the work. The rim of the wheel shown in fig 20 was ground off so that it presented a flat bearing surface

It is mounted on a sliding joint with the front vertical drum angle section. This is used to raise and lower the saw blade.

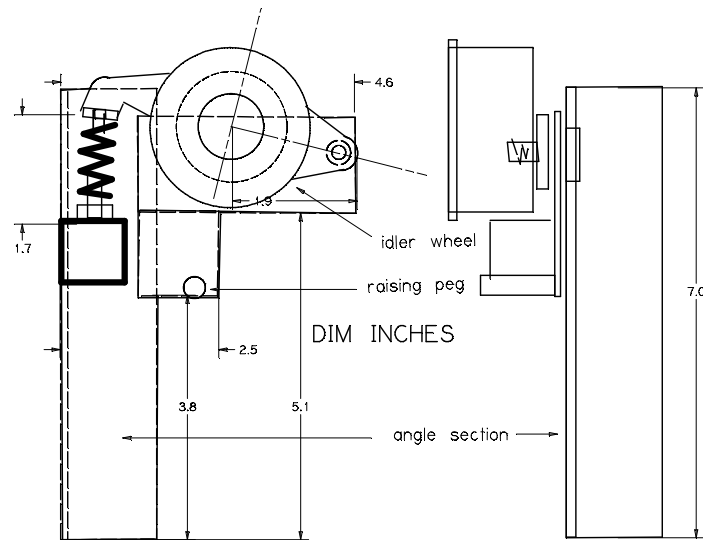


FIG 20 Blade lifter

A peg was welded to this sliding section this allows a jockey wheel to be raised or lowered by a lever pivoted on the back drum pulley upright.

The idler wheel is spring loaded to absorb the impact of the saw arm dropping on it when the work is done.

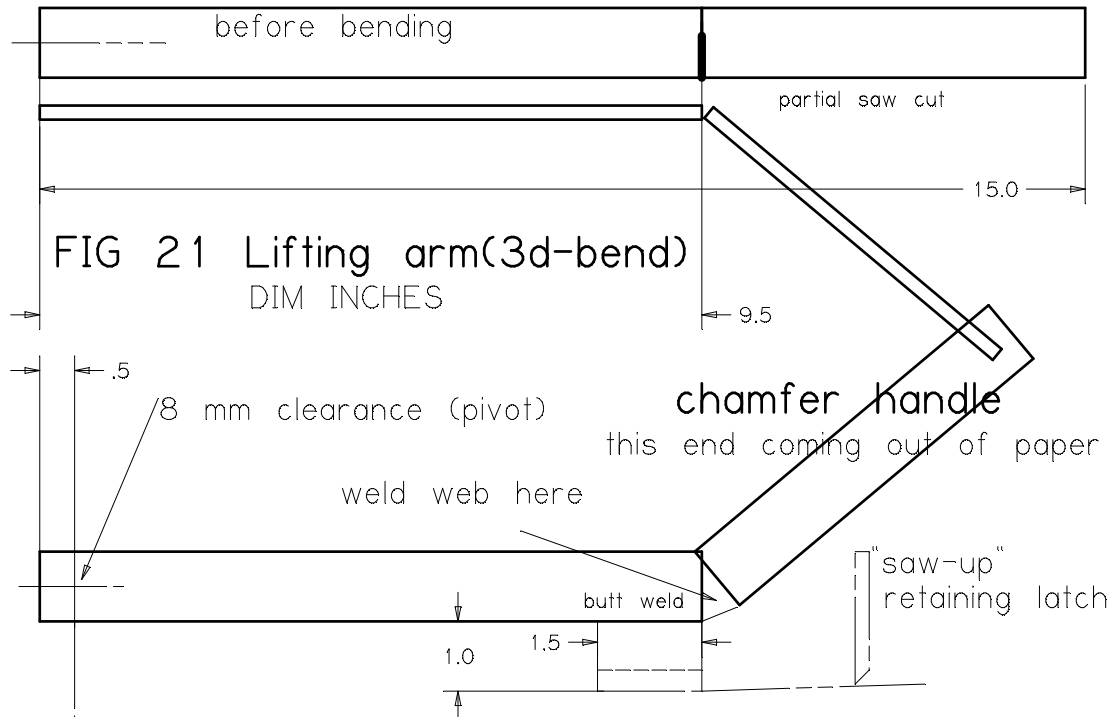
Fig 22 shows the metal strips carrying the lifting pin and the jockey wheel which are welded to the outer surface of the sliding angle section.

This was done so that it will slide unimpeded on the side of the front vertical spar supporting the crank bearing casing.



Lifting lever

The lever which operates this lifting arrangement was made by partially cutting through a piece of 22mm x 3mm steel strip and bending as shown in 3-dimensions.

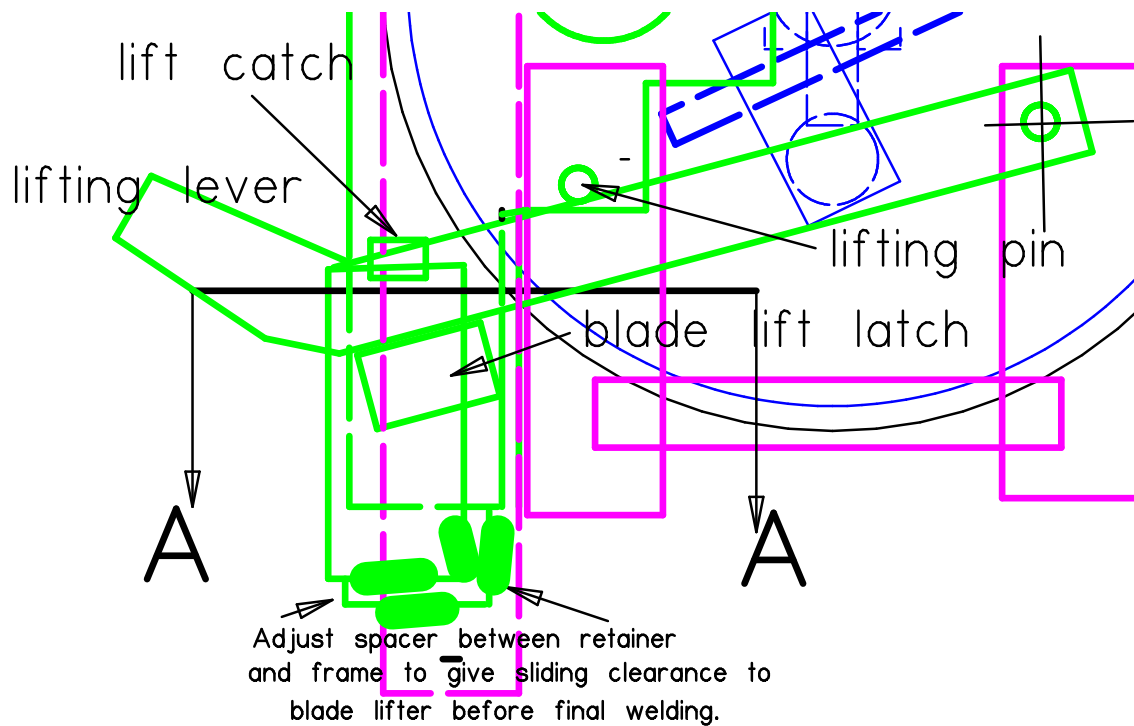


A web was welded across the "vee" when it has been proved that this lever clears the side of the saw and any long work which is likely to be sawn particularly when the vice is set to 45 degrees.

The sharpened saw retaining latch is butt welded in the position shown to give the correct spacing in the "saw-up" position.

The full-sized diagram shows how the lever and jockey wheel carrier fit together on the side of the frame. To retain the lever in the upper position a chamfered section engages with a flange on the slide retainer.

The next page shows how the blade lifter angle is sandwiched between a piece of angle section welded to the outside of the front vertical spar with the appropriate spacing piece in place. This allows it to slide when the lifting lever is operated. There is a lip which then retains the lever in the upper position. Then lifting the lever and moving to the right clears the lip allowing the blade to be lowered.



The lever is loose enough on its pivot to be able to be moved sideways when the blade is lifted by the lifting pin. Its latch can then be moved to engage with the catch plate allowing the blade to be retained in the upper position.

The opposite process is used to lower the blade.

adjust spacer to give sliding clearance before welding

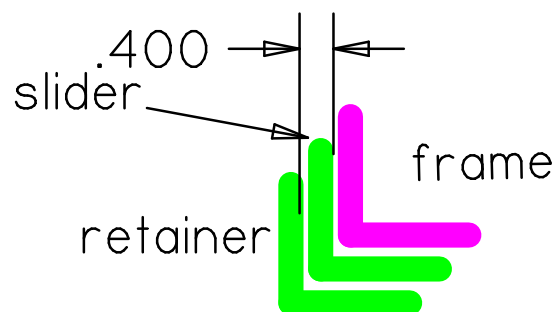
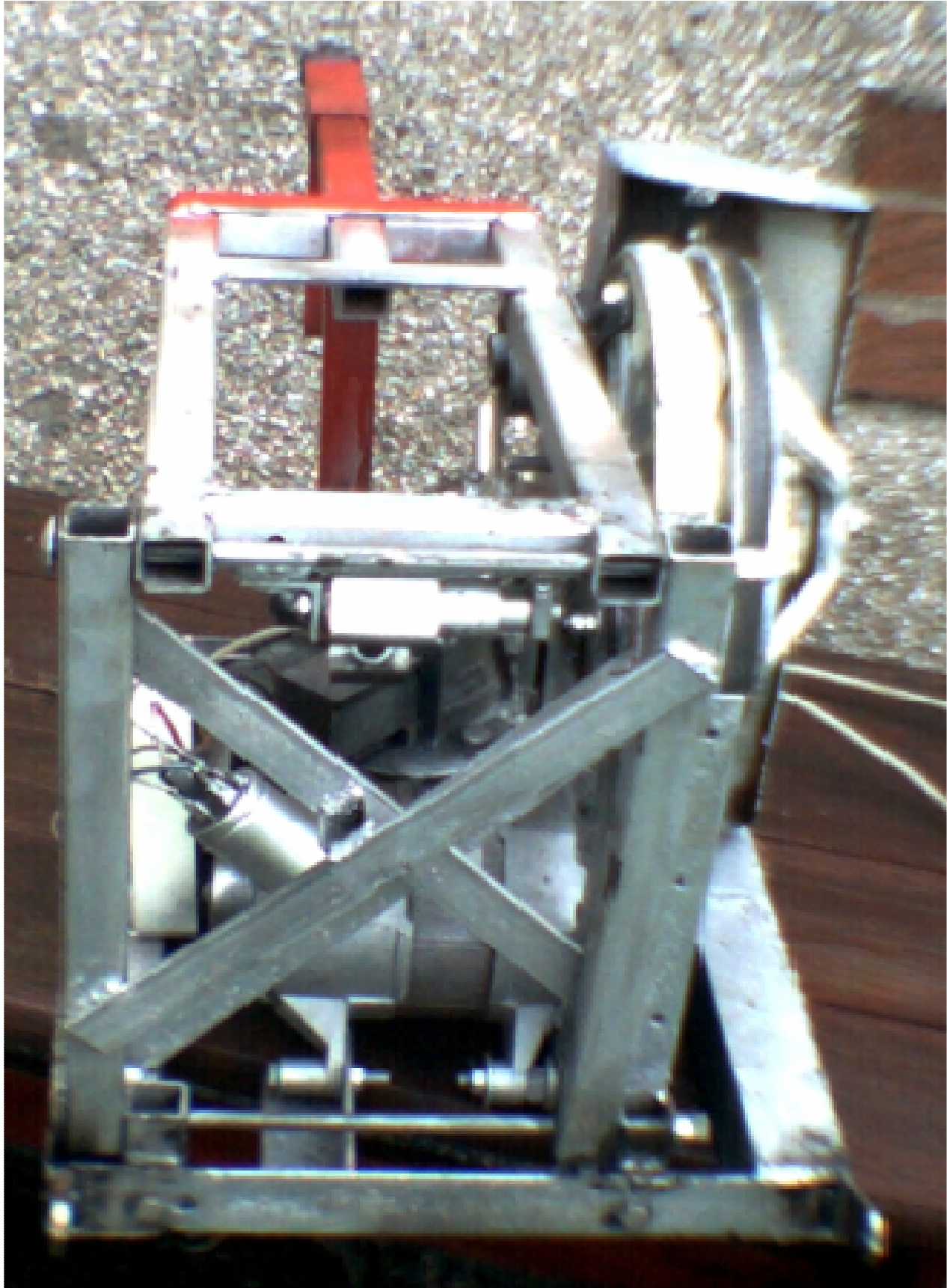


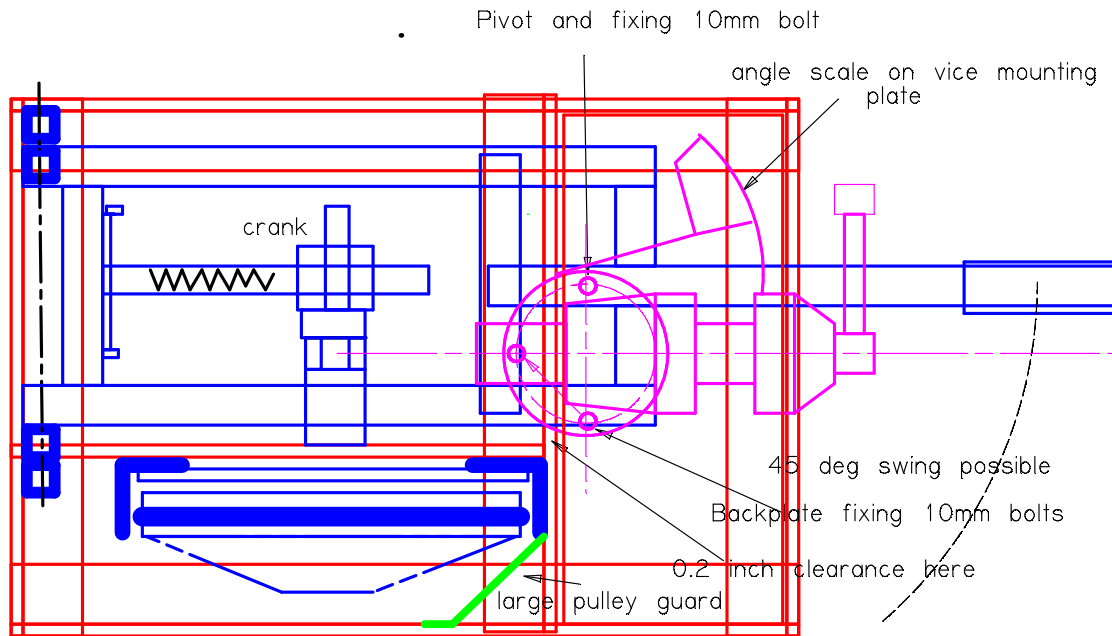
FIG 22 Section A-A the sliding joint



7. Vice table and angle setting

This was designed so that work could be cut up to a 45 degree angle. It uses a 3 inch jaw Record No1 vice which with the dimensions shown can be pivoted on one of its mounting bolts. A sector plate was made which was marked with commonly used angles. This is between the vice and the saw table.

FIG 24 Vice mounting



When the vice rotates on its fixing/pivot bolt it must not foul the front upright (on fig 31 where the 0.2 inch clearance is indicated).

Also the position must be set so that the saw blade is clear of the vice jaws for all angle settings.

When the vice is set for 45 degrees holding a long bar there has to be enough clearance with the large pulley wheel guard.

Only when all these conditions are satisfied should a pivot hole be drilled and tapped into the bedplate.

Moving the vice position towards the front of the saw is permissible as the blade stroke is large.

8. Outer casing fabrication

The outer casing was designed to enable work to be cut up to an angle of 45 degrees, this entails having a cut out on the left side.

FIG 25
Cutting the washing
machine case.

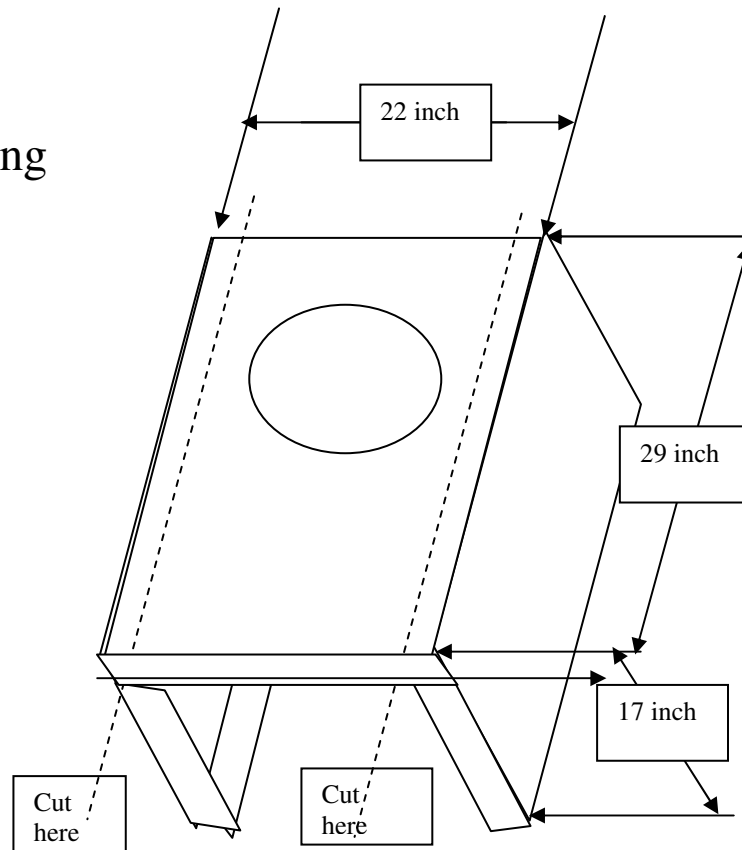
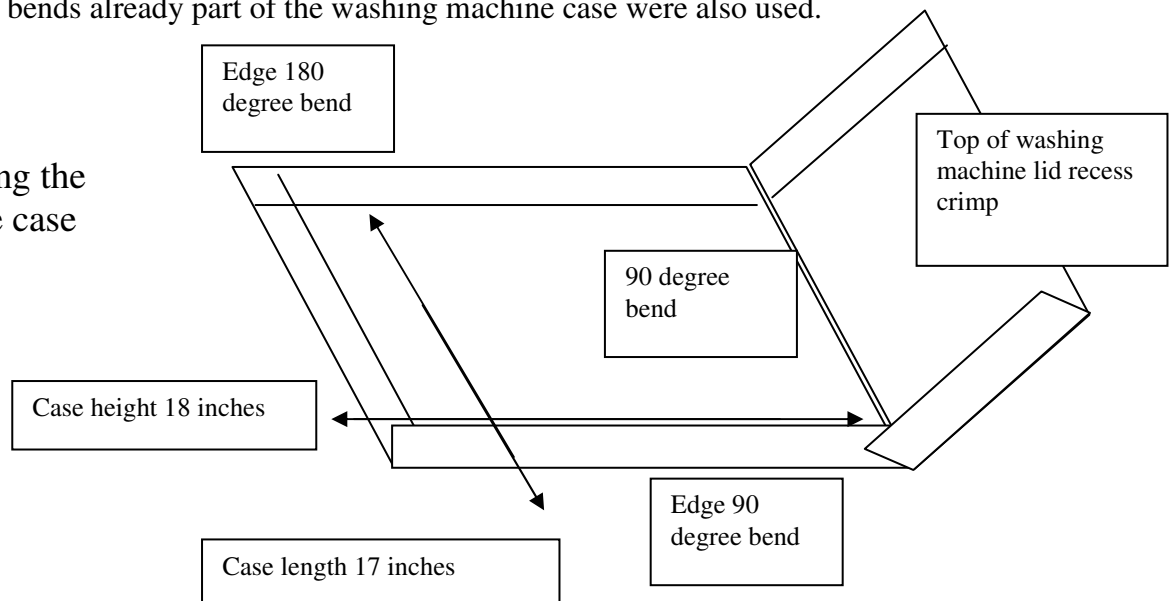
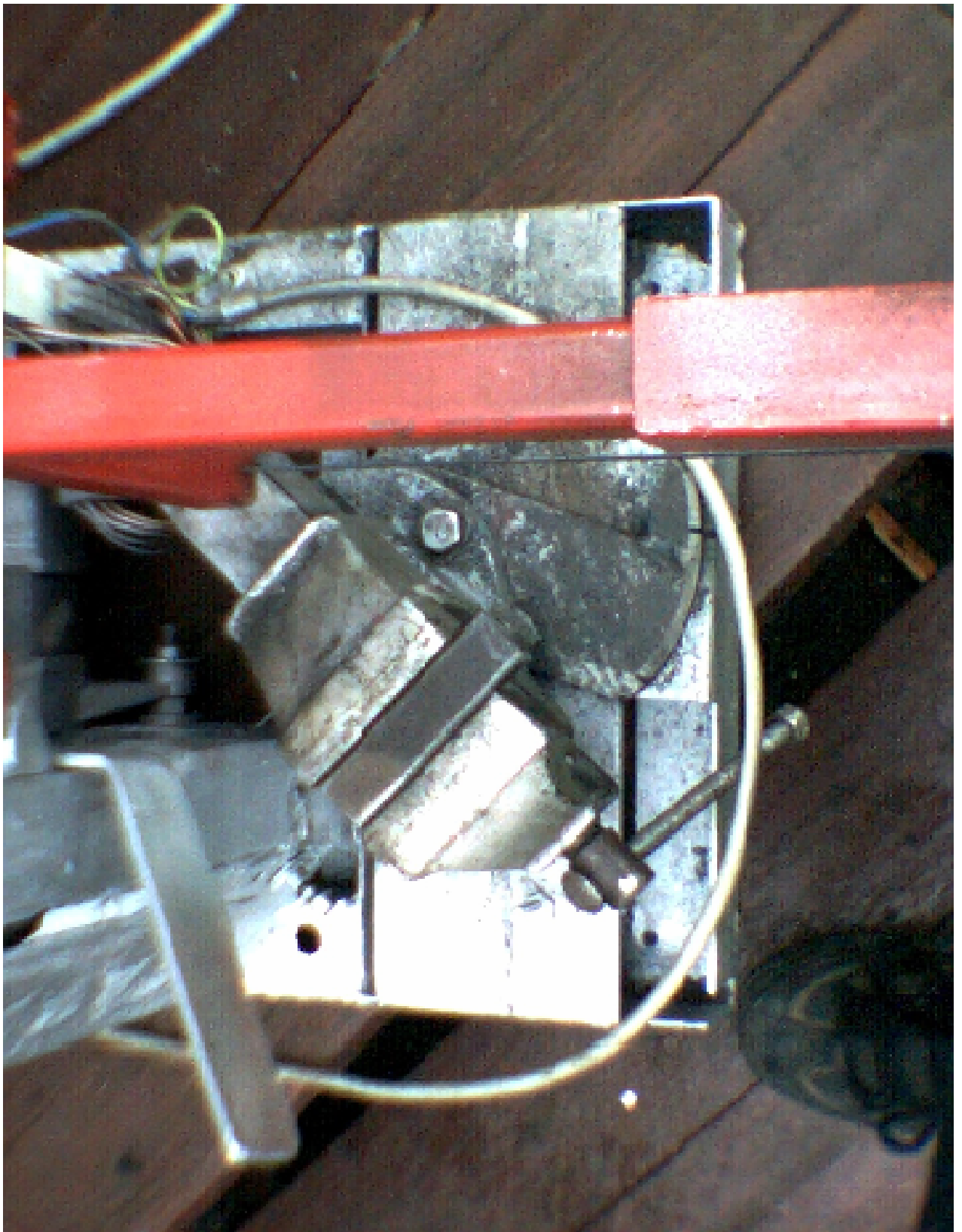


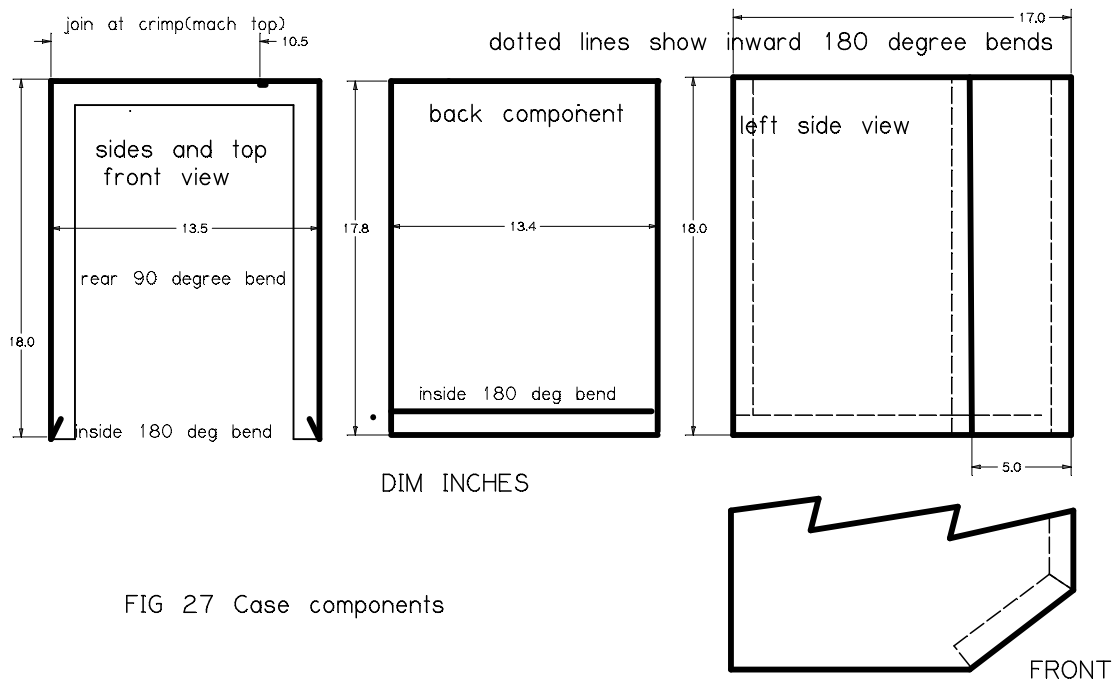
Fig 24 shows how the washing machine case was cut with an angle grinder to obtain material from which to make the saw casing. The side panels were used to fabricate the case and the bends already part of the washing machine case were also used.

FIG 26 Bending the
left side of the case

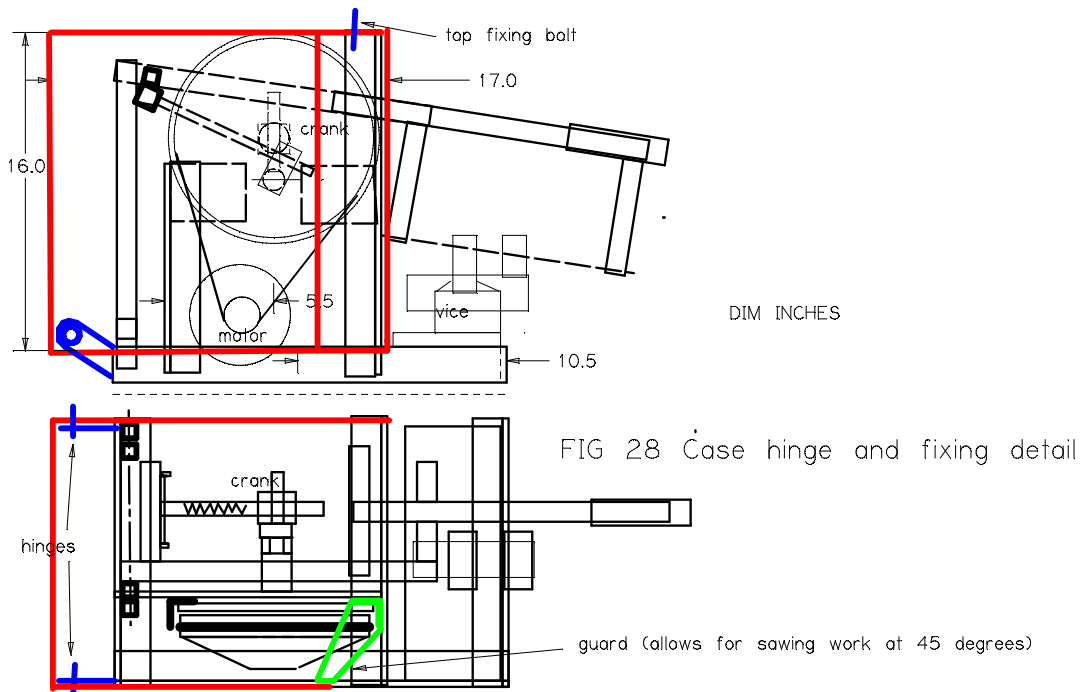




The right of the case is similar except that the top side is smaller they both were welded together using a MIG to make a case with the front view as shown below.



The back has an internal 180 deg bend to get rid of the sharp edge and 90 degree bends which go inside the back and are welded to the sides and top. There is a cut-out at the front left side to allow clearance for work cut at 45 degrees.



9. The electronic speed controller

WARNING

Knowledge of electronics is needed to complete this section if not a ready made controller will be available from the author to suit demand. This can be wired in by a qualified electrician or the user if he feels confident.

This item is essential for the operation, had it not been available the saw could not have been constructed. It uses a TDA1085C Universal Motor Speed Controller I.C together with the original triac and snubber network from the donor washing machine board. It has been included at this point in the project because it's helpful to get things moving at this stage. Although the motor can also be powered up with a "variac" variable transformer.

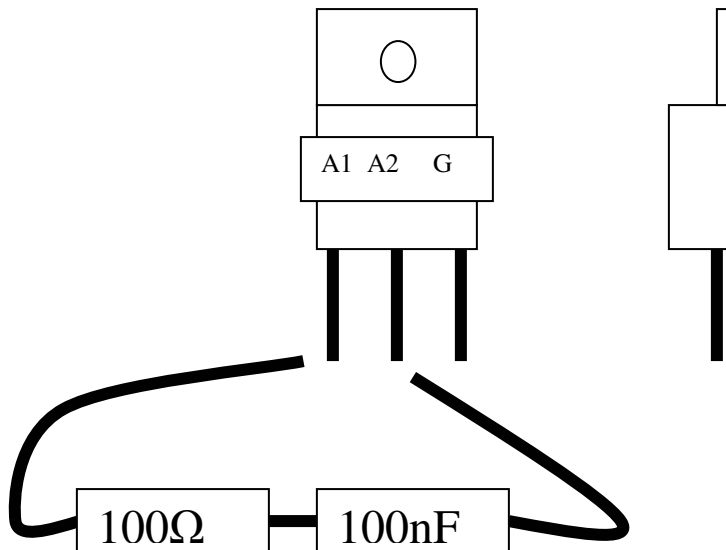


Fig 28 Case hinge fixing

BTB16 TRIAC
Mounted on a metal
heat sink FIG 29

Snubber network

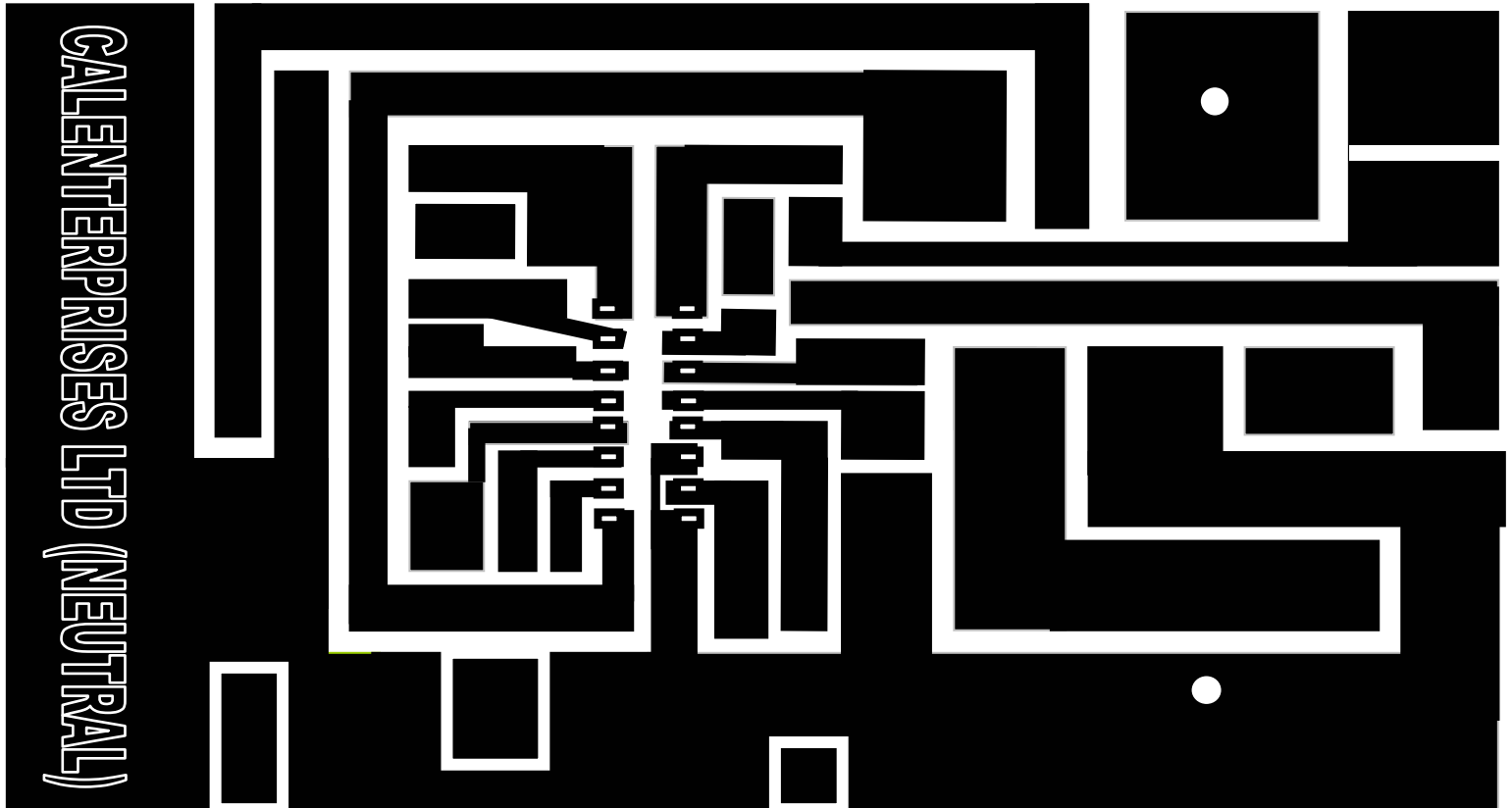
In operation the triac operates as a switch controlling the current going to the motor, the snubber prevents damage to the triac by absorbing surges. The snubber capacitor will be a fairly high voltage type.

A dropper resistor of 6.8kΩ is used to derive the 15v supply for the IC and this should be a ceramic high wattage type. Constructors from USA may need to use half this resistance. Two series silicon diodes give the potential on pin 5 to set the speed; this could be made variable up to 15000rpm for other applications.

The 50mΩ shunt which limits the motor current under fault conditions was made up from resistance wire using a 4 terminal method to determine its value.

The board was designed to fit inside a small plastic box available from Maplin electronics, the heat-sink needs to be in the open so only one half of the box was used. There is a danger of electric shock if the heat sink is touched. However the plastic box is facing towards the outside of the saw so the possibility of the other side being touched is remote.

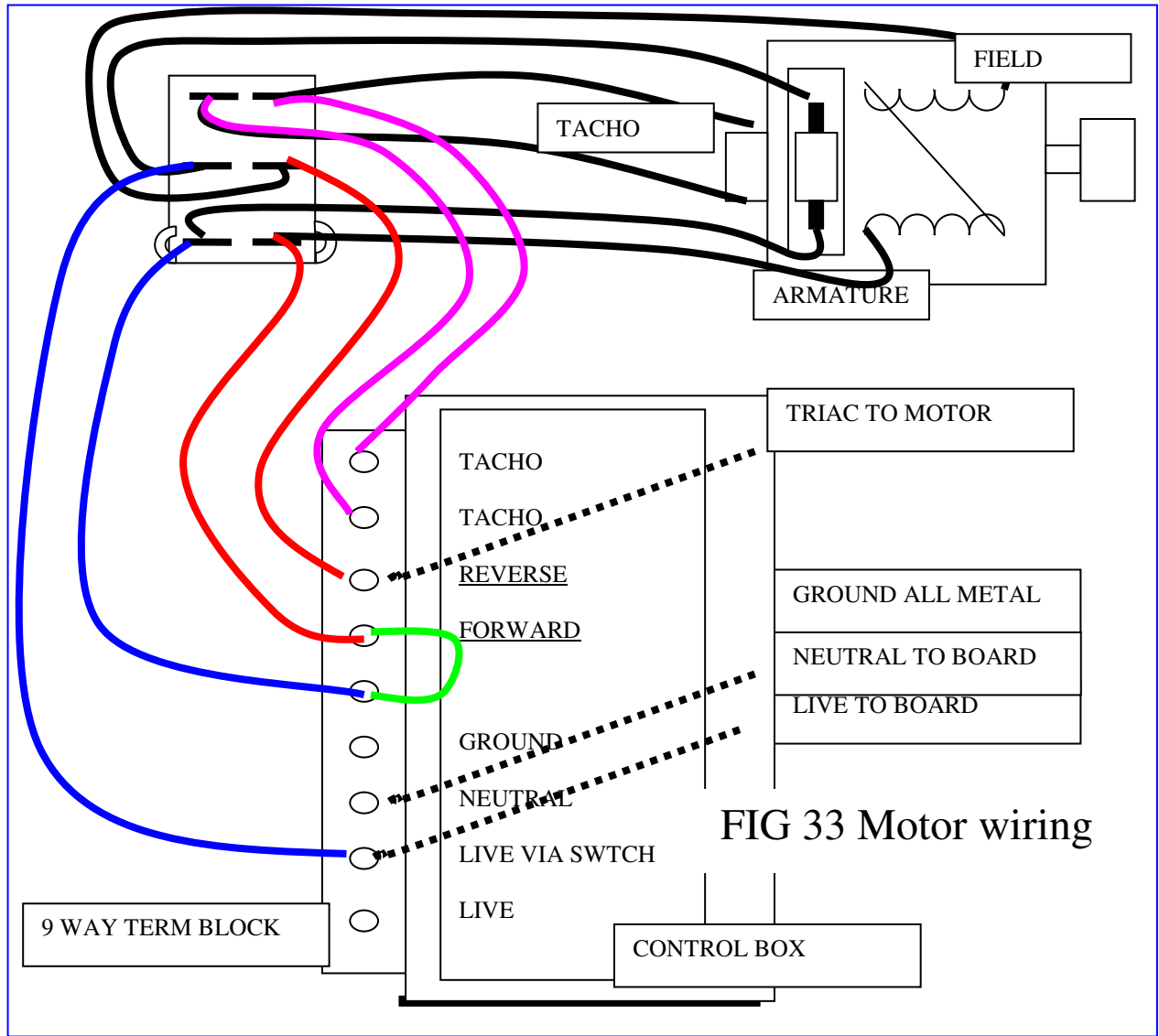
FIG 30 PCB Master track layout © Calenterprises Ltd 2006



The board was be reduced to 66% and printed on transparent film, such as used for O.H.P. The resultant transparency was then laid on UV sensitized board with the logo readable and the image transferred for etching.

Wiring and testing the controller

The motor can be wired up to the controller for testing once it is mounted securely. These motors give quite a jolt when they start off, it's not safe to have them just lying on the bench. If the triac is short circuit the motor will try to rev up to 15000rpm so it's worthwhile tying it down. The belt was of coarse left off.



The diagram shows wiring for the author's washing machine motor looking into the six way connector. Most of the time wires can be traced visually, backing up with ohm meter measurements. Across the tacho the resistance is high compared with either armature or the field.

Since the original connecting plug was retained with a reasonable length of wire attached it was a simple matter to make all the connections into a terminal strip bolted to the controller plastic box. The motor armature and field windings are wired in series and the direction of rotation can be changed by swapping the red wires.

Mains input filter

The original washing machine mains input filter was used; this is a shiny cylindrical item with 4 terminals. This may have spade terminals which fit the wiring recovered from the donor washing machine.

The washing machine single pole push button switch was used to switch the live into the filter. Its other side goes to LIVE VIA SWITCH on the controller. Neutral goes straight through the mains filter to NEUTRAL on the controller.

For the sake of safety the three pin plug should be fitted with a 5 amp fuse. The mains cable should be securely clamped to the frame with a “P” clip.

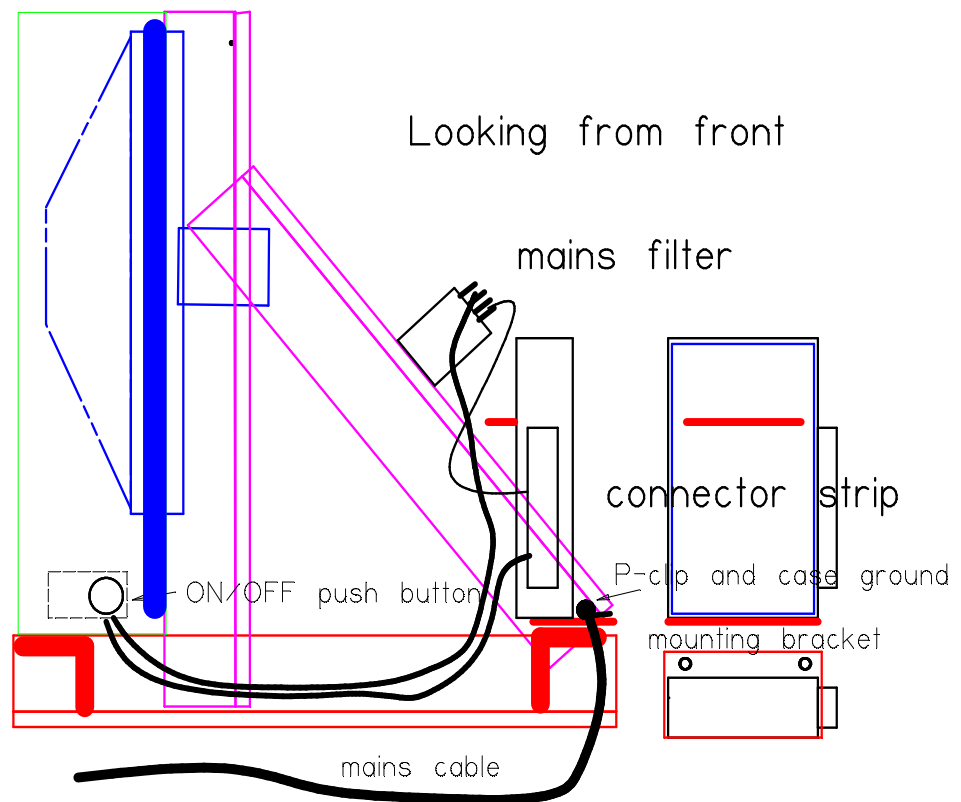
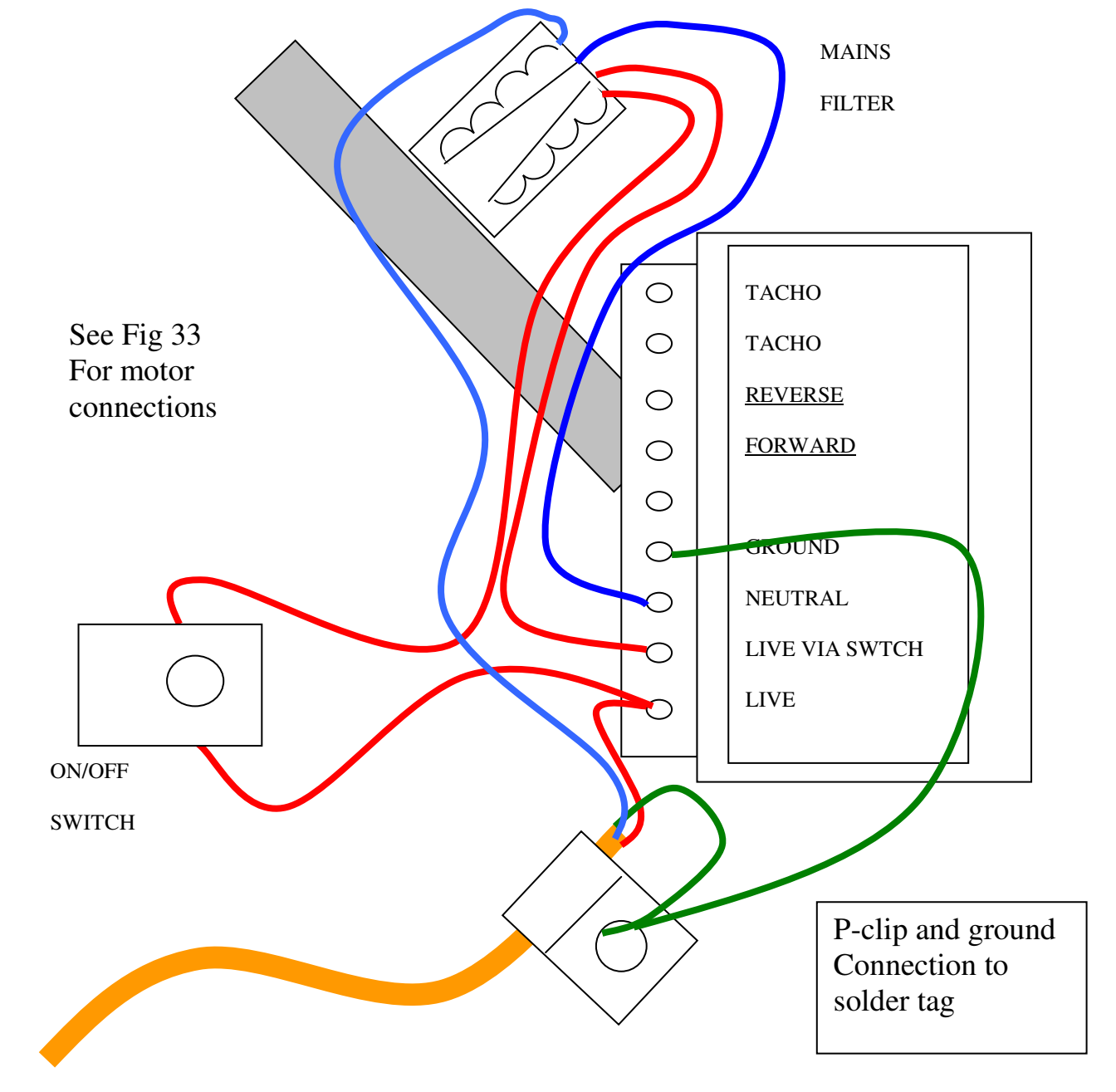


FIG 34 The electronic controller box and filter

As shown in fig 34 the electronic controller inside a 120x 80 cm Maplin box was mounted onto the main frame with the exposed parts towards the centre of the saw. Mounting the mains switch and the filter completes the electrical items.

Mains wiring

Fig 35 Mains wiring to switch, mains filter and control box.



10. Testing and setting to work

Now all the components necessary to run the saw on the blade lift are assembled for a safe trial.

Parts D (fig 12), the lower swinging arm bearing pillars were clamped to the rim of the angle section to the rear of the saw.

The position should be such that-----

1 The rear frame does not run outside the edge of the bedplate on RH side (so that the case will not foul any moving parts).

2 The right top swinging arm rail (looking from the back) runs against the blade lift wheel.

3 When the connecting stud rod is screwed in place it runs approximately in the centre of the swinging arms.

4 The saw blade clears the vice jaws when the vice is set in the straight position.

5 The saw blade runs true.

This can only be set approximately at this stage. It is better set up by making a cut. An approximate setting was achieved by tapping the rear pivot points whilst checking against a square clamped into the vice. Parts D were then drilled through the frame and fastened with 8mm bolts. This allows further adjustment if the holes are made slightly larger than the bolts.

Running the partially completed saw will reveal any faults and the crank adjustment for throw and position can be tried.

For instance it is possible to have the vertical swinging arm making contact with the back vertical pulley wheel support or at the other extreme the inside of the case.

In the prototype a jubilee clip was used to keep the connecting rod in the centre of the pedal sleeve.

Silicon rubber bathroom sealant could also be used here both to dampen vibration and seal in position. Here a fixing which allows for misalignment is needed.

The speed controller was checked with the belt disconnected. (the saw will shake itself to bits if it's faulty and runs at 1000rpm).

With the two diodes connected across pins 5 and 6 of the TDA1085C the speed should be OK.

Then the saw was run with the belt in place. In the prototype it was noticed that the speed was prone to reduce when sawing a steel bar. Although some belt slippage was noticed the main problem proved to be electronic.

The 47K Ω resistor connected to pin 3 started off as 100K Ω but this limited the motor current so it was reduced. In the event of a fault the 50m Ω measures the motor current and the TDA1085C keeps it at a safe value.

Cutting tests

Complete perfection is rarely achieved in constructing the swinging arm and blade-holder; however this can be compensated by adjustment of the rear arm bearings.

The first long cut was made into a soft wood block (it's easier to assess deviation with a long cut).

If the rear swinging arm bearings are loosened sufficiently they may be adjust by tapping with a hammer. So long as there is negligible twist in the blade a reasonable straight cut should be achieved.

Blade twist would be caused by either the two blade slits and/or carriers not being parallel. The remedy is to partially slit some welds and adjust with the hammer. Then cautiously re-welding to avoid distortion.

The rear bearing carriers may be tack welded for extra stability.

The saw was set to work cutting through so 3mm x 30mm square tube it cut through the flat section successfully but was laboring on the narrow sections. This is not unusual for any type of metal saw since there is more pressure on the blade with narrow work. Even proprietary metal cutting band saws have trouble in this respect. A spray of WD40 enabled the cut to proceed more smoothly.

No extra weight was required on the saw arm to cut at a reasonable speed.

When the saw is cutting at 45 degrees the cut is made nearer to the end of the saw arm so less leverage is operating, the saw still cut at a reasonable speed.

To sum up provided the blade is kept lubricated there should be no trouble cutting any normal steel stock.

Possible improvements

As mentioned earlier the swinging arm bearing are plane steel-to-steel which will wear particularly if lubrication is neglected. This will lead to a sloppy action.

However the open tubes which make up these bearings can be filled up with lead-bearing bronze or similar and the holes drilled out again. This would create a longer lasting bearing surface.

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