More Power at Your Elbow - Electronics

Here we get to grips with constructing the electronic circuits for driving the Wabeco milling machine table drive described in the previous article. This can of course be used to control other stepper motor drives.

I am well aware that whilst many readers with electrical knowledge may be confident when constructing electronic circuits, to many of us "tin bashers" it is something of a black art. I therefore intend to describe the components and techniques used in the construction in some detail so that those in the latter category should be able to construct this item with a minimum amount of doubt and confusion. For any electronic engineers reading this, I am not an electronics expert but simply a hobbyist who has learned by practical experience.

Overall Design Considerations

Most of us are familiar with motors of both the induction type (AC) and of the AC/DC brush type of motor. Stepper motors are considerably different in that they run on DC current which is pulsed on and off several times per second. The motor behaves similar to a ratchet gear wheel stepping round a proportion of 360° for each pulse that is provided by the control circuit. When under power, stepper motors are locked against rotation when they are not receiving pulses.

The circuit used in this project uses a bi polar motor controller bought "off the shelf" from Arc Euro Trade (SMD093064) and this is provided with low voltage pulses (+5v) to step the motor round. The pulses are provided by an oscillator using a simple and cheap 555 chip. The bi polar controller does most of the clever electronic control only requiring stepping pulses and a power supply in order to control the motor. The controller, has, in addition to the terminal for pulse input, a terminal to control the direction of rotation of the motor. Provide +5 volts to this terminal and the motor runs one way, do not provide the voltage and it runs in the opposite direction. The controller also sports a terminal called "Free". Provide +5v to this terminal and the motor become free for hand rotation instead of being locked.

Power Supply

The power supply is a dual one and we shall call the two power supplies "Motor Supply" and "Control Supply".

The "motor" side of the power supply provides 30v DC to the stepper motor controller and the supply must be capable of supplying 3 amps of current. You will see from **Fig.1** that I run on a 2 amp fuse for the transformer secondary and the motor actually draws a maximum of 1.5amps, but Arc Euro Trade recommend a 3.2 amp supply.

The purpose of the "control" side of the power supply is to run the 555 oscillator and to provide the low voltage (5v DC) to control both the direction of the motor and to power the "Free" terminal. This control power supply only needs to be able to supply about (say) 100 ma of current as it is used purely for control signals. Monitoring my unit, I see that it only draws about 25ma. My transformer has two windings, one providing 23v AC which when rectified with a bridge rectifier gives 30v DC for the motor controller. The second winding gives 10v AC which when rectified gives 14v DC. As this is to provide the 5volt supply for the control circuits the 10v supply is then fed to a 7805 voltage regulator to reduce the voltage to 5 volts.

For the less electronically minded, the transformer provides two AC voltages and the bridge rectifiers BR1 & BR2 convert these into DC

Stepper Motor Control Circuit and Power Supply

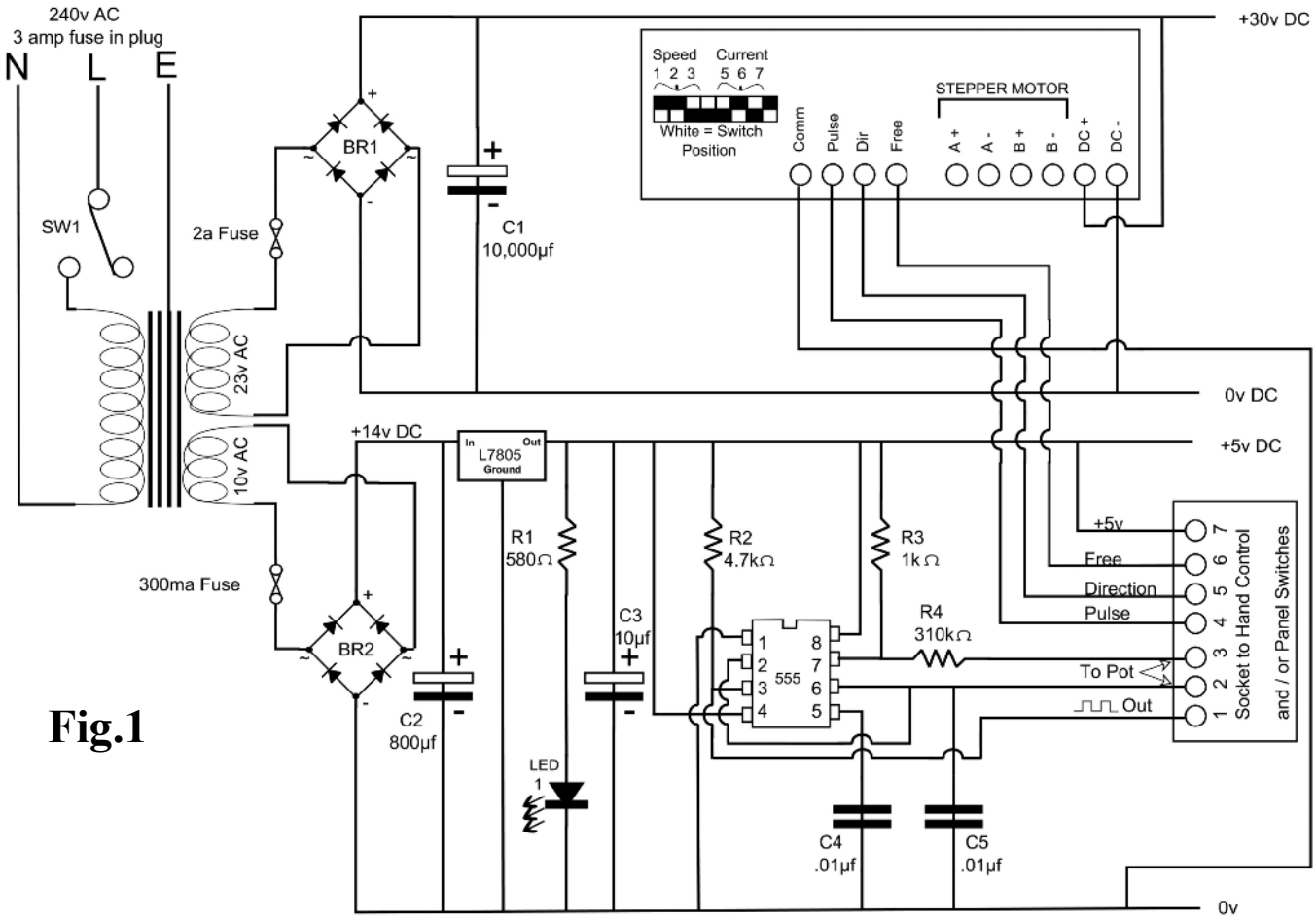
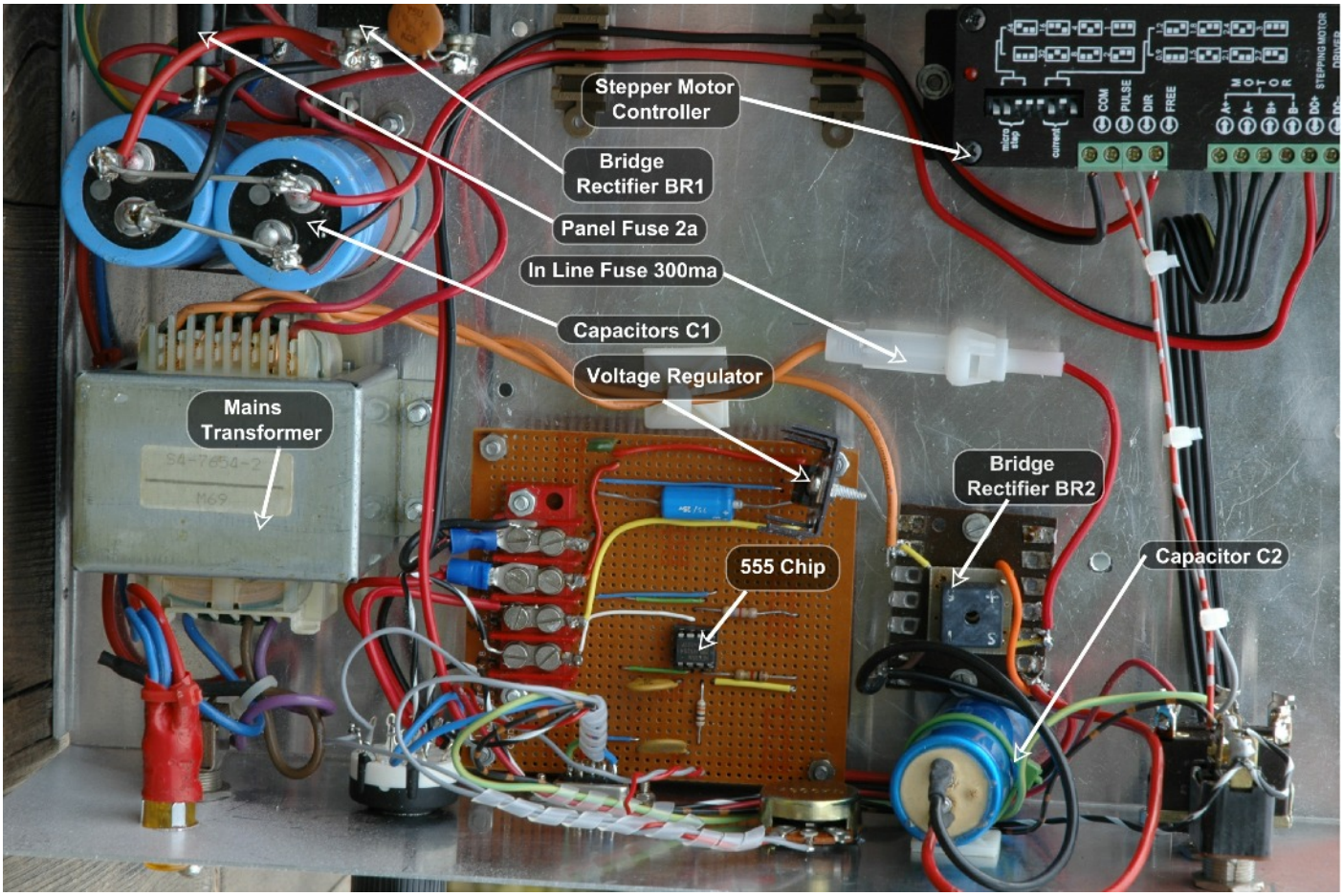


Fig.1

Interior View of Main Chassis Identifying the Main Components



voltages which are not smooth.
The Electrolytic capacitors C1 & C2 smooth these DC supplies to give two smooth, constant DC outputs.
I was lucky in finding a suitable transformer with two windings of 23vAC and 10vAC which I had previously been given.
If you are unable to obtain a transformer with a second winding, then you could use a transformer with one 25 volt winding, and use a second, smaller, transformer for the "control" supply. One of the cheap encapsulated DC power supplies, which come with almost all electronic components nowadays could be adapted to supply the 150ma low voltage supply. I would however feed this to the input side of the 7805 regulator so that your control circuit has a regulated and stable 5 volt supply.
In selecting your power source you should bear in mind the following criteria :-

1. The "motor" supply is powering the Bi Polar Stepper Motor Controller which has an absolute maximum input voltage of 40 volts. Your transformer should, therefore, not provide AC voltage of more than around 29v / 30v AC. Mine at 23volts works fine. If the voltage is lower than this then you decrease the power of the motor until at around 8 volts AC the Controller will cease to work as the DC voltage has dropped below 10v. Lower voltages also affect the top speed of the motor as at lower voltages there is not enough torque to follow the quick steps.

2. The "control" supply is powering the 555 chip via the 7805 voltage regulator. The input voltage of a 7805 must not exceed that specified by the manufacturer and this varies between +25 to +35 volts. The input voltage must also be 2½ volts above the output voltage, therefore you need a rectified DC voltage of between 8 and 25 volts DC on the input side of the 7805 regulator.

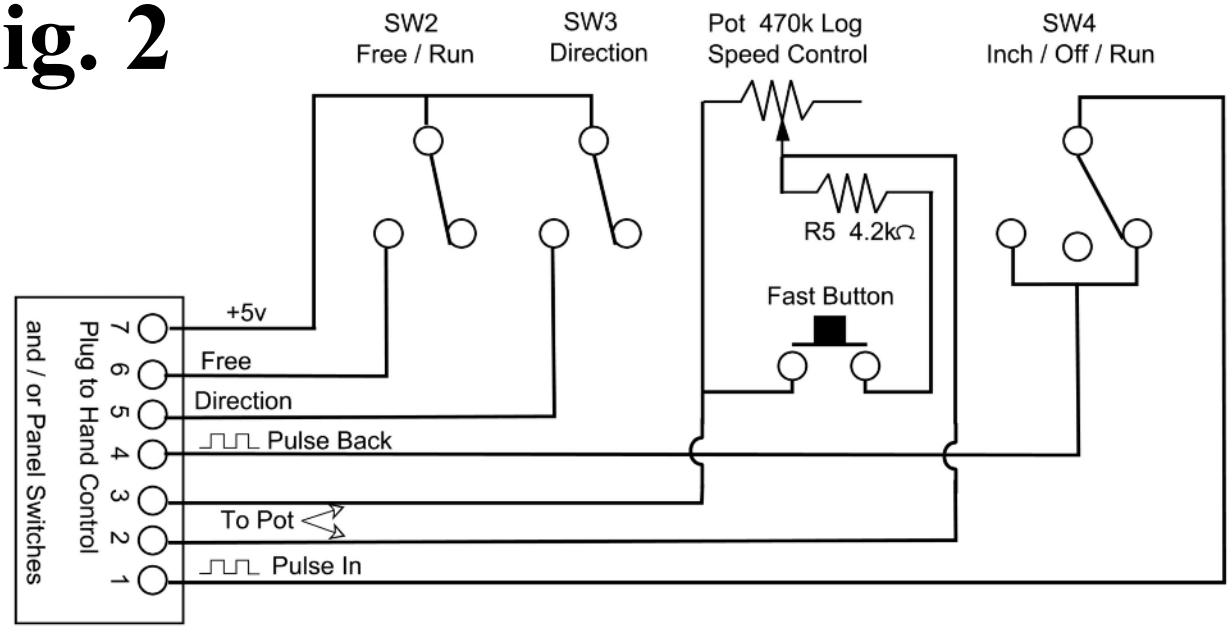
Mount your transformer in a suitable metal case and decide how you are to mount the bridge rectifiers and smoothing capacitors. My case was rather too big, but had been used before for a previous project.
Having wired the mains side of the transformer, run the secondary wires via a suitable fuse to the bridge rectifiers. The output of the bridge rectifiers is taken to the large electrolytic capacitors to smooth the supply. Ensure that BR1 is capable of 3a output. Mine was the type that bolted to the chassis for cooling which is convenient. Your capacitors C1 and C2 should be of a higher voltage than your off load voltage. Mine were both 64v and you will see from the photograph that instead of a 10,000 µf capacitor I used two 5,000 µf capacitors in parallel. These are substantial items that need mounting correctly. One word of warning. When these capacitors are charged up they contain a significant amount of power, which if not connected to any circuits will stay charged for some time. If you short out these terminals it could weld your screwdriver to the capacitors!! Have a high wattage resistor – or a mains 15w bulb to hand and get into the habit of discharging these in a controlled manner before working on the circuit. Having assembled the power supplies, plug in the unit and check the DC output voltages.

Oscillator Circuit

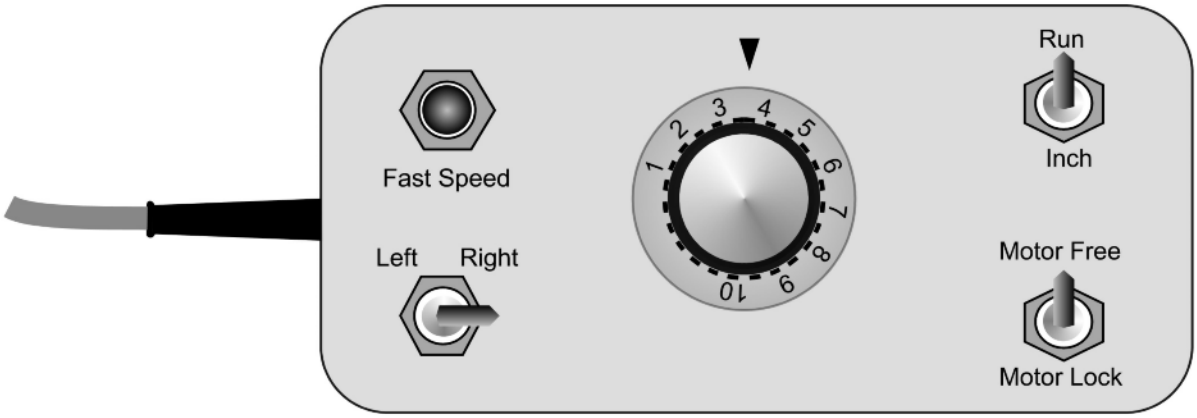
The 555 chip is actually a timer chip which when wired into the configuration shown here forms an oscillator, i.e. the output of the chip will go from 0v to +5v and back to 0v at regular intervals depending upon the value of the 470kΩ potentiometer in the hand-set. Therefore the frequency of the output pulses and thus the motor speed is controlled by the potentiometer. You will see that the fast button on the hand control shorts out the potentiometer via a 4.2kΩ resistor R6. This has the same effect as rotating the potentiometer to the fast end of the scale. On my unit this works fine when the motor is warm, but when cold, the stepper motor cannot quite follow the fast rise in speed and stalls. You may like to increase the value of R5 to (say) something like 15 kΩ.
My oscillator was built onto a piece of Vero board, in the layout shown in **Fig.3** but it is a simple circuit and many methods of construction would be suitable. I mounted the voltage regulator onto the same board and fixed a strip connector to the board to serve as connection terminals for the power connections and oscillator output. Note the configuration of the voltage regulator 7085 which is shown in a TO220 case. This chip can be purchased in various forms, but is usually supplied in TO220 configuration. If buying from Maplin the stock code is CH35Q. Once mounted on the circuit board you should bolt the regulator to a small heat sink with a little heat sink compound smeared on the joint to assist heat transfer. This heat sink could be made from a strip of aluminium sheet. Please note that this is heat sink will be connected to your 0v line and therefore must obviously not touch the case or the positive lines.
Please use an 8 pin holder for the 555 chip. It makes soldering safer and easier and if you ever have to change the chip it makes it so much easier. A chip off the old block so to speak !!
On the circuit diagram **Fig.1**, I show R1 and LED1 as a way of indicating that the power is on. I actually used a mains neon indica-

STEPPER MOTOR HAND CONTROL UNIT

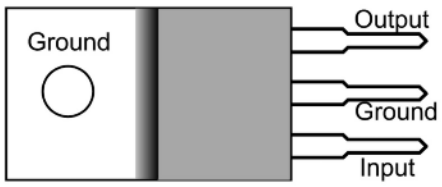
Fig. 2



SWITCH LAYOUT



L7805 in TO220 Case



NE555N Timer Chip

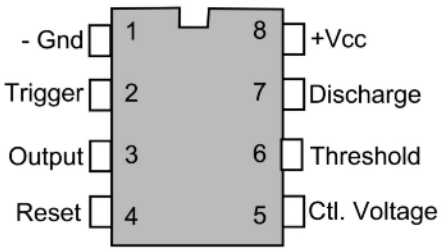
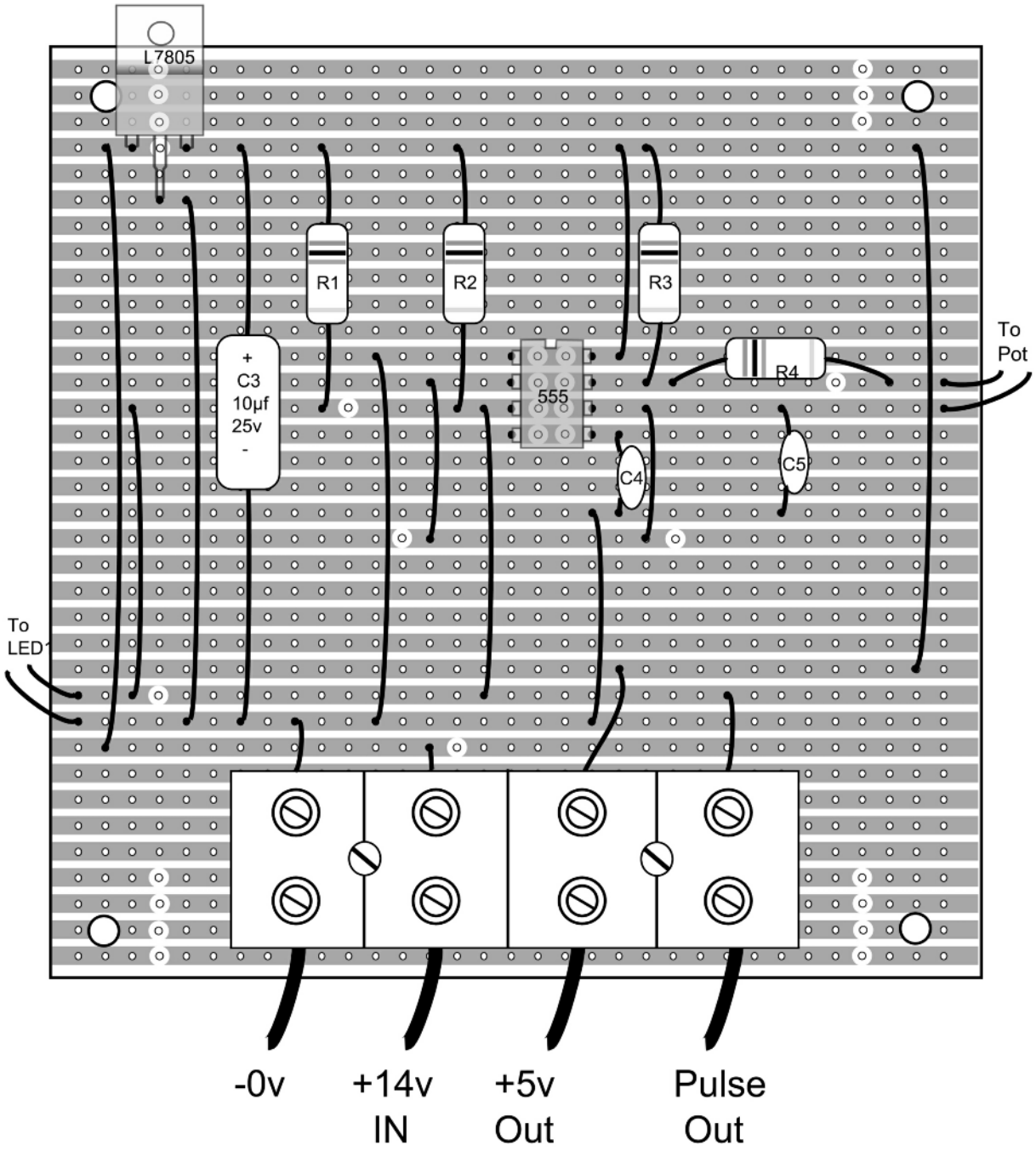


Fig. 3 Vero Board Layout as Viewed From Above



tor wired straight across the mains power switch instead. You can now buy 5v LED's with an integral current limiting resistor thus doing away with the need for R1 just put the LED between the +5 and 0v rails (Correct way round please).

The layout shown in **Fig.3** is shown from the "top" i.e. the component side of the board, but is obviously showing the copper strips on the underside of the board as if it were transparent. I have drawn the 555 chip and 7805 reg. transparent so as to show the breaks required in the copper strips beneath these components. I have a special hand tool for creating the breaks in the strips but careful drilling with either a drill ground to a shallow angle or a slot drill would be fine. Once assembled, with the pot wired in temporarily, you can power up the board and see the nice square wave output between the negative and pulse terminals, if you are lucky enough to own an oscilloscope,. Alternatively a good multi-meter should show about 2.5 volts between those terminals when set on ACv. Digital voltmeters don't always behave correctly when reading these square wave outputs.

Hand Held Control Unit

Hi-De-Hi !

A visit to Maplins (yes, my wife thinks that I really could take my holidays at Maplins !) would secure all the components for the hand held unit. The cast aluminium case (110mm x 60mm x 30mm), switches, knob and cable outlet all came from there as did the 9 pin "D socket" to connect to

the power supply box. Other suppliers are no doubt just as comprehensive. One switch deserves a special mention and that is the inch / run switch ref SW4. This was a miniature toggle switch from Maplin and in their catalogue appears to be referred to as "type C". The action is on – off – on and it is locking one way, non locking the other way, with centre off. Thus you can press one way for inch and the other way for the motor to stay on while you drink your coffee.

You will see from the photograph of the finished unit that I originally put all the switches on the front of the main case. I found this to be most inconvenient and therefore changed the "free" switch to a 3 way 4 pole rotary switch which gives the three positions - "free, Panel Control, Hand Unit Control" – an unnecessary complication in my opinion.

Connecting the Units

You will need to connect the stepper motor to the bi polar motor controller via a 3 amp 4core + earth / screen cable and a 4 or 5 pin plug. Mine was an ex W.D. one from the spares box.

To connect the hand-held unit to the power box, I used a "9 pin D Plug" as used on computer serial ports (Maplin again). Actually you are only using 7 wires plus earth/screen. For the cable I used a moulded plug and lead from an old modem and cut off one end to connect to the hand-held unit. It doesn't matter which pins you use for what so long as pin 1 from **Fig.1** connects to pin 1 on **Fig.2** etc. - if you see what I mean. Using an existing computer serial cable with a moulded plug saves a lot of fiddly soldering and looks neat. Most computer users seem to acquire many of these as they buy peripheral units, but if you can't purloin one, they can be bought from computer shops.

That is about it. Enjoy sitting about, watching your milling machine remove the metal while you enjoy that nice cup of coffee. But do remember to keep an eye on it won't you. Recently an American maker of Camper Vans was allegedly sued for not advising a purchaser the he couldn't leave the wheel of his camper to brew coffee in the back while it was travelling on the freeway under cruise control ! A sign of the times.

So let's be clear. – This unit will not stop the milling table running into your adjacent lathe, nor will it put sugar into your tea for you. It will however make milling much more enjoyable and vastly improve the surface finish that you achieve.