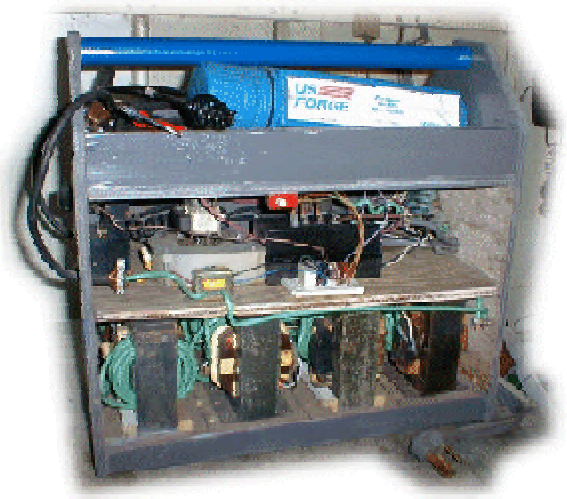
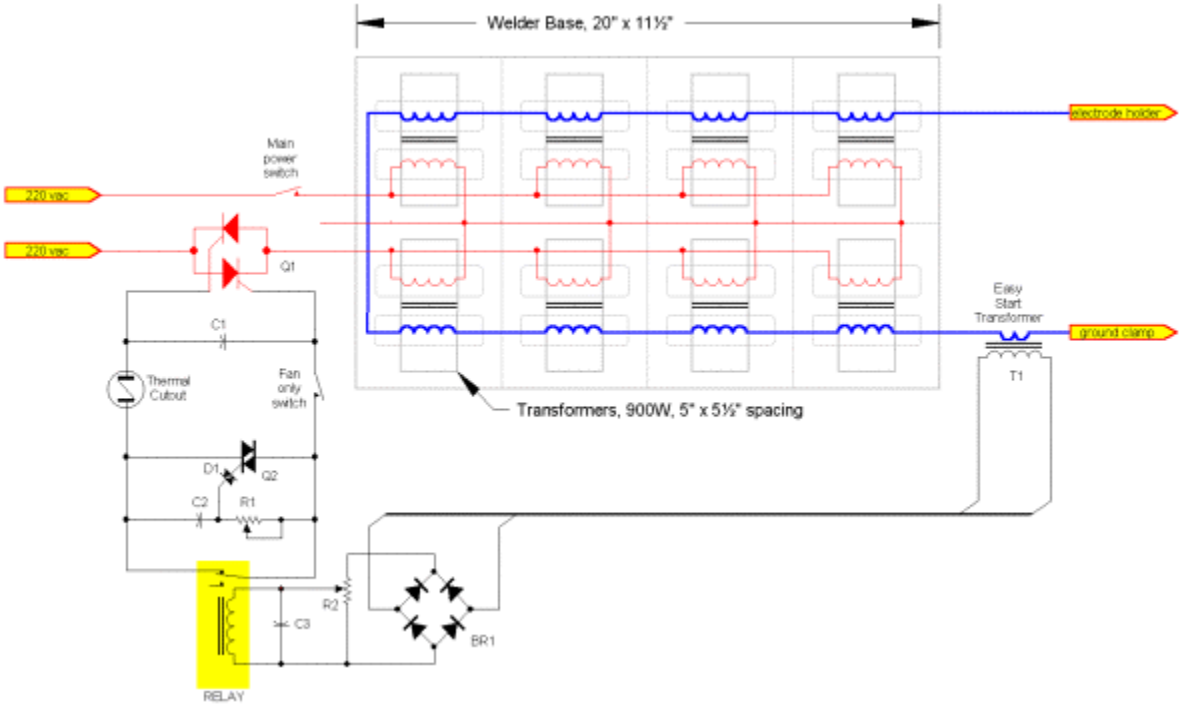
Build Your Own Arc Welder

It's constructed of salvaged microwave oven transformers. The solid state SCR module provides power adjustment, unlike the common AC welders which simply switch a multi-tapped transformer.



Here is a photo. As you can see, there are three sections. The bottom section, which is the base of the cabinet, carries the 8 transformers. (Four are visible.) The center section holds the cooling fans, the power controls, and most of the wiring. The top section is the tool tray and carrying handle. (I say 'carrying handle' a bit cautiously; this beast weighs 140 pounds!) Scroll down to see the schematic and design notes!



Click on the picture to get a larger view. This is what most of you wanted to see, so I have placed this image up here at the top of the page. It is also included further down on the

page where there is more information on each component. Please note that this shematic is not absolute. Semiconductor and inductor tolerances vary enough that you will have to experiment with values and configurations to get it to work in your own unique situation.

Why build your own welder?

With technology at virtually everybody's fingertips, there is an increasing opportunity to the home hobbyist. You likely are reading this manual either knowing the potential of easy to find parts built into simple designs or with a desire to know more about it. That's what this manual is about; my goal is to communicate these designs and allow you as the reader to build useful tools and benefit not only from using them, but from the knowlege and experience gained in actually planning, assembling, and completing such a project.

Facts about homemade equipment

- **There are some important facts about homemade tools. You can't always save money by building your own equipment. Making your own tools can be very time consuming. And homemade equipment isn't always better than storebought.**
- **Here is the other side of these facts. Most of us have more time than money. If we can find sources for cheap or free parts, we can save a lot of money, time being the only other expense. Also, some homemade tools are not even available in the store or may have handy features that their storebought counterparts lack.**
- **People build their own shop equipment for a variety of reasons, and some of these I've already hinted at:**
    - **They like to build things**
    - **They want to improve a design.**
    - **They need a tool that cant get any other way.**
    - **They need a tool to build another tool.**
    - **They want to save money.**

Studying the Arc Welder

You don't need to know how to weld to benefit from this manual. Even if you know all about welding, what is inside a welder is a different story . Before you can successfully build an arc welder, you need to understand how they work and what components they use.

An arc welder is a high amperage, low voltage power supply. There are two types of these: constant amperage and constant voltage. The stick welder is the constant amperage type. Wire feed welders are constant voltage. Arc welders generally use transformers to reduce the voltage and boost the amperage to levels useful for welding. TIG and other types of welders use special high frequency power supplies which are beyond the scope of this manual.

Laminated iron core transformers have a constant amperage characteristic that makes them ideal for welding. Inside of practically any welder there is a transformer which consists of three basic parts: Primary windings, secondary windings, and a laminated iron core. The windings are copper. The primary windings connect to line voltages, and in welders this is generally 240 volts. The secondary windings power the arc and are much heavier copper windings. The windings are wound on the iron core. There is no electrical connection between the primary and the secondary windings. Electrical power is transferred magnetically throught the iron core.

A welding power supply also needs a way to vary the power to the arc. There are several ways to accomplish this. One way is to have an incremental number of taps along the

secondary windings to draw various amounts of power from. Another is to configure the transformer so that the primary winding may be moved toward or away from the secondary, delivering more or less magnetic flux to the secondary. Another is to vary the pulse width of the line current to the primary winding. The welder in this manual uses the pulse width type of controller.

Modifications to the welder

You can build the welder any way you choose. A much simpler design would be to switch different combinations of transformers on and off to give a variety of heat settings. Or you could remove the end blocks of two transformers, put them end to end, and configure a moving primary controller. The reason I chose the pulse width controller for this manual is was that it provides a simple reliable design with few moving parts.

The transformer and the heat selector are the basic building blocks of an arc welder. There are, however, a number of other support components that need mentioning. The cabinet that encloses the welder must be designed to keep out welding dust. This cabinet assembly must include a cooling fan to provide enough air flow to keep the components cool. A ground clamp and electrode holder (often not included when you buy a welder) are also needed before you can weld. And you need a 220 volt receptacle to plug in your welder, and the cord and plug on the welder itself.

Getting the parts

Part of the thrill in building the arc welder is obtaining and modifying the components that make the power supply. The transformers, cooling fans and parts of the cabinet come from old microwave ovens.

What I did was went around to the local appliance dealers and service shops and told them what I wanted to do and they were happy to give me their scrap microwave ovens. I also put an ad in the paper, because most appliance retailers charge a fee to accept their customer's old appliance, and people were elated to bring their microwaves to me knowing that I wouldn't charge them to accept it and that it would be recycled into a piece of homemade shop equipment.

One word of warning, though. Your yard or garage will become cluttered with microwave ovens awaiting dissasembly. You will need eight large transformers to complete this project, and you will need microwaves from 950 watts and up. If you advertise in the newspaper, you won't be able to choose what you get, but don't despair; those odd ones may have just the right transformer for your easy start sensor or just the right fan for the cooling system. I counted a total of 22 ovens before my welder was complete. I probably wouldn't have needed that many, but I got many good parts and probably enough transformers to build another welder. At the time of this writing, I am toying with the idea of a smaller welder that can operate on 120 volts for lighter projects.

The cabinet front and bottom are made from wood. The parts you will need to buy are listed below. Most of these parts come from a hardware store, except for the IRKT71 SCR module. This you will have to order from an electronics supply company. I ordered mine from Newark Electronics, but you may also find this part at Digikey Electronics, or you can locate other sources on International Rectifier's website.

Modifying the transformers

Microwave oven transformers are step up transformers. That means that the voltage at the secondary winding is higher than the primary. In microwave ovens, the primary accepts standard house current, 120 volts. The secondary voltage is typically 4000 volts. The secondary winding must be removed and a low voltage winding put in its place. The new secondary winding has a typical open circuit voltage of 10 volts. Under an arc welding load, this voltage will drop to between 2 - 4 volts, and up to 250 amps. You will use #6 single conductor wire for the new secondary winding.

Mounting and wiring the transformers

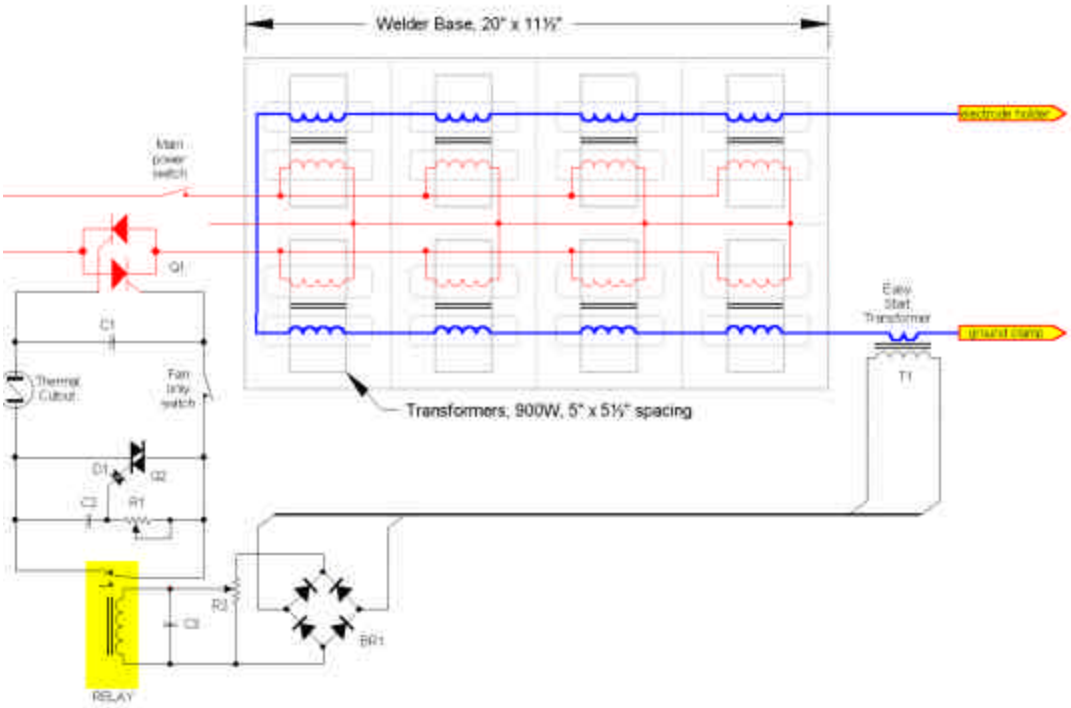
Here are the details for the bottom board of the arc welder that the transformers are mounted on. Since not all the transformers are the same, you will have to improvise where needed. Mount the transformers in such a way that the primaries and secondaries can be

wired correctly and neatly. You can even draw out the mounting patterns on the bottom board to help organize it.

Building the cabinet

The cabinet design for the home built arc welder has several functions. The top part resembles a tote tray and serves as a place to store electrodes, welding gloves, cables and clamps, chipping hammers and other items used in welding. The carrying handle is made of a 1 1/2 dowel, and provides a clue as to the weight of this machine.
The cabinet also functions as a chassis for the transformer and other components. The cooling fans are mounted on the same plywood bulkhead that the controller is built on. The transformers are mounted on the bottom which is a short piece of pine 2x12. Building a sturdy cabinet is imperative because the finished welder will weigh around 120 pounds. Don't skimp here.
You can paint the cabinet with any color scheme you so desire, but the main purpose for the paint is to seal the wood against moisture and solvents. It also gives the machine a professional look that will bring a sense of worth to all your efforts.

Building the controller



Parts List

C1: 600pf 2kv ceramic
C2: 0.1mf 400v epoxy
C3: 22mf 250v electrolytic
Q1: IRKT71 SCR module
Q2: Lamp dimmer triac
BR1: RB152 1A bridge rectifier
D1: Trigger diac
R1: 1M Linear potentiometer
R2: 5k Linear potentiometer

The controller is the pulse width type. It works by energizing the transformers with short bursts of current, medium bursts, or continuous current depending on the setting on the heat selector dial, R1. It is the same type of control circuit used in rotary light dimmers.
You can use predrilled perfboard, but I recommend building the phase control circuit on an experimenter socket. It's not that much more expensive, and if a component blows, you can easily plug in a new one without even having to warm up your soldering iron. Make extra sure your connections are correct before you apply power, and never handle the circuit with power applied!
For an SCR module I first used two Teccor S6070W scr's wired in an inverse parallel circuit, as you see in the schematic. These proved to be too light duty and they fried when I tried to weld at full heat with 5/32 rod. After carefully comparing prices in several industrial electronics catalogs, I selected International Rectifier's IRKT71 Inta-pak SCR module. It costed about $50 as I remember. I purchased it through Newark Electronics. Well worth the price. It had 3 big screw terminals on top and 4 smaller spade type

connectors at one end for the control circuitry. It contains two SCR's internally and is configured with inverse parallel circuitry in mind.
The SCR module and heatsink assembly must be configured to receive a blast of air from one of the cooling fans. Use heatsink grease between the SCR module and heatsink to provide a good heat conducting contact. This assembly generally won't be getting very hot, and that's just the point. Carefully make and verify the connections to the phase control circuit, overheat sensor, and fan only switch.
The easy arc starting circuit is optional. R2 controls the sensitivity. Adjust it to the least sensitive setting at lowest heat. That way it is sure to work at all heat settings. It works by putting full power to the electrode until you strike the arc. This helps to keep the electrode from sticking to the work. Use a brain board transformer from one of the ovens for this and modify it as following: Identify and remove the secondary winding bobbin and run one loop of #6 stranded cable through it. Connect the primary winding to the indicated connections on BR1.

Tying up all the loose ends

This chapter deals with the final details needed to make your welder functional.
Do the final wiring according to the schematics. Connect the welding cables and put on the ground clamp and electrode holder. Install the range cord and wire it to the main power switch and transformer terminal block. Attach the heat selector knob and you're ready to plug in your new arc welder.
Calibrating the heat selector dial can be done any way you wish, it is not important to know the exact amperages that are right for each welding application. I calibrated mine with open circuit voltages, which when squared are roughly proportional to welding current. To do this, set your voltmeter to a scale suitable for 80 volts. Turn on the welder and disconnect the easy start relay. Turn the heat selector knob to full power and mark the spot on the dial. Then turn the knob back so that your voltmeter reads 70 volts and mark the spot on the dial. Turn the knob back to 60 and mark the spot. Repeat this process at 10 volt increments. Or you can increment it in 5 volts steps. If you can figure out a way to calibrate the dial in amps using a very large ammeter, you can of course do that. You may photocopy the any of the dials near the end of the manual.

A crash course in welding

If you have never welded before, I recommend that you go to the library and check out a manual on welding. If you MUST weld immediately after finishing your welder, please read this chapter.
BEFORE you strike an arc. It is important that you be properly dressed for welding. You need a welding helmet to protect your eyes from the ultraviolet rays and to keep sparks from getting into your hair. Fire retardant hats are a good idea, too. You can get them from welding supply houses. You also need gloves to protect your skin from arc sunburn and welding spatter. Leather aprons and leather boots keep welding spatter from getting to your skin. And remember to weld only in well ventilated areas. Welding makes choking, dusty smoke. Read the instructions and warnings on the labels of welding supplies and equipment.
Striking and maintaining the arc. Striking an arc isn't complicated. With your helmet up, position your electrode about 1/4 inch away from where you want to start welding. Lower your helmet and make a quick jab with the electrode. Be watching for the arc. Be prepared to pull the electrode away SLIGHTLY. Very soon you will have to slowly move the electrode into the weld as it melts off fairly quickly into the weld pool.
Laying a bead. A properly maintained arc makes a hissing, crackling sound as the electrode burns. Holding the arc too far away makes more buzzing and spattering. Holding the arc to close makes the rod overheat and sometimes stick to the work. It is important in laying a bead to keep the electrode moving into the weld pool as you move along. Horizontal beads are the easiest. With vertical beads, it is the easiest to work from the top down. When welding long beads, it is important to tack weld every 6" to keep the work

from warping. For instance, if you are welding a metal box together, tack the entire box together and then go back and lay the beads solid. If you don't, the whole mess will be so warped out of shape after the first two seams you won't be able to finish the other welds. Finally, remember that welding is something that takes practice. You can't learn it from a manual. You must spend some time just laying beads and experimenting. Try welding bicycle frames. The challenge here is to make nice welds without burning through the metal. I've discovered you can cut bicycle frames and other thin metal sections with a large welding rod on high amperage. Welding expertise, however, is beyond the scope of this manual. Go to the library and get some books on welding. Use them to guide your progress as you practice.

Troubleshooting

- **The welder seems stuck at high amperage and changing the heat selector dial has no effect. There may be a number of things wrong here. Make sure the easy start relay is wired properly. If this relay doesn't pull in when you strike the arc, the welder doesn't switch down to the power you select.**

- **The arc is hard to start at low heat settings. The easy start mechanism may be at fault. Make sure it is wired properly and that the normally closed contacts are used. When you strike the arc, the relay should open. You also have this problem if your welding rod has its protective coating damaged at the striking end.**
- **The welder worked beautifully, but after welding 15 or so 5/32 rods, it suddenly quit. You have overheated the welder. The overheat sensor has done its job and shut down the controller. The fans should still run. Let the welder cool off for a few minutes and it should weld again.**
- **The welder worked beautifully, but after welding for two hours solid, something smells funny and you either get no arc or only full amperage. You have fried the SCR module and overheated the transformers. Most welders have a duty cycle. That means that if your welder has an 80% duty cycle, you must weld for no more than 8 minutes, and then let it rest for 2 minutes before welding again. Or if it has a duty cycle of 30%, you must wait 7 minutes in between 3 minute welding spurts. A duty cycle hasn't been determined for this arc welder. It actually varies depending on how high an amperage you are welding with. And remember to keep the air vents open and to keep the insides of the welder free of dust build up. Dust acts as insulation and hinders proper cooling. Another thing to do to help the welder stay cool is to hit the fan only switch between welds. This allows air to circulate the transformers while they are idle.**