# VIII. Techniques for Basic Weld Joints

## Arc Length, Gas Cup Size, and Electrode Extension

As a rule of thumb, the arc length is normally one electrode diameter as seen in Figure 8.1. This would hold true when AC welding with a balled end on the electrode. When welding with direct current using a pointed electrode, the arc length may be considerably less than the electrode diameter. Torches held in a fixed position allow for holding a closer arc than for manually held torches.

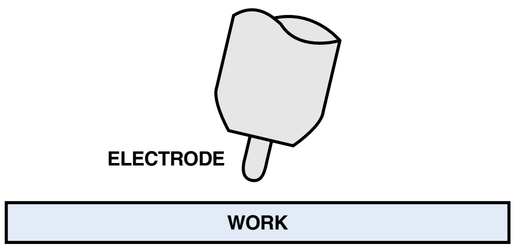


**Figure 8.1** Illustration shows the relationship between electrode diameter and arc length.

The inside diameter of the gas cup should be at least three times the tungsten diameter to provide adequate shielding gas coverage. For example, if the tungsten is 1/16" in diameter, the gas cup should be a minimum of 3/16" diameter. Figure 8.2 is an example of gas cup size and torch position.

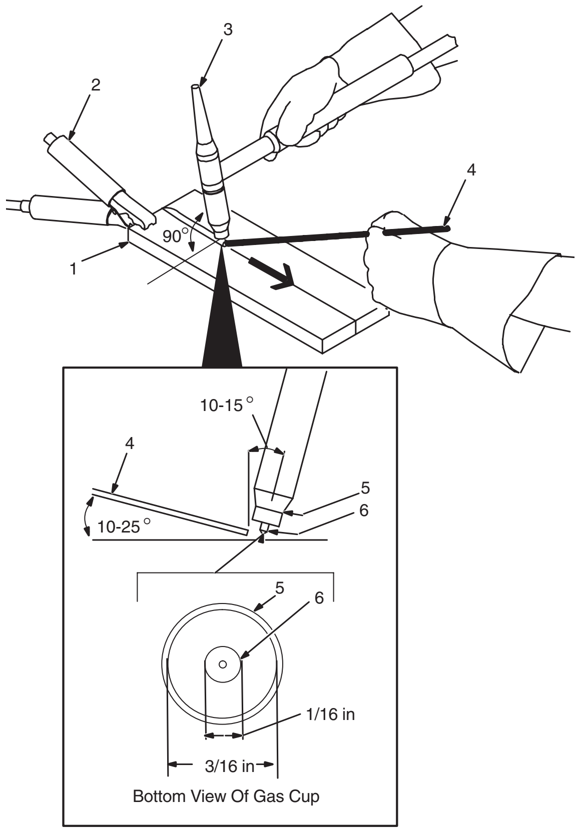


**Figure 8.2** Gas cup size and torch positions. 1-Workpiece, 2-Work Clamp, 3-Torch, 4-Filler Rod (If Applicable), 5-Gas Cup, 6-Tungsten Electrode.

Tungsten extension is the distance the tungsten extends out beyond the gas cup of the torch. Electrode extension may vary from flush with the gas cup to no more than the inside diameter of the gas cup. The longer the extension the more likely it will accidentally contact the weld pool, filler rod being fed in by the welder, or touch the side of a tight joint. A general rule would be to start with an extension of one electrode diameter. Joints that make the root of the weld hard to reach will require additional extension.

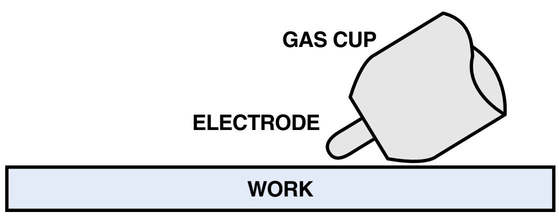


**Figure 8.3** Resting the gas cup against the work in preparation for a high-frequency start.

## Torch Position for Arc Starting with High Frequency

The torch position shown in Figure 8.3 illustrates the recommended method of starting the arc with high frequency when the torch is held manually. In this way the operator can position the torch in the joint area and after lowering the welding hood, close the contactor switch and initiate the arc. By resting the gas cup on the base metal there is little danger of touching the electrode to the work. After the arc is initiated, the torch can be raised to the proper angle for welding.

## Manual Welding Techniques

### Making the Stringer Bead

The torch movement used during manual welding is illustrated in Figure 8.4. Once the arc is started, the electrode is held in place until the desired weld pool is established. The torch is then held at a 75° angle from the horizontal as shown in the illustration and is progressively moved along the joint. When filler metal is used, it is added to the leading edge of the pool.

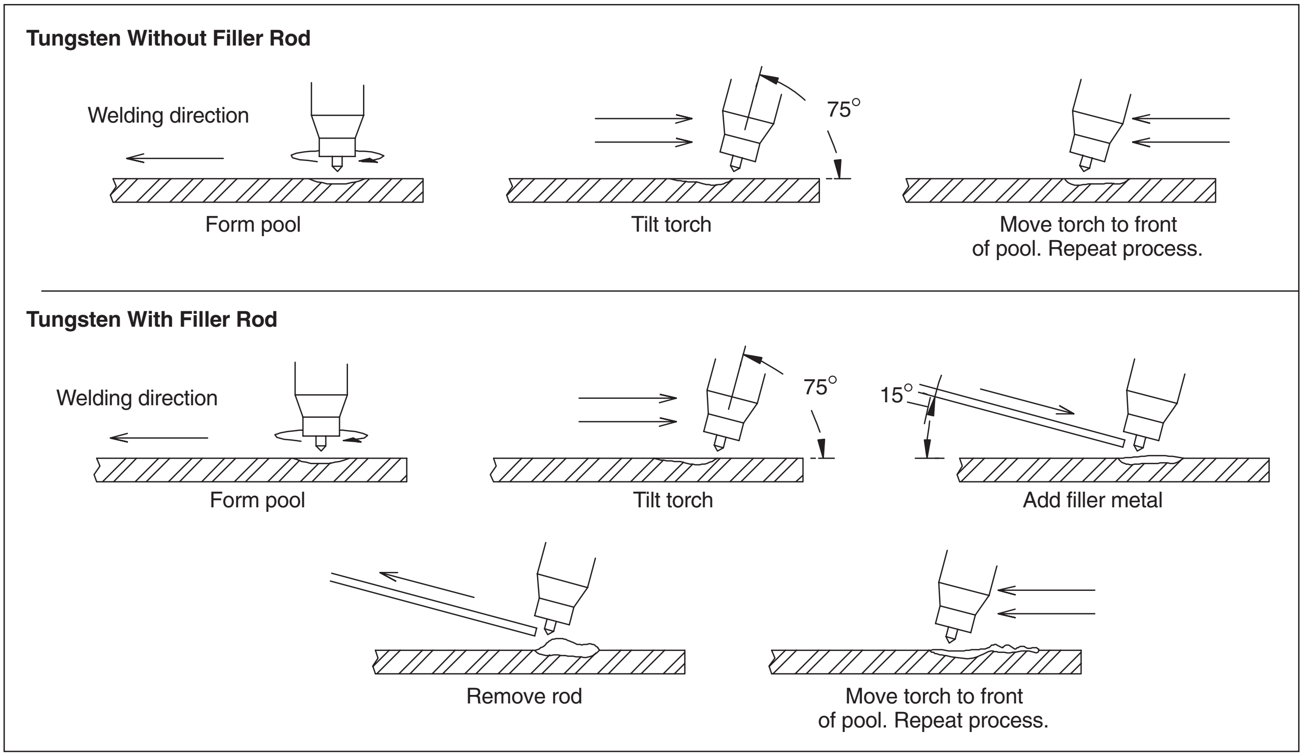


**Figure 8.4** Torch movement during welding.

The torch and filler rod must be moved progressively and smoothly so the weld pool, the hot filler rod end, and the solidifying weld are not exposed to air that will contaminate the weld metal area or heat affected zone. Generally a large shielding gas envelope will prevent exposure to air.

The filler rod is usually held at about a 15° angle to the surface of the work and slowly fed into the molten pool. Or it can be dipped in and withdrawn from the weld pool in a repetitive manner to control the amount of filler rod added. During welding, the hot end of the filler rod must not be removed from the protection of the inert gas shield. When the arc is turned off, the postflow of shielding gas should not only shield the solidifying weld pool but the electrode and the hot end of the filler rod.

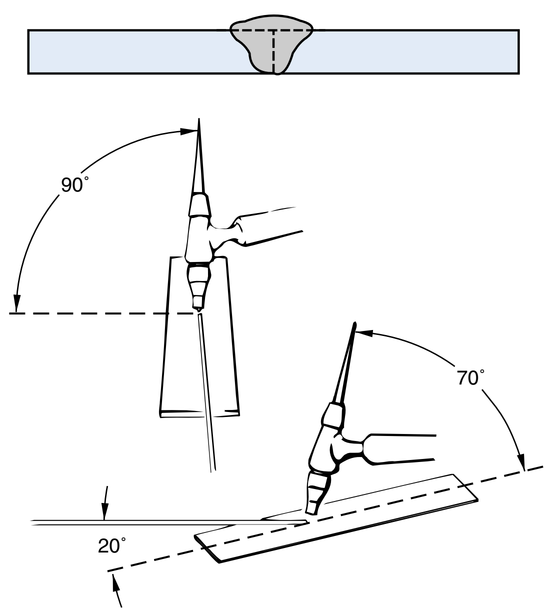


**Figure 8.5** Welding the butt weld and stringer bead.

## Butt Weld and Stringer Bead

### Torch and Rod Position

When welding a butt joint, be sure to center the weld pool on the adjoining edges. When finishing a butt weld, the torch angle may be decreased to aid in filling the crater. Add enough filler metal to avoid an unfilled crater.

Cracks often begin in a crater and continue through the bead. A foot operated amperage control will aid in the finishing of a bead as amperage can be lowered to decrease pool size as filler metal is added.

# Lap Joint

### Torch and Rod Position

Having established an arc, the pool is formed so that the edge of the overlapping piece and the flat surface of the second piece flow together. Since the edge will become molten before the flat surface, the torch angle is important. The edge will also tend to burn back or undercut. This can be controlled by dipping the filler rod next to the edge as it tries to melt away. Enough filler metal must be added to fill the joint as shown in the lap joint illustration. Finish the end of the weld the same as before by filling the crater.

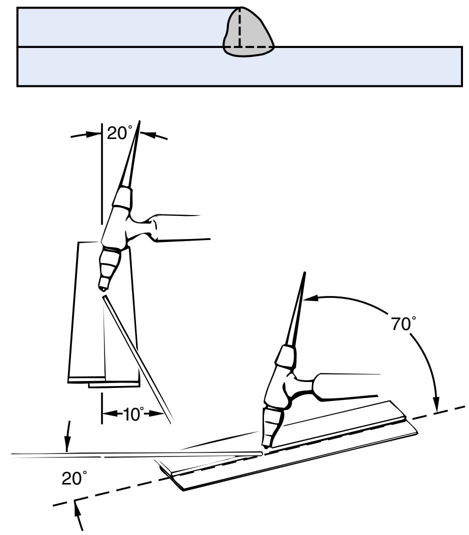


**Figure 8.6** Welding the lap joint.

# T-Joint

### Torch and Rod Position

A similar situation exists with the T-joint as with the lap joint. An edge and a flat surface are to be joined together. The edge again will heat up and melt sooner. The torch angle illustrated will direct more heat onto the flat surface. The electrode may need to be extended further beyond the cup than in the previous butt and lap welds in order to hold a short arc. The filler rod should be dipped so it is deposited where the edge is melting away. Correct torch angle and placement of filler rod should avoid undercutting. Again, the crater should be filled to avoid excessive concavity.

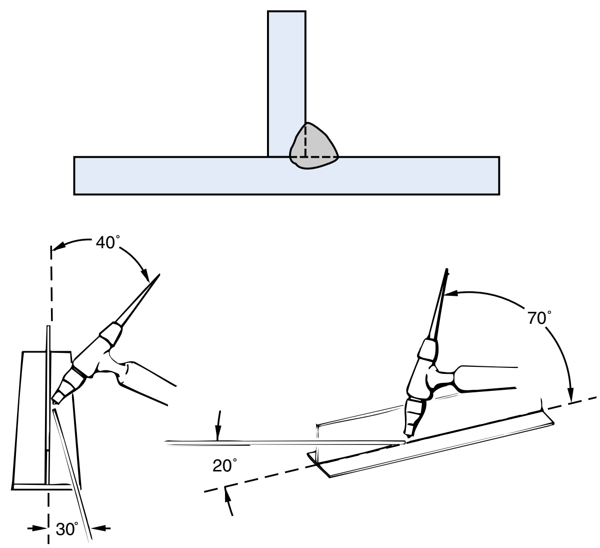


**Figure 8.7** Welding the T-joint.

# Corner Joint

### Torch and Rod Position

The correct torch and filler rod positions are illustrated for the corner joint. Both edges of the adjoining pieces should be melted and the pool kept on the joint centerline. When adding filler metal, sufficient deposit is necessary to create a convex bead. A flat bead or concave deposit will result in a throat thickness less than the metal thickness. On thin materials, this joint design lends itself to autogenous welding or fusions welding without the addition of filler rod. Good fit-up is required for autogenous welding.

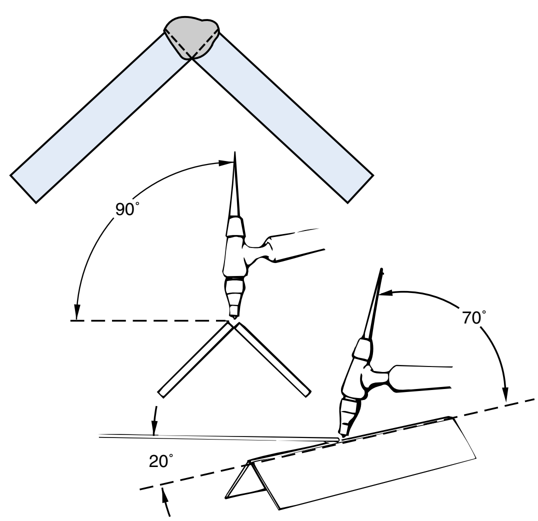


**Figure 8.8** Welding the corner joint.

# Techniques for Out-of-Position Weld Joints

During the welding process, all action is centered in the weld pool. The weld pool is the point at which fusion and penetration occur. With practice controlling the pool becomes quite easy while welding in the flat position. Eventually as additional experience is acquired, welding out-of-position will be much easier for the welder. Controlling the weld pool and penetration is the prime concern for all positions of welding.

There are many variables to take into consideration in out-of-position welding, such as amperage, travel speed, tungsten type and torch position. Volumes could be devoted to this subject alone. Therefore, we will try to provide a few tips and make a few general statements regarding out-of-position weld joints.

**Welding in the Vertical Position**

**Figure 8.9** Welding in the vertical position.

Gravity is the enemy of all out-of-position welding. In the vertical position, both up and down, gravity will try to pull the molten weld pool downward and out of the joint. A good welder however, will learn to use gravity to his or her advantage.

In vertical up welding, the weld is begun at the bottom of the joint with the filler metal being added from above. Attempt to establish a "shelf" with each dab of filler metal for the next filler metal addition to rest on. If the joint is wide, work back and forth across the joint to establish this shelf.

If the joint to be welded is a V-groove, the tungsten electrode extension can be increased, and the gas cup can be rested against the edges of the joint and maneuvered back and forth. This will greatly assist in providing a steady hand, although this technique makes it difficult to actually see the weld pool.

Vertical down welding makes use of both surface tension and arc force to hold the molten weld pool in the joint. Mastery of the vertical down technique is useful when welding on thin material. Practicing the vertical up and down techniques on a flat sheet or plate will greatly assist the welder who desires to move on to pipe welding because nearly all pipe beads are accomplished with the same techniques. However, vertical down is rarely used when TIG welding thicker sections of plate or pipe.

**Welding in the Overhead Position**

**Figure 8.10** Welding in the overhead position.

Welding in the overhead position is thought by most welders to be the most difficult of all positions. The welder who can consistently produce high quality overhead welds is much sought after by industry.

As with vertical welding techniques, gravity is the enemy of overhead welding. Unlike the vertical position, overhead welding cannot rely on the building of shelves on which to place consecutive beads. Instead, it relies on surface tension of the pool, arc force, and a combination of lower amperage and higher travel speeds.

One of the techniques used in vertical welds that can be utilized in the overhead position is extending the tungsten electrode and resting the gas cup against one or both sides of the joint to be welded. This procedure is usually used only in groove welds and some fillet welds. When the welder is putting in fill passes he can extend a few fingers on either the torch hand or the filler rod hand and actually rest them on the plate to be welded. This will help steady the hand.

**Figures 8.11 and 8.12** Demonstrations of two common methods of grasping the torch for pipe welding. There is no single "correct" method of doing this and each welder is encouraged to experiment with several different methods until one is found that is most comfortable, and results in satisfactory welds.

Heat input to the overhead weld pool is extremely important. Generally speaking, the heat input of an overhead joint would be less than the amount used for a comparable weld in the horizontal or flat position. This keeps the pool size small and thereby prevents sagging or the weld pool from falling out of the joint.

The possibility of falling molten metal makes the need of proper protective clothing and equipment absolutely essential. Never attempt to make this type of weld without all safety gear in place.

No doubt the overhead position is difficult. It is extremely fatiguing for the welder to accomplish, making it a slow process and increasing the time needed to accomplish the job. This is one of the major reasons industrial use of overhead welding is kept to a minimum.

## Techniques for Pipe Welding

Pipe welding with the GTAW process requires a great deal of skill, and should only be attempted when the welder has mastered the principles of GTAW welding on plate.

GTAW produces the highest quality pipe weld of all the arc processes and with a minimum of distortion.

As with our previous segments on out-of-position welding, the different combinations of metals, positions, tungstens, gases and so on make this a subject to which an entire book, or even library, could be devoted. Therefore this segment will be limited to a few helpful hints and tips.

Consumable inserts are items often used in pipe welding. Consumable inserts are composed of the same type of material that is being welded and are used to keep root passes uniform. The consumable insert is melted into the root pass and becomes an integral part of the weld bead.

Because most pipe joints require a gapped joint, protection of the weld bead in the form of gas coverage inside the pipe is necessary. This coverage can be accomplished by covering the ends of the pipe with pipe caps made for that purpose, or by simply covering the ends with paper and tape, and then inserting a shielding gas hose.

GTAW pipe welding also requires a special treatment of the tungsten electrode tip. A common electrode would be a 1.5% lanthanated or 2% thoriated tungsten. Once the tip is ground to a point, the very tip is flattened to a width of about .020. This small flat spot helps to distribute the arc evenly at the joint edges.

One of the most popular techniques for GTAW welding of pipe joints is the walking-the-cup technique. This technique utilizes a specific manner of manipulating the torch, along with a series of increasingly larger gas cups to produce consistently good welds with a minimum of fatigue.

**Figure 8.13** Demonstration of how the torch and filler rod are held to accomplish the "walking-the-cup" method of pipe welding.

The two sections of pipe to be welded should be gapped slightly less than the diameter of the filler rod to be used. The filler rod should rest in the groove without slipping through. For the root pass, rest the gas cup in the groove contacting both sides and aimed slightly to either the right or left of the joint. The cup is then rocked slowly back and forth and slight pressure is applied to the torch so that it travels forward along the groove at the same time.

The filler rod is not dipped in and out of the pool, but remains in contact with the leading edge at all times. When the root pass is completed, a larger cup is then placed on the torch so that it now contacts both sides of the groove as well as the surface of the root pass. The torch is now rocked back and forth in the joint pivoting on the surface of the root pass while being guided by the sides of the groove. The filler rod is kept at the leading edge of the pool without dipping in and out. The third and all remaining passes are accomplished in the same manner except that increasingly larger gas cups are used. Make sure the tungsten extension is adjusted so that it does not dip into the weld pool, but remains close enough for proper control.

## Arc Starting Procedures

The arc starting requirements of the material to be welded will have a great impact on the choice of welding power sources.

**Scratch Start** — This method of arc initiation is utilized by GTAW power sources with no added arc starting capability. The arc is started by briefly placing the tungsten electrode in contact with the work and then quickly withdrawing it as the arc is established. The advantage of this method is simplicity of operation. This starting method is not acceptable for critical applications since small tungsten particles may become embedded in the workpiece and contaminate the weld. It is not advisable to use this method with inverter-type power sources equipped with touch start.

**Figure 8.14** This welder (who happens to be left handed) demonstrates still another style of torch and filler rod manipulation used to accomplish a pipe weld.

**Lift-Arc™** — This type of arc starting method was developed to eliminate tungsten contamination associated with the scratch start method. With touch start the tungsten is brought into contact with the workpiece. When this occurs, the power source senses a short circuit and establishes a low voltage current in the weld circuit. This voltage and current are not great enough to establish an arc, but do contribute to heating the electrode. When the electrode is lifted from the workpiece, the power source senses the absence of the short circuit condition and automatically switches to the current set on the machine. The fact that the electrode has been pre-heated assists in arc initiation.

**Carbon Start** — In this method, the tungsten is placed close to the work, then the resulting gap is momentarily bridged with a carbon rod or block. Once the arc has begun, the carbon rod or block is removed or the arc is moved to the beginning point of the weld. This method is also unacceptable in critical weld applications because carbon particles may easily become entrapped in the work. The application of the carbon rod may be frequently impractical.

**Pilot Arc** — A small current is maintained between the electrode and the gas nozzle to provide a conductive path for the main weld current. This is a method used often with the GTAW spot welding process and when the process is used for machine or automatic welding applications.

**Hot Tungsten Arc** — The tungsten is resistively heated to a cherry red. At this temperature, the shielding gas in the area of the tungsten becomes ionized and therefore will conduct electricity. The presence of the power sources open circuit voltage under these circumstances is enough for the arc to establish itself between the electrode and the work. The necessity of heating the electrode and the resulting preheating of the work are considered disadvantages of this method.

**Capacitor Discharge (CD)** — In this method, the arc is initiated with a momentary burst of high voltage (normally provided by a bank of capacitors) between the electrode and the work. This high-energy spark creates an ionized path through which the weld current starts flowing. This method is generally used with DC power supplies in machine or automatic welding applications.

**High-Frequency Start** — Perhaps the most common of all arc starting methods, high frequency can be used with DC or AC power sources for manual through automatic applications. This method uses the ionizing capability of a high-frequency voltage superimposed over the welding current to provide a path for the arc to become established. Some power sources discontinue the high frequency once the arc is established and some feature continuous high frequency to take advantage of the stabilizing control it has on the arc. Special precautions must be taken to prevent the high frequencies electromagnetic interference (EMI) from radiating too much energy and causing interference with communication systems and computerized equipment.

**Impulse Arc Start** — Used when a noncontact, TIG arc starting method is required. A single pulse of high-frequency (HF) voltage is superimposed from the electrode to the workpiece to initiate the arc. Impulse arc starting can be used for DC TIG or AC TIG using the Advanced Squarewave power source. The main advantage to impulse arc starting is the electromagnetic interference (EMI) generated by the welding power source is significantly reduced. Thus, the chance of causing other electronic equipment in the immediate vicinity to malfunction or be damaged is diminished.

**Arc Assist** — Utilizes a high voltage DC spike that is induced into the weld circuit to assist starts and provide stabilization during AC welding. These high voltage spikes are present only when the output voltage is greater than 30 volts. In DC welding, as the welder brings the electrode close enough to the work, the pulses jump start the arc, the weld circuit voltage drops to its normal 14 or so volts, and the arc assist circuitry drops out. In AC welding, the voltage passes through the zero point twice each cycle and the arc will tend to go out. Because the voltage increases during these arc outages, the Arc Assist circuitry is automatically engaged for that part of the cycle only, thereby providing a stabilizing effect.

## GTAW Arc Starting Tips

The following list is developed from the experiences of welding engineers, welding technicians, welding instructors, and others employed in the welding field. They were asked to provide tips and techniques they have used for the sometimes difficult task of starting the gas tungsten arc. The list of arc starting "hints and tips" are in no particular order of importance, and are submitted in the interest of taking advantage of the many years of experience of welding professionals.

- Use the smallest diameter tungsten possible.
- Buy the highest quality tungsten available (of the proper alloy).
- Use the shortest length torch possible.
- Use premium quality cable for torch and work leads.
- Keep torch and work leads as short as possible. Move the power source as close as possible to the work. If the power source cannot be moved closer and a high-frequency arc starter is being used, move it closer to the weld.
- Attach work lead as close as possible to the weld.
- Avoid long cable runs over bare concrete floors, or insulate cables from floor by laying them on boards.
- If the welding machine is being used for both GTAW welding and for Stick electrode welding, make sure the Stick electrode holder is detached from the machine when GTAW welding.
- Check and tighten all connections.
- Keep the torch cable from contacting any grounded metal such as work benches, steel floor plates, and the machine case.
- Use 100% argon shielding gas if possible.
- Check the secondary current path and tighten all connections.
- If the machine has adjustable high-frequency spark gaps, increase gap to manufacturer's recommended maximum.
- Check for mineral deposit build up in water-cooled torches to avoid high-frequency shunting back to ground through deposit material.
- Increase intensity adjustment if available.

## Tips for Automatic Applications

- Check all of the above, they still apply.
- Mount the torch in a non-metallic holder or clamp.
- Use a metallic gas cup on the torch. Attach a 6000 volt lead with a .001 mfd mica-capacitor between gas cup and ground.