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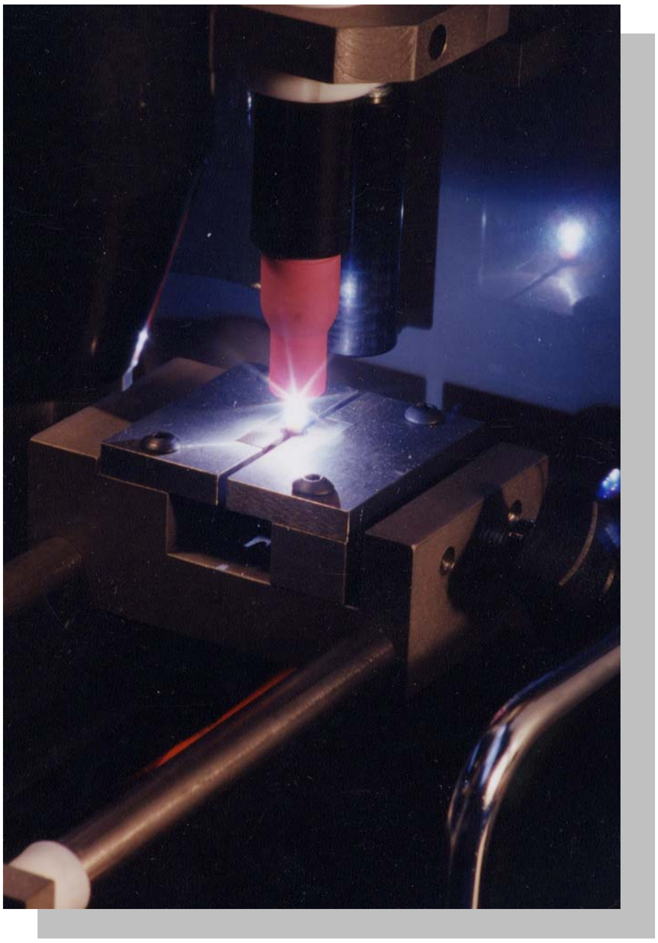


MINERAL INSULATED THERMOCOUPLE WELDING MACHINE

INSTRUCTION MANUAL

Date modified 17-08-2016

Mineral Insulated Thermocouple Welding Machine

1 Scope

This machine is specifically designed for welding the hot junctions of mineral insulated thermocouples. Either Earthed (Bonded) Junction or Insulated Junction welds can be accommodated. The machine will weld thermocouples from1.0mm to 6.0 mm outside diameter. The welder is divided into two sections to accommodate the two different welding processes associated with the junction of an MI thermocouple.

1.1 Physical Construction – The machine is constructed from 16 gauge Mild Steel, Epoxy powder coated on all inner and outer surfaces. The panels that make up the main case are bolted together by M6 bolts into captive nuts. There are no welded sections or self-tapping screws. The side panels have punched holes to allow airflow through the machine, which is assisted by an internal fan. Internal components are mounted on mild steel substructures, which can be removed for maintenance and repair. Two handles are provided on the sides of the machine, however it is recommended that two people carry out any lifting or handling of the machine using approved lifting principles.

Dimensions

The maximum outside dimensions of the machine, including the microscope and weld table are:

500mm Wide
450mm High
775mm Deep

The bench footprint is

500mm Wide
480mm Deep

1.2 Supplies

Electrical power.

The machine operates from a single-phase 220-250v-ac-50Hz supply and is rated at 2000VA. For countries using 110V 60Hz please specify at time of order.

Gas

The machine requires a supply of High purity Argon Gas. Use of any other gases e.g. Argon/Nitrogen, Helium etc will alter the characteristics of the weld arc. Advice should be sought before using special gas mixes.

1.3 Shipping

The welder is shipped in four parts as follows

1. Main body of the machine
2. Microscope and lenses
3. Microscope support shaft
4. Accessories box and spares

After removing from the crate and removing the outer packaging from the machine, remove any protective wrapping from the torch and lead, also remove the protective wrapping from the weld table and vice.

There is NO internal packing and it is not necessary to open the machine.

2 Using the machine for the first time:

2.1 Mains connection

The machine must be connected to the mains via a permanently wired-in connection box with a double pole switch. To ensure the machine complies with E-M regulations it must be on its own independent line.

2.2 Gas Connection

There are two bulkhead gas connectors on the rear of the machine. Both connectors are push-in types and must be used with 6mm nylon tube. A 1m length of tube is supplied with the accessories.

The top connector is for the pure Argon supply for the weld shroud gas. This must be connected to an adequate supply of gas via a pressure regulator set between 2 and 5bar. (On older machines the internal gas switch requires a pressure of 2 bar for the pilot valve to operate.)

The lower connection is for the supplied Gas Gun, which is used to blow away excess powder when manufacturing MI junctions. This gas can be any inert gas such as Argon, Nitrogen, helium etc. however for cost purposes it is recommended that **Nitrogen** be used.
It is **NOT** recommended to use compressed air since it often has unacceptable levels of water content, which will seriously affect the weld quality.

There are regulations regarding the use of Gas Guns and any operators must familiarise themselves with the regulations before using this equipment. (see Appendix 1)

The welder will not operate if the gas pressure is too low or absent. During operation of the machine the absence of gas prompts a message to appear on the screen and the weld cycle is inhibited. However it is possible to have pressure but not allow gas flow if the gas **flow** regulator is turned fully down. This will allow the machine to operate but not let gas through to the arc. The resultant arc will burn fiercely in air and will damage both the electrode and potentially the torch holder. **Always check the gas flow before welding.**

WARNING
ULTRA-VIOLET LIGHT

As with all welding machines this machine produces damaging ultra-violet light while the arc is running. Never look directly at an arc other than through approved welding filter glass. (UK Shade 11 to BS679)
Do NOT use goggles or glasses intended for gas brazing as these will NOT filter out the high levels of U-V radiation. Do NOT remove the arc shield on the front of the torch except for maintenance reasons with the machine turned off.

2.3 Capacitance Discharge

Part of this machine is designed to produce a weld by high-energy capacitance discharge. If an open discharge of this nature is being carried out then there will be a substantial amount of Radio Frequency interference during the discharge. The machine must only be used in an environment where this amount of interference is acceptable. **DO NOT** operate the machine next to sensitive electronic equipment that may be damaged by RFI. The mains supply of the machine is fitted with a filter compliant with VDE0871 and EN55011 (industrial) to reduce mains borne interference. This filter must not be removed or tampered with.
High-energy capacitance discharge can produce a very loud ‘pop’ when activated. This is normal but can alarm people in the vicinity if they are unaware. Always alert others near to the machine if using high levels of capacitance discharge. (Between ~300 and 1000 Joules)

Never leave the ceramic nozzle off the torch or in any other way touch the metal parts of the torch assembly while welding. The machine generates a high voltage high-energy series of sparks to initiate the weld, which can a cause a serious electric shock.

3 Tig welding theory

Tig stands for **Tungsten Inert Gas**, which describes the method used to generate a hot flame for welding. The principle is to use an electric arc, which can be maintained over time with stable characteristics. An arc struck between two points in air is very unstable and will simply jump around anywhere it pleases.

3.1 Ionisation

To get a controlled arc requires the addition of a gas with a low ionisation potential. That is, where the electrons in the gas stream readily separate from their parent atoms when a high voltage is applied. This is called ionisation and the best are the inert gases Argon, Nitrogen and Helium.

Once the electron is stripped from the atom the remaining part is the positive ion and is much heavier than the electron. The positive ion accelerates towards the work-piece and the effect of the ions bombarding the work-piece is to raise the temperature at the point of contact.

3.2 Weld power

For a practical welder the arc is struck between a Tungsten Electrode and the work piece. The electrode collects the electrons and the positive ions concentrate onto the work piece. The whole process relies on there being a high electric field density around the Tungsten electrode. To achieve this the electrode is sharpened to a fine point to concentrate the electric field density. The arc will be maintained if there is sufficient supply of gas atoms and electrical energy. A TIG arc will support currents of many hundreds of amperes and it is only necessary to provide sufficient bulk in the conducting components to maintain welding. However achieving fine quality small welds means that the welding machine has to establish and maintain an arc at a very low electrical energy level. This can only be realised by raising the voltage at which the arc runs while lowering the current. At the same time the current must be maintained at a very stable value to ensure arc stability.

3.3 Arc characteristics

In the MI welding machine the arc voltage has a curved characteristic, the initial voltage before the arc is struck is high (210v dc) when the arc strikes the voltage is dependant on the current set. For instance for very low currents below 2 amps almost all of the 210 volts is applied, however above 4 amps the voltage falls dramatically to around 40v or less. This has the effect of improving the starting characteristics of the machine as well as providing enhanced stability at low currents.

3.4 Starting

It is not sufficient to apply a voltage and an inert gas to produce a weld arc; the arc has to be kick started in some way. Touching the electrode onto the work piece and then withdrawing it is an impractical method in this case so a very high voltage spark is used to produce a flood of ionisation. This encourages the cascade effect that allows the arc to establish.

3.5 RF Protection

With the MI welding machine the spark is in fact a series of sparks over a period of 250milliseconds. This is often referred to as an HF spark but in fact is no higher in frequency than the mains supply of the machine. There is however a sharp rising edge on the waveform, which can cause interference. The machine is designed to include many protective circuits to prevent the Radio Frequency produced from interfering with the electronics components.

3.6 Weld Profile

In addition to achieving a stable arc the MI welding machine allows the use of five control characteristics enabling a wide variation in weld profiles. They are:

1. Provision of a pre weld gas flow to clear oxygen out of the weld path
2. A sloping characteristic that raises the current from the starting current to the chosen welding current over a set time period
3. The main welding period and level
4. A sloping characteristic that lowers the current from the chosen welding current to the starting current over a set time period
5. Provision of a post weld gas flow to allow the work piece to cool in a relatively oxygen free atmosphere to reduce oxidation.

Six dials on the control panel of the machine control these characteristics.

3.7 Capacitance Discharge

The MI Welding machine uses two delivery systems for the TIG arc. The first, described above uses current distributed over a relatively long period of time and within a controlled weld profile. The second method uses a very high current delivered over an extremely short time. This is achieved by discharging a bank of electrolytic capacitors through the arc (termed capacitance discharge or CD).

The effect is to deliver a very short high power pulse to the work-piece, creating a small globular weld due to the instantaneous melting and solidifying of the work-piece.
The amount of energy used in the capacitance discharge section is varied by two mechanisms; the level of charge in the capacitors and the number of capacitors selected. The power available is from <5.0 Joules to 990 Joules and is infinitely variable. Like the TIG section the CD section has a provision to allow Argon gas to flood the work-piece prior to the weld discharge and a similar period after discharge to prevent oxidation during cooling. These periods are controlled by the machine and do not usually require changing. (See CD purge time)

3.8 The MI Welder

All of the above features are included on the MI Welder. The machine is designed to manufacture the hot junctions of MI thermocouples without using any other machine. That is the junction weld and the Sheath closure weld can be carried out on the same machine.
Preparation of the Thermocouple consists of cutting and drilling the junction end prior to using the machine. In addition the Insulation Resistance of the Thermocouple must be maintained up to the point of welding.

The front panel of the machine is divided into four sections:

- **Left Hand Side** - The Mains on/off push button Switches, the gas flow regulator, the fan, on and Pressure indicator LED's and the Test gas pressure push button Switch
- **Centre Section** – The main weld preparation and provision area, the microscope support and the microscope light.
- **Right Hand Side Upper** – the controls for Capacitance Discharge operation and sequence selection
- **Right Hand Side Lower** – The controls for TIG welding operation

All preparation and welding takes place in the central section. To help clarify the functions of each part of the welder components refer to the following diagrams

3.8.1 Left Hand Side – When the machine is switched on at the wall switch the cooling fan begins to run and the fan LED is illuminated. No other circuits are functional at this point. This is so that the machine can be 'off' but still cooling after a long welding session. To activate the machine push the lower button marked 'ON' the machine will show that it is on by illuminating the LED's in the centre of the panel ('ON' and 'PRESSURE'). If the pressure LED does not illuminate check that the Argon gas line is connected and set to >2bar. The Flow gauge can now be set to the correct Argon Flow. To do this, depress the switch on the upper section and hold. Adjust the flow gauge to give an argon flow of Approximately 5cu ft/Hr. (You may wish to alter this later)
To deactivate the machine press the lower 'OFF' button, the fan will remain running until the wall switch is turned off.

3.8.2 Right Hand Side – When the machine is activated you will notice the Display on the right hand panel will illuminate. After a second or two the words 'Doing power on test' – this is the electronic circuit checking all the functions of the machine internally (it does not check if the gas is present or any external parameters). Once this check is finished the display will read 'Power on test OK' and then switch to working mode. The display will now shown data depending on the position of the Mode Switch (CD, Standby, TIG).

Right Hand Side upper – This is the CD section and is active when the mode switch is set to CD. The selector switch at the top has five positions each of which increases the number of capacitors in circuit. The multi-turn dial to the right of the selector switch adjusts the voltage level to which the selected capacitors are charged.
As soon as the CD selector switch is set the capacitors will begin to charge to the set values. It is therefore prudent to set these controls before switching to CD unless you are repeating the settings. This sequence allows the machine to quickly charge ready for the next weld. This is to reduce production time and reduce switching sequences for ease of use.
The CD is fired using the START button located below the capacitor selector switch. The machine is factory set to allow 2 seconds of gas flow prior to the actual weld sequence (this can be changed to anything from 0 to 10 seconds but requires entry into the machine so is best carried out by the installation engineer or requested prior to shipment)

The STOP button can interrupt the sequence during the 2-second purge time.
After welding the Argon gas will flow for a further 2 seconds (this period is fixed)

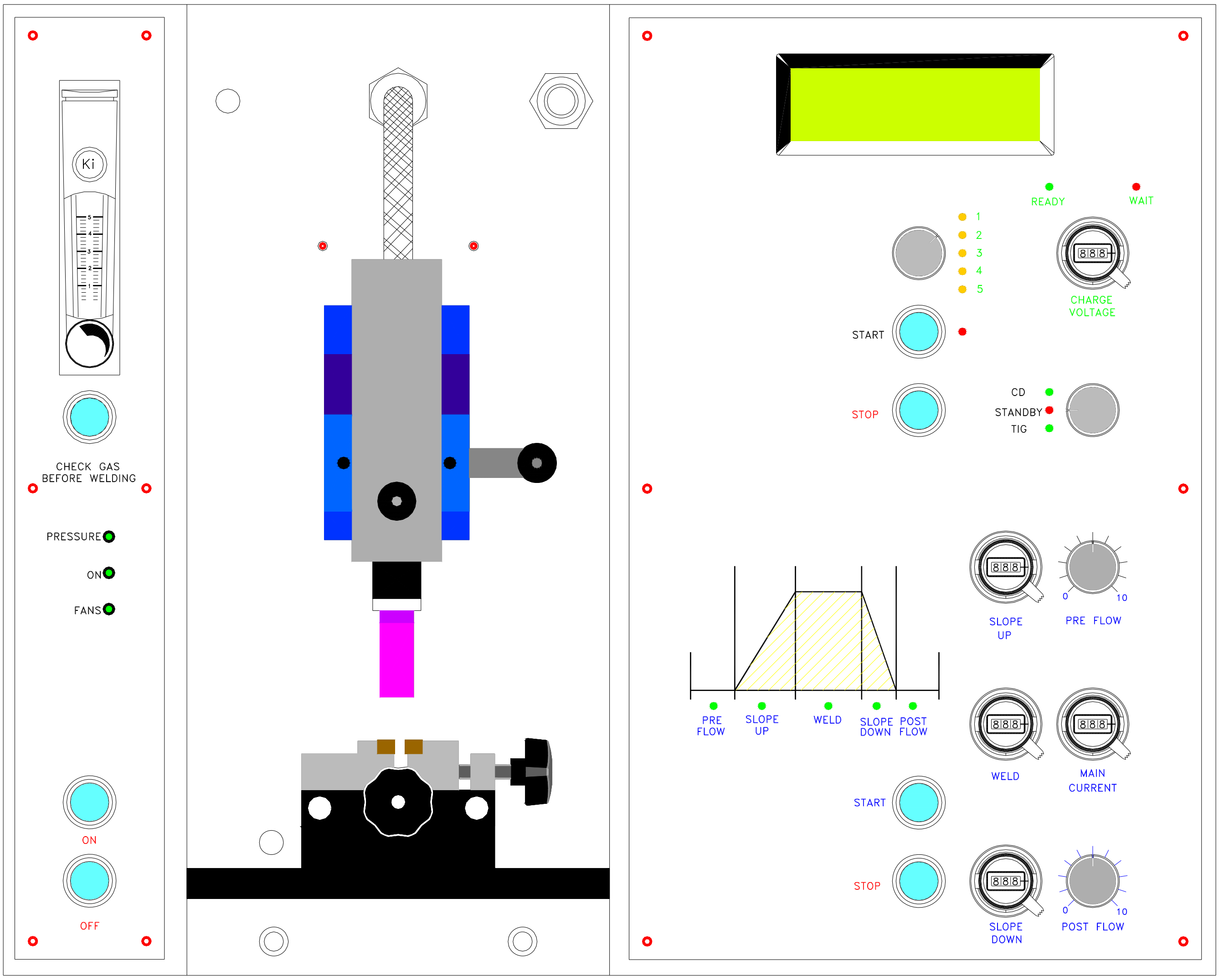
Right Hand Side Lower – This is the TIG section and is active when the mode switch is set to TIG. There are four precision 10-turn dial potentiometers and two single turn potentiometers that control the aspects of the weld arc. There are also start and stop push buttons.
The controls affect the arc as follows –

Pre-Flow this control sets the time that gas flows prior to the arc initiation. This clears the oxygen from the weld site to eliminate poor starting and oxidation.
Slope up this sets the time taken for the weld current to rise from the start current to the maximum weld current (set by the **Main Current** potentiometer.) This prevents sudden application of the maximum weld current a helps to distribute the weld pool.
Weld this control potentiometer sets the time that the main weld current is delivered.
Main Current This is the maximum current delivered to complete the welding operation.
Slope Down The slope down control is the reverse of the slope up control. It reduces the weld current from the maximum to the background level over the time set by the potentiometer. This has the effect of pinching off the current rather than turning it off instantly which can produce a hole in the centre of the weld pool.
Post Flow Finally the post flow control allows the weld gas to flow after the weld flame is extinguished. This is to allow the weld pool to cool in an inert atmosphere reducing the chances of oxidation and cracking.

The weld sequence for any individual thermocouple is set using these controls. During the weld cycle the display indicates which part of the sequence the machine is controlling. This is also shown by the green LED's on the mimic diagram next to the controls.

To start the sequence once the controls are set up press the '**Start'** button. The '**Stop'** button will interrupt the sequence and is described in more detail later.

3.8.3 Front Panel Layout



Multi turn dials

The Right hand panel incorporates 5 Ten-turn dials. These dials have three digit displays. For the CD Voltage setting (top Dial) the dial indicates the volts with **NO decimal part.**

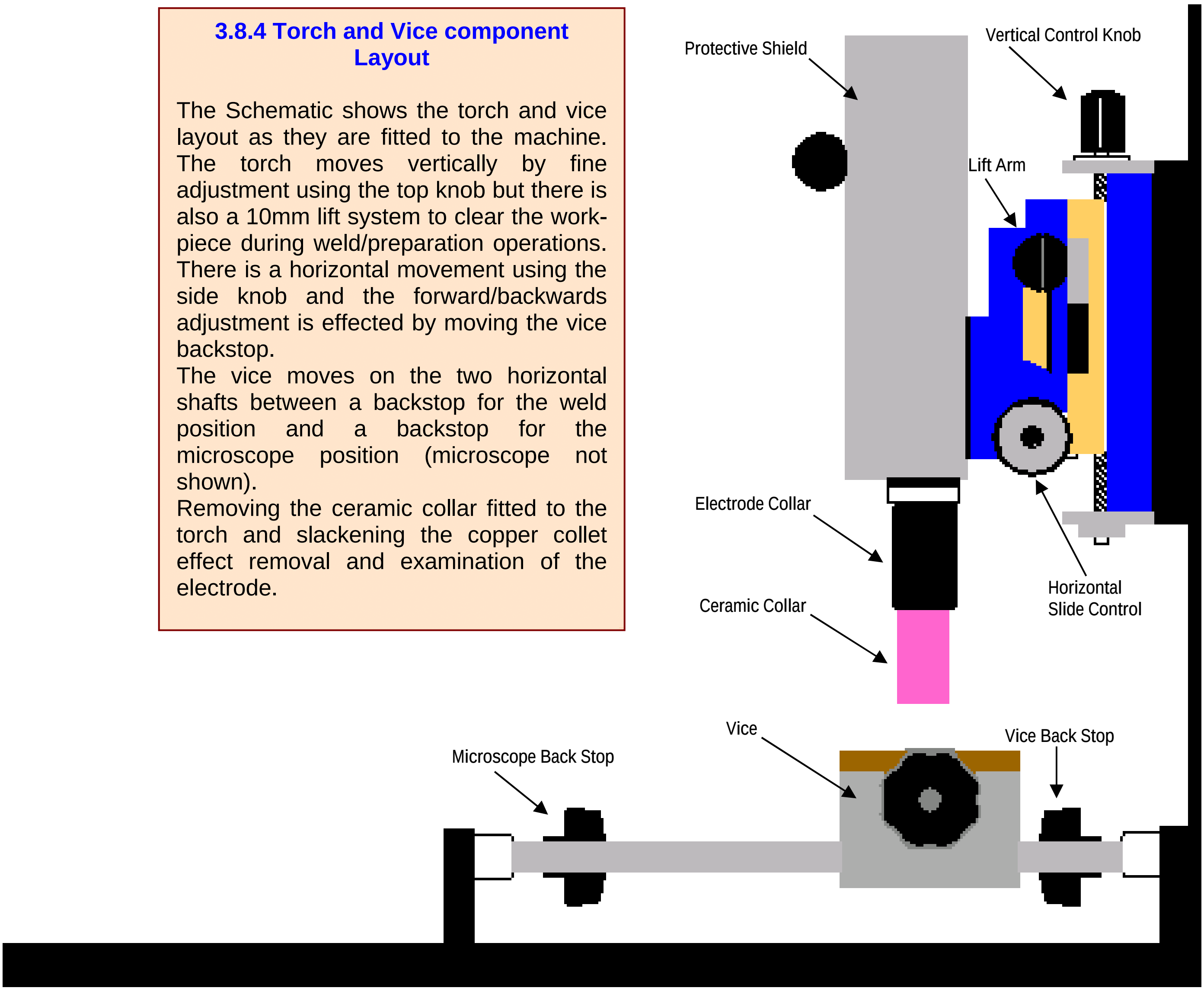
100 = 100 Volts

For the TIG Section the dials indicate **ONE decimal place**

999 = 99.9 Seconds or Amps
001 = 00.1 Seconds or Amps
035 = 03.5 Seconds or Amps

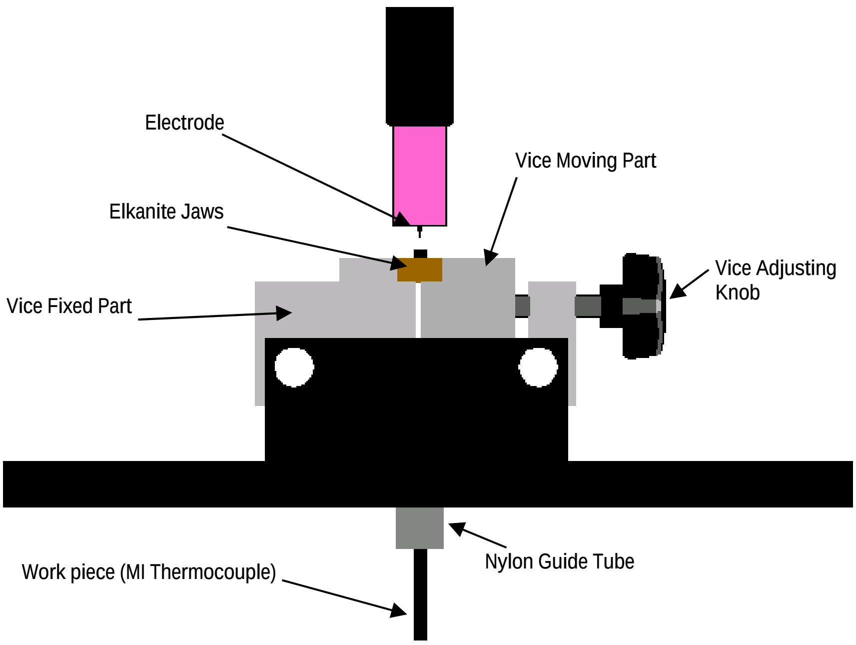
3.8.4 Torch and Vice component Layout

The Schematic shows the torch and vice layout as they are fitted to the machine. The torch moves vertically by fine adjustment using the top knob but there is also a 10mm lift system to clear the work-piece during weld/preparation operations. There is a horizontal movement using the side knob and the forward/backwards adjustment is effected by moving the vice backstop.
The vice moves on the two horizontal shafts between a backstop for the weld position and a backstop for the microscope position (microscope not shown).
Removing the ceramic collar fitted to the torch and slackening the copper collet effect removal and examination of the electrode.



3.8.5 Position of Torch when welding

The diagram shows the vice and Torch from the front. The Electrode is positioned over the work-piece using the controls shown above. The Elkanite jaws are specially constructed to grip each individual size of thermocouple. Elkanite is an amalgam formed from 75% Copper and 25% Tungsten. This material will not melt under normal welding conditions and therefore will not stick to the thermocouple. Do **NOT** use substitute materials.

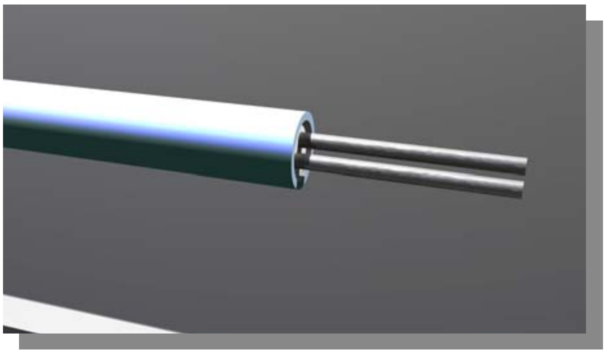


4 Preparing and Manufacturing MI Thermocouples

The following sections describe the process of preparing the thermocouple cable and manufacturing a finished unit. There are two Procedures, firstly a procedure for all cable sizes followed by a procedure for 6.0mm diameter only, which is slightly different.

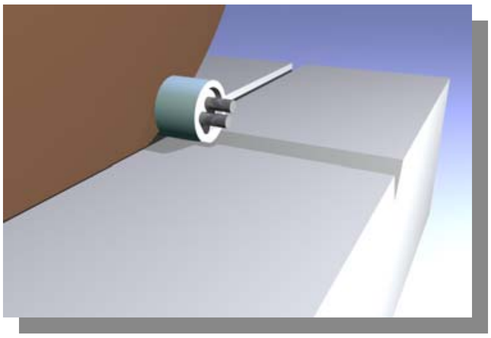
4.1 Preparation of cable ends for insulated hot Junctions

4.1.1 **Strip** back the cable sheath to expose at least 10 mm of conductor.
Clean the conductors using a sharp knife or emery paper taking care not to get material into the cable insulation.
Seal this end of the cable in the usual manner (Hot-melt seal or Heat shrink tube.)

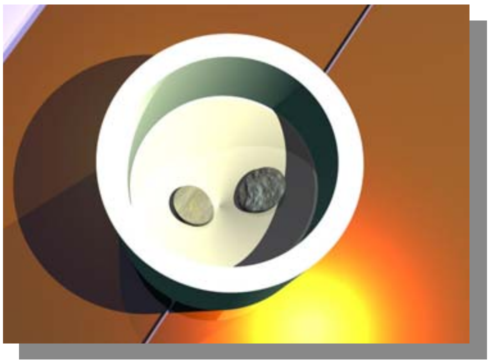


4.1.2 **Test** the cable insulation Resistance reads infinity @ 500Vdc using a Megger insulation Resistance tester.

4.1.3. **Cut** off the hot end with a high-speed rotary saw to give a right angle cut with no rag or burr.

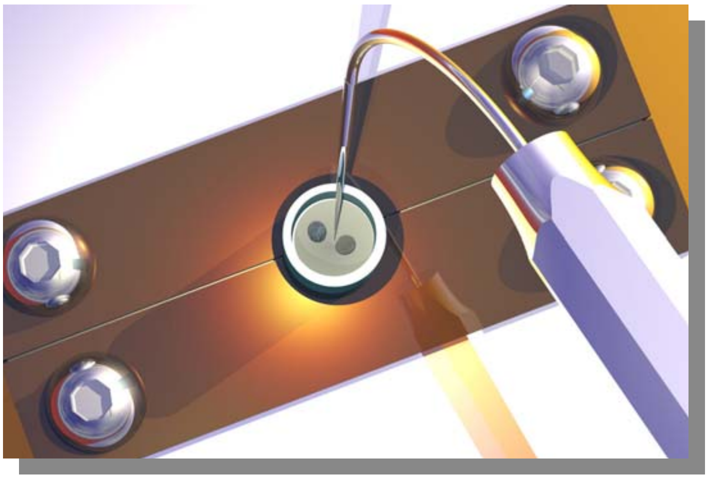


4.1.4 **Drill** the cable end using the Precision MI Drilling jig. (Instructions for operating drilling jig are given in Appendix 2)

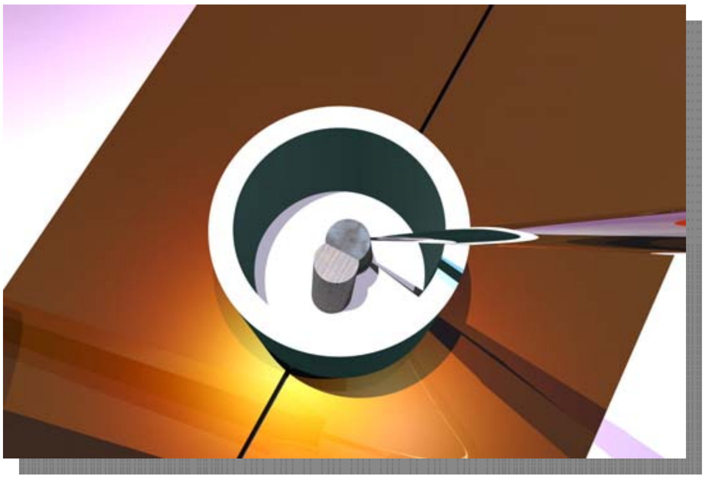


4.1.5 Using the correct size jaws for the thermocouple being welded push the thermocouple up through the guide tube and into the open jaws. Tighten the vice jaws until gripping the cable. Do not over-tighten. The general rule is to allow a measurement equivalent to one half the diameter of the cable sample to protrude above the surface of the jaw.

4.1.6 Using a **Powder Probe (Dental pick)** remove the insulation from around the conductors. Use the **Gas Gun** to remove excess powder as it builds up.
Enough of each conductor must be exposed to allow the two ends to be bent over and touched together.



4.1.7 Using the Powder Probe gently push the two conductors together so that they touch along the drilled surfaces. You will need to keep blowing away excess insulation to keep the weld area clean.
Once the conductors are in position the first weld process can proceed.



4.1.8 As discussed earlier the first weld process involves discharging energy from a capacitor bank through the weld arc. This can be done on all cable sizes from 1.0mm to 6.0mm however there is a considerable energy discharge when welding 6.0mm cable conductors using capacitance discharge. If necessary welds of 6.0mm cable conductors can be carried out using straight TIG and this procedure will be dealt with later. (Welding 6.0mm using capacitance discharge will not damage the machine)

4.1.9 First connect the CD weld conductor lead to the tail end of the cable using the clip provided.

The CD control is the top section of the right hand panel (shown outlined in Red.)

4.1.10 Select CD on the mode selector switch
4.1.11 Using the selector chart as a guide
Select the required Capacitance value (1 to 5)
Select the Required Charge voltage (~40 to 600V)

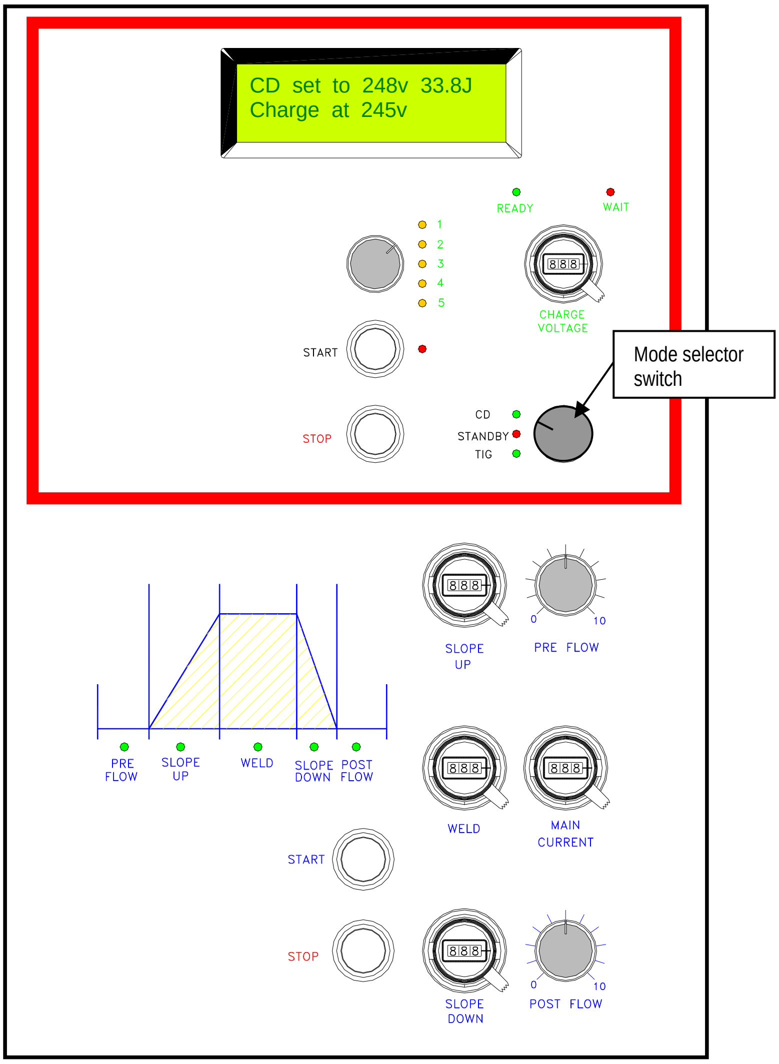
4.1.12 Ensure that the thermocouple is positioned correctly under the electrode (centralised on the cable axis and approximately 0.5 to 1.0 mm above conductors.)

4.1.13 Check the gas flow (~2.3ltrs/min – 5 cu ft/hr)

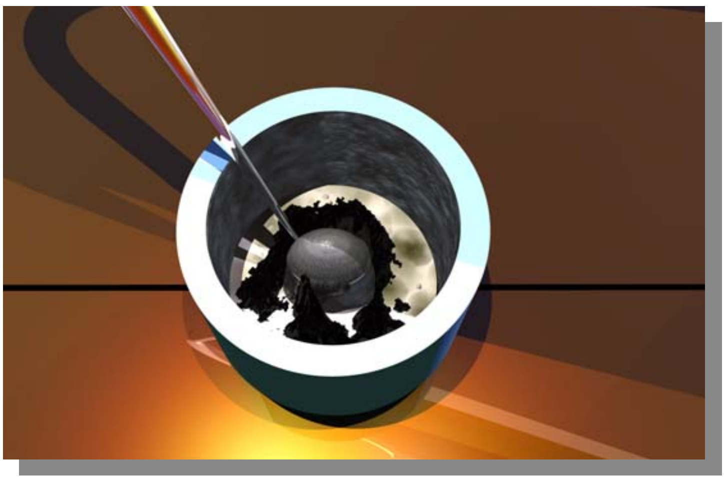
4.1.14 To initialise the weld press the **Start** button. There will be a two second delay as the gas purges the weld site. It is possible to interrupt the sequence at this point by pressing the **Stop** Button.
The weld will then fire and there will be a second purge time as the weld is allowed to cool. The display will indicate **'CD Fired'.**
4.1.15 When the sequence is finished lift the electrode and pull back the table to examine the weld.

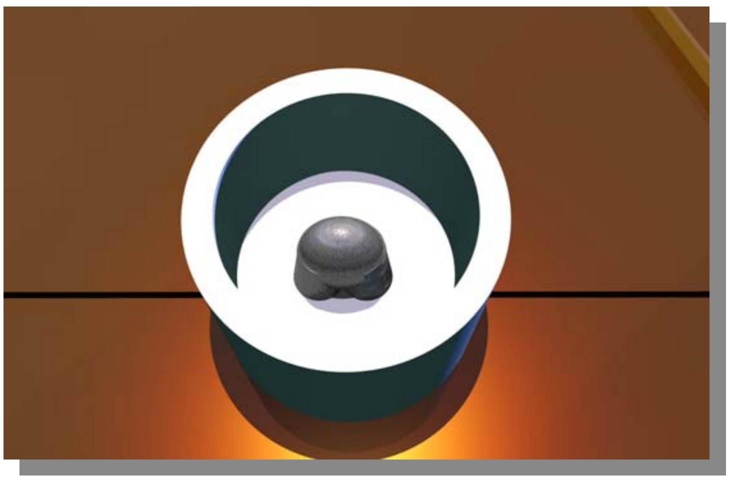
There will be some degree of debris around the welded conductors; this is normal, caused by the very high temperature during the weld.

4.1.16 Remove the debris and blow the weld site clean.



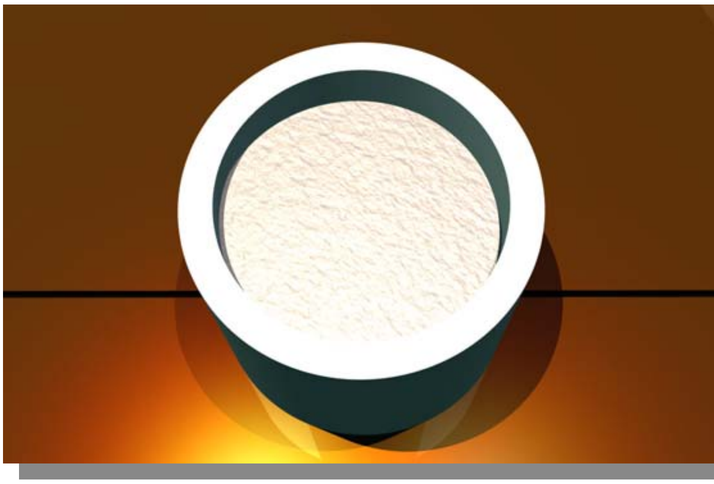
Once the weld site has been cleaned up the thermocouple should look much as shown in the lower illustration. Effectively the diameter of the weld material should by the same as the diameter of the conductors. This is a subjective view as different specifications require different degrees of weld mass.





4.2 The next part of the procedure involves using caps and back-filling powder. Many thermocouple manufacturers do not use either items and the procedure goes directly to the finished weld from here. However some specifications demand the use of caps and back-filling powder especially for the larger cable sizes. The instructions that follow assume that this is the case.

4.2.1 Using Magnesium oxide (Magnesia) stored at 100°C fill the space around the welded conductors and press down to avoid air pockets. Try not to leave Magnesia on the top rim of the thermocouple. The top surface of the powder should be just below the top of the thermocouple. Do not over-compact or the cap will not seat properly in the next stage.

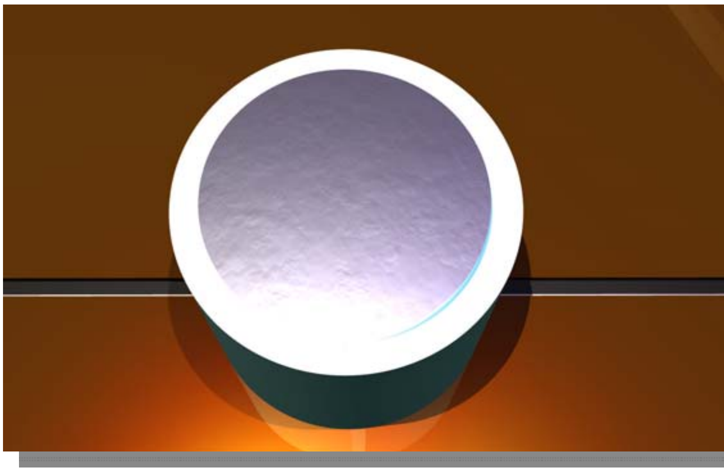


4.2.2 Once the powder is compacted select the appropriate cap size for the cable diameter and material. Carefully fit the cap into the end of the thermocouple with the domed surface uppermost. Try to ensure that the cap is level and not misaligned.
4.2.3 Using a lightweight hammer gently tap the cap into the cable until the upper surface is level with the cable sheath rim.

A **loose cap** should be replaced with a larger size or the cap can be tapped on a metal surface to expand it slightly.

Tight caps will distort the cable sheath producing a bad weld.

4.2.4 Finally blow away all residue of magnesia from around and on top of the cap. This material would burn in the high temperature weld flame and contaminate the weld pool leading to cracking, incomplete welds and potential failure points.



4.2.5 Remove the Capacitor Return Clip from the conductors before welding the sheath.

The TIG section control is on the bottom section of the right hand panel outlined in red opposite.

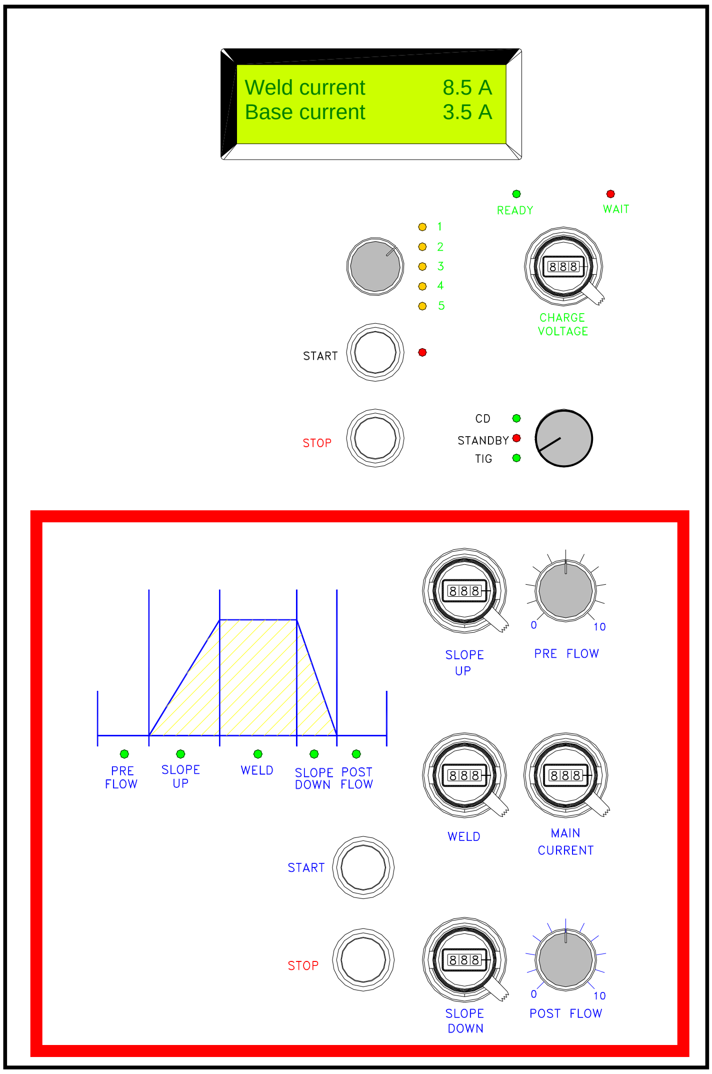
4.2.6 Set the weld mode selector switch to TIG.

4.2.7 Using the selector chart as a guide

Set **pre-flow** to desired seconds (0 to 10s)
Set **Slope-up** to desired seconds (0 to 99.9s)
Set **Weld** time to desired seconds (0 to 99.9s)
Set **Main current** amperes (0 to 50amps)
Set **Slope-down** to desired seconds (0 to 99.9s)
Set **Post-flow** to desired seconds (0 to 10s)

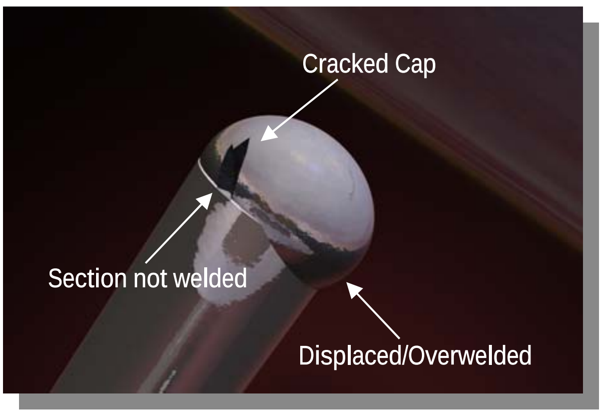
4.2.8 Ensure that the thermocouple is positioned correctly under the electrode (centralised on the cable axis and approximately 0.5 to 1.0 mm above the cable cap)
4.2.9 Check the gas flow (~2.3ltrs/min – 5 cu ft/hr)

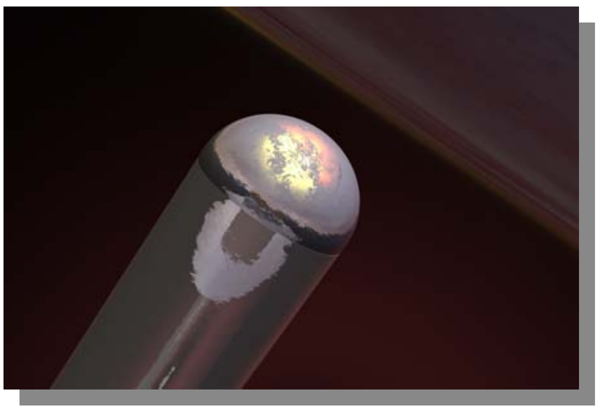
4.2.10 To initialise the weld sequence, press the **Start** button. The weld progress will follow the diagram given on the TIG section, with the LED's indicating the progress through the cycle. The weld cycle can be interrupted in two ways during the sequence. Firstly pressing the **stop** button briefly (less than ½ second) will cancel the portion of the sequence currently in progress and will move control to the next step.
Secondly pressing the **stop** button and holding (greater than ½ second) will interrupt the weld sequence completely.
4.2.11 When the sequence is finished, lift the electrode and pull back the table to examine the weld.



4.2.12 Check weld Quality

The illustration on the left indicates several weld Defects.
The illustration on the right shows how a good weld should look.



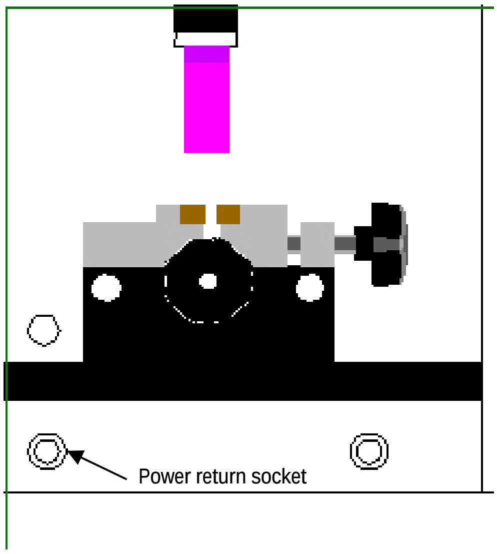


4.3 Procedure for welding 6mm thermocouple cables.

4.3.1 As previously described there are two ways to weld the conductors of 6mm Cable. Firstly by using a very large capacitance discharge (in excess of 440 joules). Secondly by using the TIG welding section of the machine. To use the TIG section the return power needs to be directed to the conductor not to the sheath. Normally the return current passes through the weld vice jaws and back to the machine via a plug underneath the welding table.

4.3.2 To weld the conductors disconnect this lead and insert the extension cable from the accessories box.

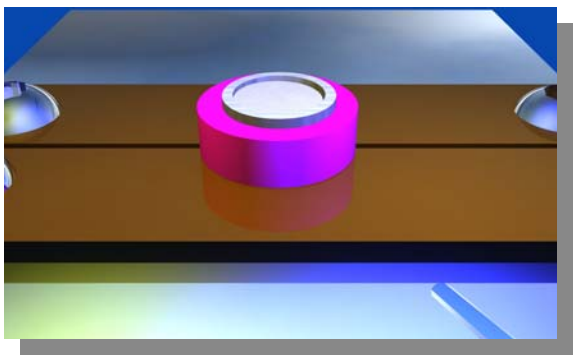
4.3.3 Connect the large plug supplied to the extension cable and clip it to the MI cable tails. Ensure that the clip tightly holds both conductors. Proceed as for welding the sheath.



4.3.4 When welding the sheath of 6mm cable, the mass of material involved means that some distortion occurs in the weld pool during the process. The end result requires some degree of cleaning-up such as extensive grinding. The ground tip may appear to be adequate but there is no certainty that there is enough material to form a serviceable weld.

To overcome this for quality welds a disposable ceramic collar with a 6mm inside diameter is used to contain and direct the weld pool to form a perfect weld. (allow cable to protrude 1.5mm above ceramic surface)

The low cost of this component is offset against the labour time used to grind the excess material away if it is not used.



NOTE

Do not use the welding machine for repeated sheath-only welds of 6mm cable. An uninterrupted run of more than 10 welds of this nature will begin to heat up the vice and power delivery components beyond their acceptable temperature. This will shorten the life of these components.

CD and TIG Control Settings

Conductor Weld Settings

Cable Outside Diameter	Drill size (Cable i/d less 0.1mm)	Drilling Depth	MgO Fill	Conductor Weld	Energy
mm	# mm	mm	mm	Caps / volts	Joules
1.0	73 0.6	1.00	0.5	1 100	5.5
1.5	65 0.85	1.50	1.0	1 200	22
2.0	56 1.1	2.00	1.3	3 200	66
3.0	46 2.0	3.00	1.5	5 200	110
4.5	31 3.0	4.50	2.0	5 300	247.5
6.0	19 4.2	6.00	2.0	5 400	440

These settings are given as a guide only. The choice of weld settings varies considerably therefore it is advisable to create a table of settings similar to the above using empirical/preferred values.
These settings were based on a number of repeated samples of 0.5metre length.
Drill sizes vary depending on cable manufacture. As a guide use the cable inside diameter less 0.1mm.

Cable Length Allowances

Restrictions on Conductor length are due mainly to the energy losses brought about by the I^2R (heating) losses within the conductor and the energy required to create a good conductor weld. The dissipation time, which is resistance related also effects weld quality. Cable parameters vary and definitive cable lengths are difficult to obtain. However the following table should be regarded as a good guide.

Type K Mineral Insulated Cables Only

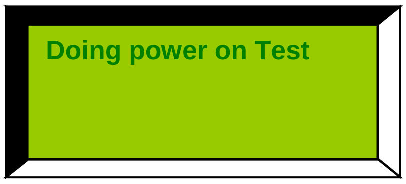
Cable Outside Diameter mm	Maximum Length Metres
1.0	60
1.5	90
2.0	110
3.0	130
4.5	100
6.0	50

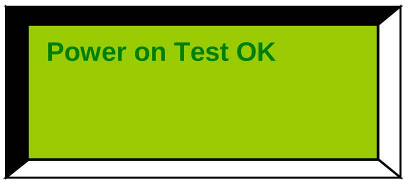
The value for 6.0 mm assumes the weld is carried out using CD. If the weld is made using TIG then amount of cable that can be welded is longer.

Sheath Weld Settings Guide

Cable Diameter	Pre Flow Time	Slope Up Time	Weld Time	Weld Current	Slope Down Time	Post Flow Time
1.0 mm	2.0 S	0.0 S	1.0 S	6.0 A	1.0 S	2.0 S
1.5 mm	2.0 S	0.0 S	2.0 S	8.0 A	1.0 S	2.0 S
2.0 mm	2.0 S	0.0 S	2.5 S	13 A	1.0 S	2.0 S
3.0 mm	2.0 S	2.0 S	3.0 S	18 A	1.0 S	2.0 S
4.5 mm	2.0 S	10.0 S	6.0 S	18 A	2.0 S	2.0 S
6.0 mm	5.0 S	12.0 S	6.0 S	18 A	2.0 S	2.0 S

Displays and sequences





Initial Display sequence

The sequence shown is activated when the machine is first turned on. The microprocessor is checking various routines to ensure that the electronics/software are working correctly. The test does not check any other functions of the machine. Provided the weld-mode switch is set to Standby the final display will be as shown

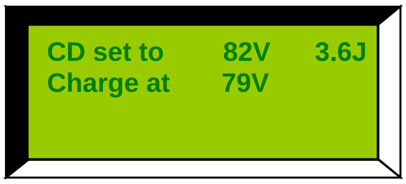
Display sequence during CD welding.

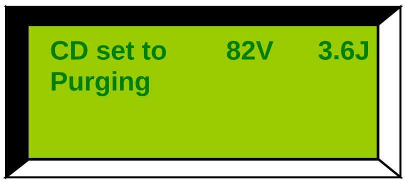
The Display shown three Parameters – the voltage set on the dial, the actual charge voltage and the Energy level (this is in Joules equivalent to $1/2CV^2$).

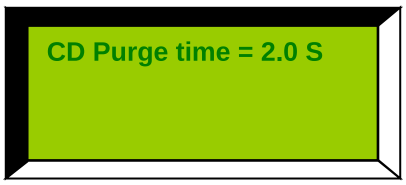
When the CD start button is pressed the sequence begins. The Purging time is factory set to 2.0 S but can be reset from 1 to 10.0 S by request.

It can be seen from the table that the required energy level can be obtained with more than one combination. The rule is to use high voltages and low capacitance for long cables and low voltage high capacitance for shorter cables.

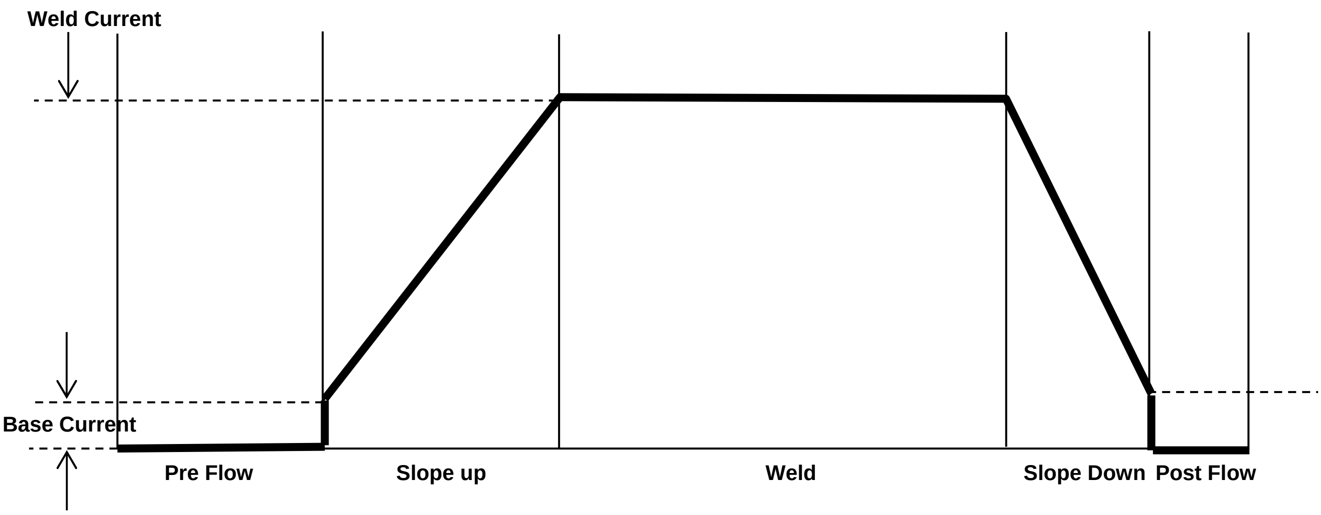
Switch Position	Selected uF	Energy at Charge Volts					
		100v	200v	300v	400v	500v	600v
1	1100	5.5 J	22 J	49.5 J	88 J	137.5 J	198 J
2	2200	11 J	44 J	99 J	176 J	275 J	396 J
3	3300	16.5 J	66 J	148.5 J	264 J	412.5 J	594 J
4	4400	22 J	88 J	198 J	352 J	550 J	792 J
5	5500	27.5 J	110 J	247.5 J	440 J	687.5 J	990 J

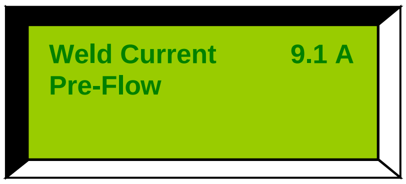


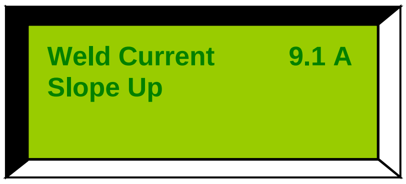


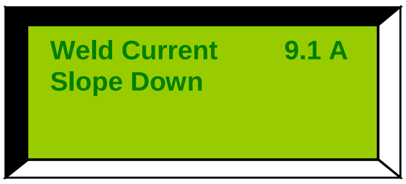


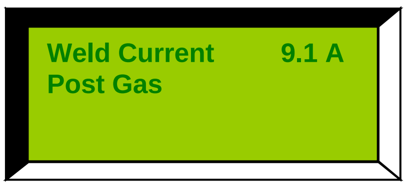
To check the CD Purge time set the weld mode switch to Standby then press the CD START and CD STOP buttons together and hold. The display will be as shown.











TIG Welding Sequence

The TIG weld sequence follows the diagram above. The sequence starts with the gas only for the **Pre Flow** time. This clears the weld site of any oxygen residues that will cause burning during the weld cycle. The welding starts at the base current (because the weld flame cannot start at zero amps) the base current is automatically set to 3.5 Amps when the machine is turned on. This setting is for average welding conditions but can be reset as detailed in the next box.

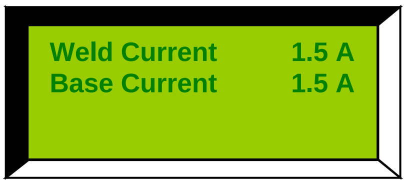
As soon as the weld flame is established the current rises from the base current to the main welding current at a rate set by the **Slope Up** timer control. The display will indicate the sequence of events during the weld cycle.

The weld current will remain fixed at the setting on the **Main Current** control for the *time* set by the **Weld** period timer control.

After the main current period the current will begin to reduce in accordance with the **Slope Down** period timer control.

Finally there will be a flow of Gas to allow the heat to dissipate from the weld site without causing undue oxidation. The time allowed is set by the **Post Flow** timer control.

When the stop button is pressed the Base current changes to the Main current setting.



After adjusting the Base current, the Main current assumes the value set on the control.

Readjust the Main current last.

Changing the Base Current

In order to weld at very low currents it is sometimes necessary to alter the base current. This prevents a surge of current greater than the Main Weld Current, which occurs even if the Slop up time is set to zero. To change the base current whilst in TIG mode press and hold the TIG **STOP** button for more than 0.5 Seconds. The display will change as shown. Keep the stop button depressed and the base current can now be altered using the **MAIN CURRENT** control. It can be adjusted to any value but there is little point in using high currents. Also the weld is unlikely to start if the base current is set to zero. *Remember to reset the Weld Current after setting the Base current*. When the machine is turned off the base current will be automatically reset to 3.5 Amps.

When having difficulty welding some materials at higher currents it is often easier if the base current is raised above 3.5 Amps. This will not harm the machine.

1.39 6/02/97

When beginning a weld sequence the Software automatically checks to see if the weld table is in position and if the gas pressure is normal. In either or both instances the weld sequence will be inhibited and the display will have either or both of the following messages.

Appendix 1

Mandatory instructions for use of Blowguns (gas gun) as applied in the United Kingdom. See local regulations for units used outside the UK.

Before using the blowgun your attention is drawn to the following safety points.

1. Pressure supply should be regulated to a supply pressure of 2.3 bar to comply with Statutory Health and Safety at Work Regulations. Outlet pressure is directly proportional to supply pressure.
2. Eye protection should always be worn when using blowguns.
3. NEVER direct gun at skin or clothing.
4. NEVER attempt to impede the flow of gas through the gun.
5. Ensure all equipment is in good working order prior to pressure being applied.

Appendix 2

Note: For the new Precision Drilling jig please ignore this section and see separate instructions accompanying the Drilling Jig.

Mineral-Insulated Thermocouple Drilling Machine.

Introduction:

Two machines are available to cover the range of 1.0mm - 6.0mm diameter cables. One machine is suitable for 1.0mm to 3.0mm cables and the other for 4.5mm and 6.0mm cables. Each machine consists of a 250Vac electric motor connected to a guide system incorporating a depth gauge to ensure accuracy and repeatability to comply with IEC1515 specifications.

Operating Instructions:

Ensure that the machine is securely fastened to a flat work -surface before operating.

Select the appropriate drill bush and secure into the machine with the retaining clip. The drill bush has different diameter holes at each end to accommodate the drill (smaller diameter.) and the cable (larger diameter.).

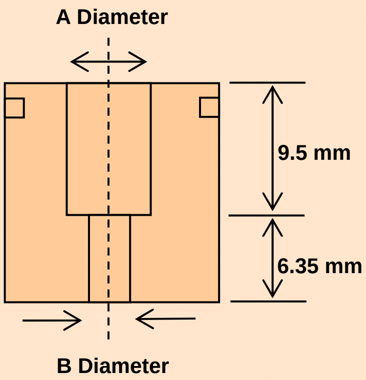
1. Set the required drill depth using the adjustable threaded rod.
2. Switch on the machine. Holding the cable, gently push the carriage forward to allow the drill to enter the cable and remove the required amount of powder and conductor material.
3. Remove the cable and clean out any remaining powder in preparation for welding.

Note: The guide system is aligned very accurately with the drill and any mishandling may cause the drill to remove too much sheath material, which will adversely affect the final weld quality. Do not lift the machine by holding the motor spindle - always support both ends. The holes in the drill bushes are drilled accurately to ensure that when in use the correct amount of powder is removed.
Before use please ensure that each drill to be used will fit smoothly into the bush as there can be slight differences in drill diameters (even when supposedly of the same size), which can cause the drill to seize in the bush.

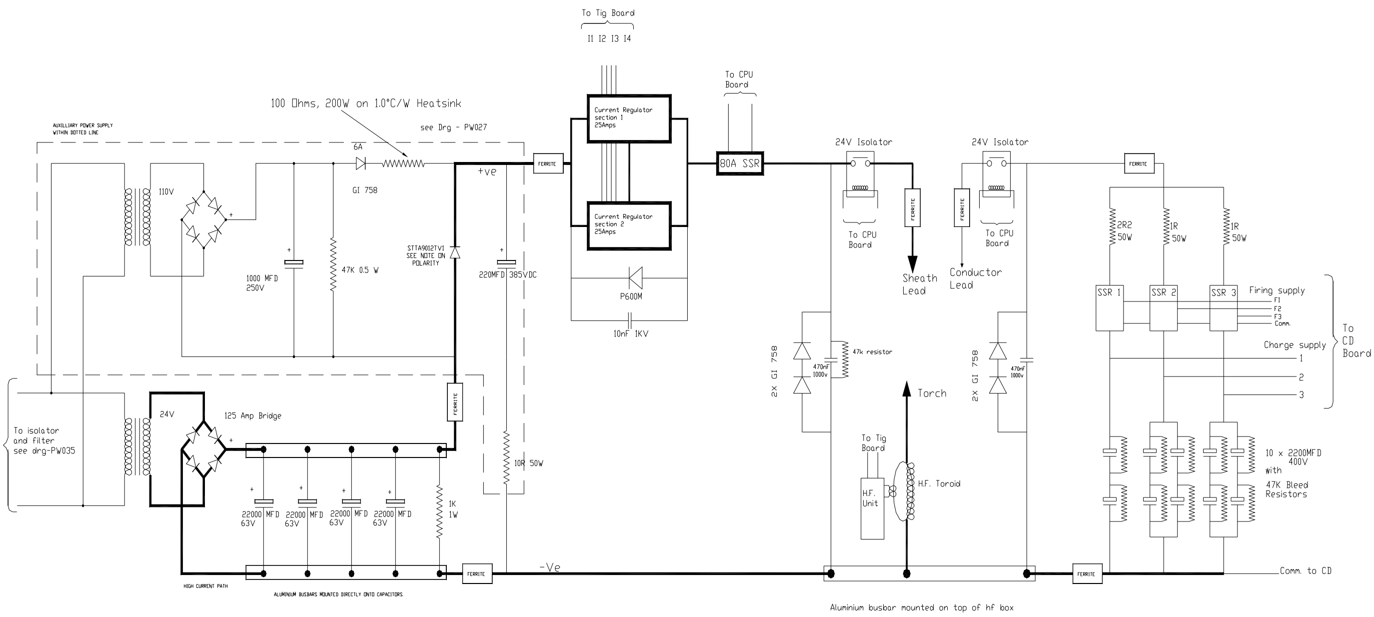
The metric drills listed are slightly smaller than the recommended number-drill sizes and should only be substituted if necessary.

Cable ‘A’ Diameter	Drill ‘B’ Diameter
1.0 mm	73 (0.6 mm)
1.5 mm	65 (0.85 mm)
2.0 mm	56 (1.1 mm)
3.0 mm	46 (2.0 mm)
4.5 mm	31 (3.0 mm)
6.0 mm	19 (4.2 mm)

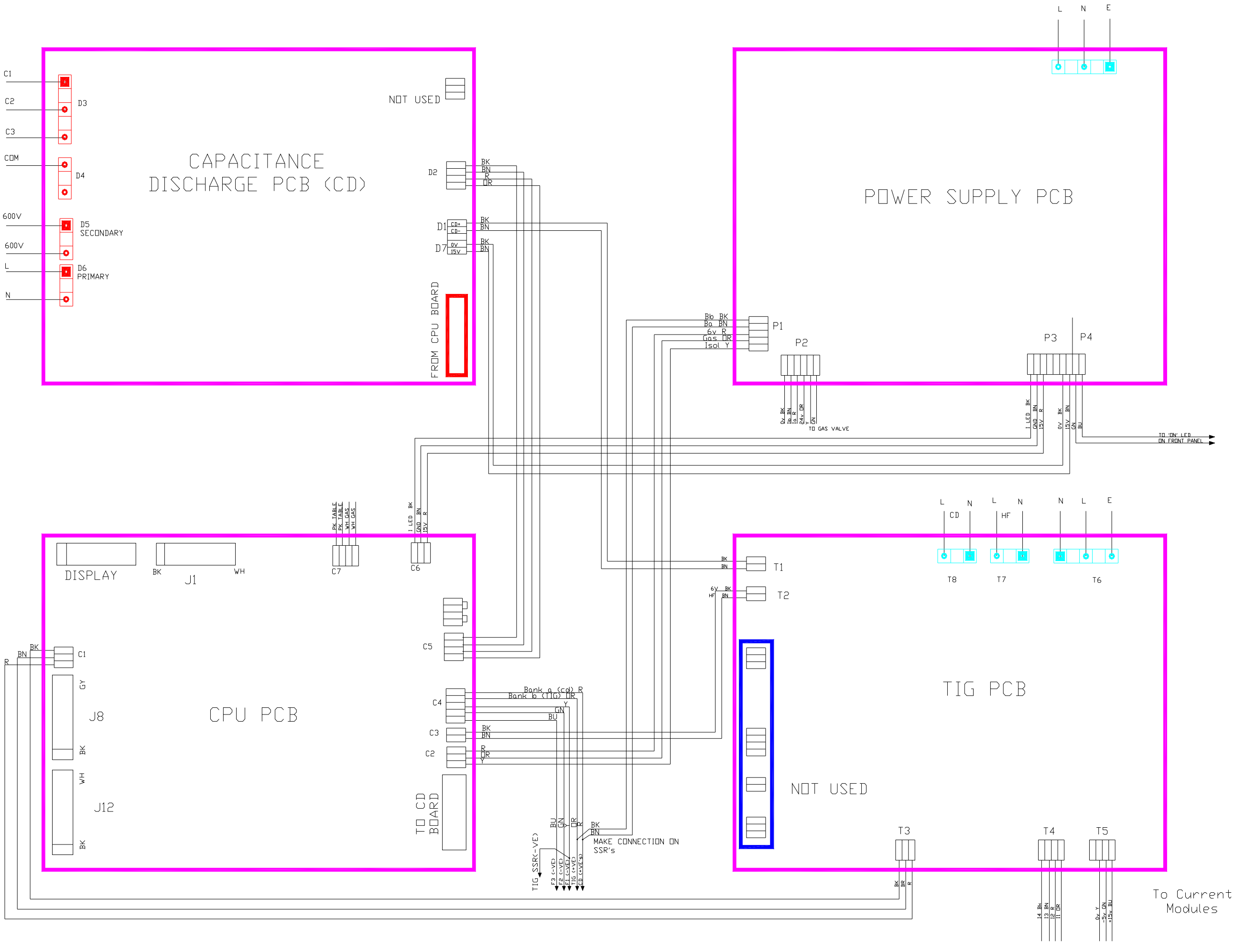
Drill Bush Dimensions



Appendix 3
Electrical Circuit Diagrams



Machine Electrical Schematic



PCB's and main electronics Loom diagram

Appendix 4

MI Thermocouple Welding Machine - Component List
Subject to availability and design changes

1. Case
2. Large Display Panel
3. Small Display Panel
4. Main Printed Circuit Boards
5. Current Regulator
6. Spark Generator
7. Main Power Supply
8. Auxiliary Power Supply
9. Capacitor Bank
10. Other Main Components
11. Gas Components
12. Torch Assembly
13. Vice Assembly

The lists do not include components on the PCB's. These are not client serviceable parts.
Where a part supplier is indicated as TET please contact the company for any queries.

Wire, Fasteners, Fixings, Tubing, Ties, Insulators and Minor Components are not included.

Fa Farnell Electronic Components Limited
RS RS Components Limited
Ra Rapid Electronic Supplies
Va Various sources

1. Case

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
1.1	Base		MICC		1	
1.2	Front Panel		MICC		1	
1.3	Left Panel		MICC		1	
1.4	Right Panel		MICC		1	
1.5	Rear Panel		MICC		1	
1.6	Lid		MICC		1	
1.7	Internal Shield Box		MICC		1	
1.8	Feet		Fa	606-017	6	
1.9	Side Handles		Fa	861-303	2	
1.9	Trim		MICC		2	

2. Large Display Panel

Ref. No.	Component	Value	Supplier	Supp. Ref;	Quantity	Cost
2.1	Large P.C.B.		MICC	CDLEDS	1	
2.2	Small P.C.B.		MICC	TIGLEDS	1	
2.3	Ferrite		Va		1	
2.4	Bezel		Fa	175-710	1	
2.5	Switch		Fa	480-400	4	
2.6	Potentiometer		RS	351-283	2	
2.7	10 Turn Pot.		RS	351-799	5	
2.8	10 Turn Mechanism		RS	107-3849	5	
2.9	Counting Dial		Fa	106-205	5	
2.10	Switch 3 way		Fa	480-514	1	
2.11	Switch 5 way		Fa	480-514	1	
2.12	L.E.D.	3mm Red	RS	247-1139	4	
2.13	L.E.D.	3mm Green	RS	229-2497	2	
2.14	L.E.D.	3mm Yellow	RS	229-2504	10	
2.15	Engraved Panel		MICC		1	

3. Small Display Panel

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
3.1	Air-Flow Meter		RS	198-2919	1	
3.2	Switch		Fa	480-400	3	
3.3	L.E.D.	3mm Green	RS	229-2497	2	
3.4	L.E.D.	3mm Yellow	RS	229-2504	1	
3.5	Engraved Panel		MICC		1	

4. Main Printed Circuit Boards

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
4.1	CPU		MICC	CPU200	1	
4.2	TIG		MICC	TIG101	1	
4.3	CD		MICC	CD106	1	
4.4	PSU		MICC	PWR102	1	

5. Current Regulator

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
5.1	Printed Circuit Board		MICC	IREG51	2	
5.2	Diode	P600M	RS	183-4472	1	
5.3	Capacitor	10nF/1Kv	RS	107-791	1	
5.4	Heatsink		MICC		2	
5.5	Plate		MICC		2	
5.6	Strip		MICC		2	

6. Spark Generator

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
6.1	Printed Circuit Board		MICC	SPK100	1	
6.2	Coil		MICC		1	
6.3	Heatsink Box		MICC		1	
6.4	Pillars		Fa	627-240	4	
6.5	Bypass Capacitors	470nF 1Kv	Fa	106-369	2	
6.6	Bypass Diodes	P600M	RS	183-4472	4	
6.7	Bypass Resistor	47K 2W	RS	214-2178	1	

7. Main Power Supply

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
7.1	Transformer	240/24 1.5KVA	MICC		1	
7.2	Terminal Block	16xAKZ4	RS	823-347	1	
7.3	Capacitor	22000UF/63v	RS	189-793	4	
7.4	Nylon Spacers		Fa	147-967	4	
7.5	Tufnol Board		MICC		1	

8. Auxiliary Power Supply

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
8.1	Transformer	55-0-55	RS	223-8055	1	
8.2	Capacitor	1000UF/250v	RS	189-888	1	
8.3	Capacitor	220UF/385v	RS	189-939	1	
8.4	Capacitor Clip		Fa	653-494	2	
8.5	Bridge Rectifier	4A	RS	183-4258	1	
8.6	Power Diode	STTA9012TV1	Fa	705-851	1	
8.7	Diode	P600M	RS	183-4472	1	
8.8	Resistor	100R/50W	RS	225-1222	2	
8.9	Resistor	10R/50W	RS	158-339	1	
8.10	Resistor	1k/0.5W	RS	132-494	2	
8.11	Resistor	47k/0.5W	RS	132-898	1	
8.12	Flange Mounted Relay		Fa	625-656	2	
8.13	Terminal Block	14xAKZ4	RS	823-347	1	
8.14	Tufnol Board		MICC		1	

9. Capacitor Bank

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
9.1	Capacitor	2200UF/400v	Fa	471-550	10	
9.2	Resistor	470k/0.5W	RS	131-693	10	
9.3	Resistor	2R2/50W	RS	158-317	1	
9.4	Resistor	1R/50W	RS	158-301	2	
9.5	Solid State Relay		RS	362-2372	3	
9.6	Contactor	24V	Fa	448-886	1	
9.7	Main Mounting Plate		MICC		1	
9.8	Small Mounting Plate		MICC		1	
9.9	Clips		RS	543-507	10	

10. Other Main Components

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
10.1	Contactor	24V	Fa	448-886	1	
10.2	Heatsink		RS	402-383	2	
10.3	Solid State Relay		RS	362-2372	1	
10.4	Power Rectifier	105A	Fa	305-3295	1	
10.5	Small sub panel		MICC			
10.6	Fuse Block		RS	421-839	1	
10.7	Contactor	5.5KW	Fa	213-846	1	
10.8	Filter		Fa	453-699	1	
10.9	Fan		RS	498-081	1	

11. Gas Components

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
11.1	Solenoid Valve		Fa	285-079	1	
11.2	Pneumatic relay		RS	200-9318	1	
11.3	Connector		Va		1	
11.4	Bracket		MICC		1	

12. Torch/Holder Assembly

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost

13. Vice Assembly

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost

1.5 Rear Panel

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
1.5.1	Transformer	600V	MICC	725-9335	1	
1.5.2	Gas Connectors	6mm	RS	327-2343	2	

1.2 Front Panel

Ref. No.	Component	Value	Supplier	Supp. Ref:	Quantity	Cost
1.2.1	L.C.D. Display		Fa	142-657	1	
1.2.2	Socket (TIG)		Va		1	
1.2.3	Gland (power)		Va		1	
1.2.4	Gland (Fibre optic)		Va		1	
1.2.5	Gland (cap. Dis.)		Va		1	
1.2.6	Gas Regulator		RS	721-462	1	
1.2.7	Blow Gun (accessory)		Fa	706-9170	1	
1.2.8	Fibre Optic		Fa	148-680	1	

Appendix 5

Use the blank tables below to note preferred settings or for new cable sizes.

CD Settings

Cable Outside Diameter	End cap size	Drill size	Drilling Depth	MgO Fill	Conductor Weld	Energy
mm	mm	# mm	mm	mm	Caps / volts	Joules

TIG Settings

Cable Diameter	Pre Flow Time	Slope Up Time	Weld Time	Weld Current	Slope Down Time	Post Flow Time

Appendix 6

Welding electrode

To remove the electrode from the welding torch first carefully take off the ceramic collar. With a 6mm AF spanner slacken the collet and remove the electrode downwards. Do not remove the electrode by slackening the black holder as this dislodges the collet and collet holder inside. After sharpening the electrode replace it allowing 0.5 to 1.0mm to show below the ceramic collar.

The choice and sharpening of the welding electrode is important for Consistent starting, welding operation and weld quality.

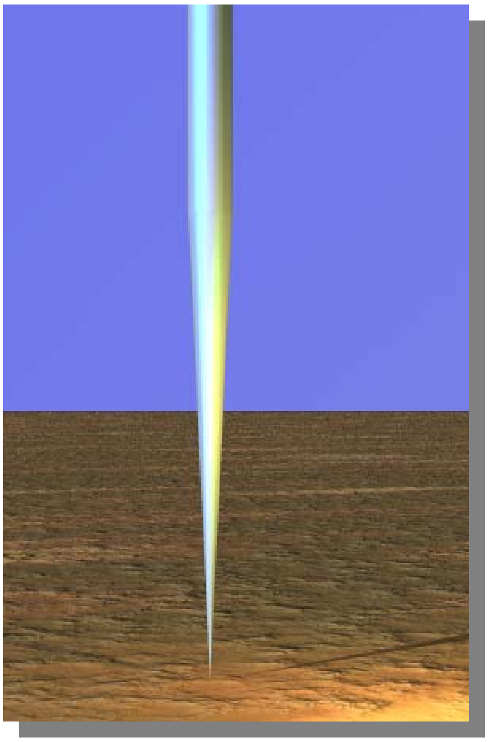
The recommended Electrode type is **2% Ceriated Tungsten** and has to be 1.6mm (16 gauge) size.

Sharpening the electrode is **different** from sharpening electrodes for general TIG operation.

Because of the relatively low currents used and because the electrode is not hand controlled the angle of the point is considerably steeper than normal.

For repeatable, first time striking an angle of less than 10 degrees is required. The point should be ground with as smooth a finish as can be obtained using a fine grinding wheel.

The Ground electrode should not be more than 75mm long. It is advisable to sharpen both ends.



A good trick to determine if the electrode is sharp enough is to run it lightly over your thumbnail. If the point digs in it is sharp if it slides it needs a little more grinding.