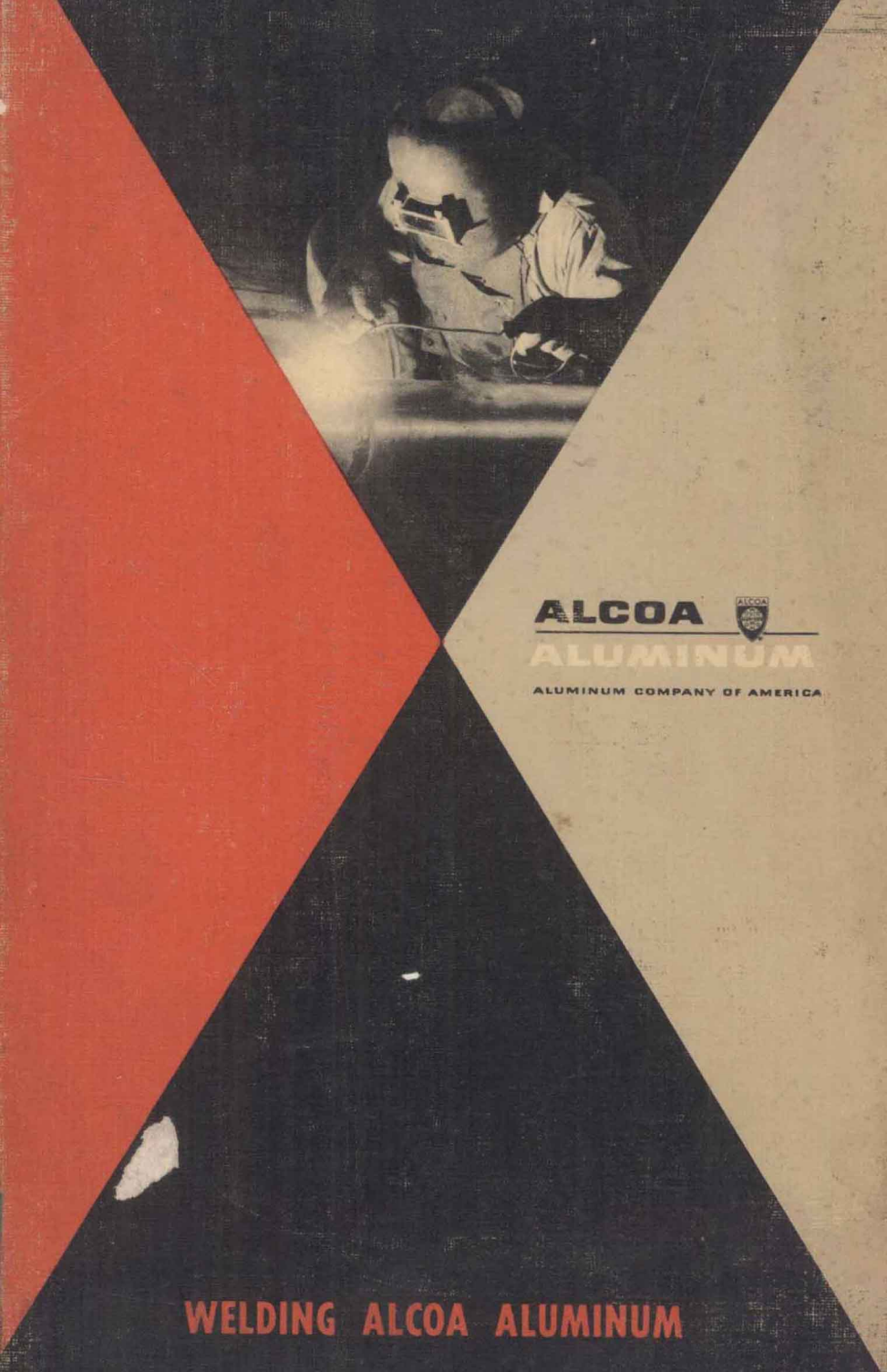

ALCOA ALUMINUM

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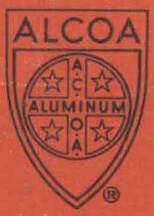
# WELDING ALCOA ALUMINUM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# WELDING ALCOA ALUMINUM

*Aluminum Company of America*

*Pittsburgh 19, Pennsylvania*

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## Foreword

During a fairly short time, many changes in the technology of welding aluminum alloys have occurred. New methods and improved techniques have reached commercial importance. At the same time, some of the pioneering methods have been relegated to narrower fields of application.

This booklet reflects such changes. In addition to basic, practical data on the individual processes, it includes information on choice of method to assist welding engineers, shop men and designers at that important stage in the job when decisions are being formulated.

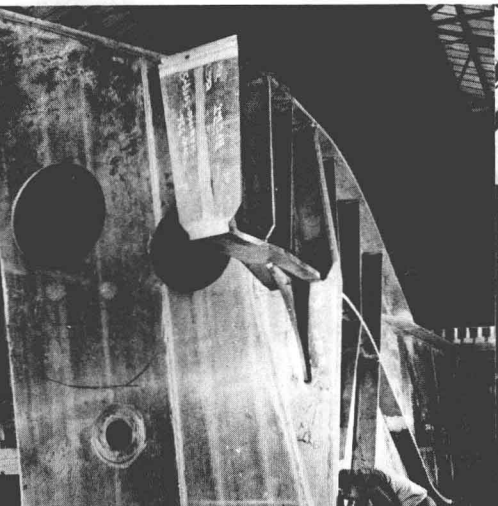
The predecessor to this booklet was titled *Welding and Brazing Alcoa Aluminum.* Now, brazing is treated separately in *Brazing Alcoa Aluminum.*

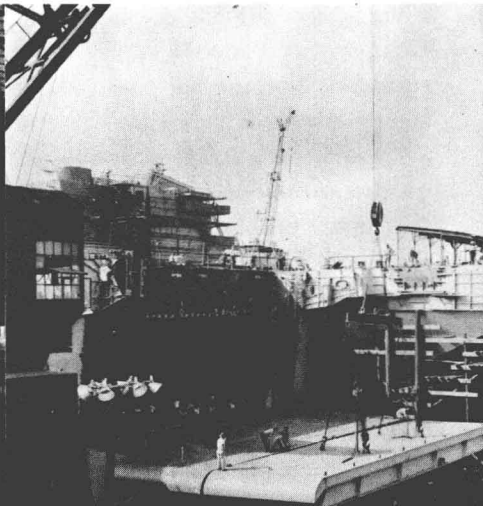
Some of the materials and methods discussed in this book are covered by patents or patent applications owned by Aluminum Company of America or by others, including welding equipment suppliers. Nothing herein should be construed as an invitation to use such methods or materials without proper arrangements.

Tabular data and descriptive text in this book should answer most routine questions about welding aluminum alloys. But we realize that many problems will still need individual attention.

We cordially invite you to get in touch with your local Alcoa sales office if you need further information or guidance. Our sales representatives will find a solution to your problem if they can. If not, they will call on Alcoa specialists and laboratory scientists to get the facts you need.

*This huge welded aluminum structure, for a flight deck elevator aboard a modern aircraft carrier, measures 52 by 62 feet. By employing welded aluminum construction, 114 tons of weight were eliminated in comparison to sister ships of the same class.*





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*Welding is one method used to join aluminum in today's aircraft.*

*Welding makes possible the development of graceful aluminum furniture.*

# 1

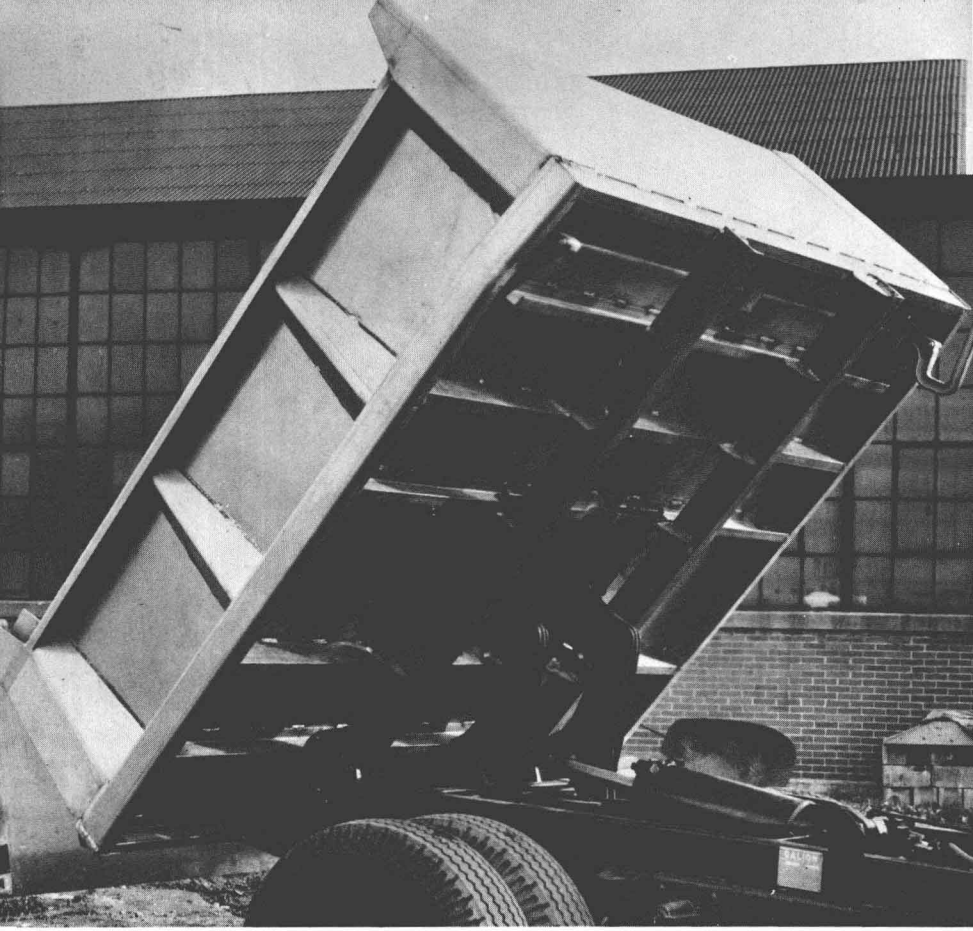
# Introduction to Welding Alcoa Aluminum Alloys

**Sound, reliable welds** have been made in aluminum alloys for many years. Welded joints are strong. Decades of service under widely different conditions can be cited to demonstrate their high quality.

Millions of beverage, food and chemical containers, cooking utensils, many kinds of pressure vessels, structural components, process equipment, tanks for railroad cars—examples of welded aluminum are almost everywhere. Resistance welding is a useful assembly method in aircraft manufacture—and in many other fields.

**Improvements have widened the scope of welding.** In the past, the nonheat-treatable alloys of aluminum were welded extensively. Now, the stronger alloys are welded too. Great strides have been made in overcoming difficulties with cracking, brittleness and loss of desirable mechanical properties.

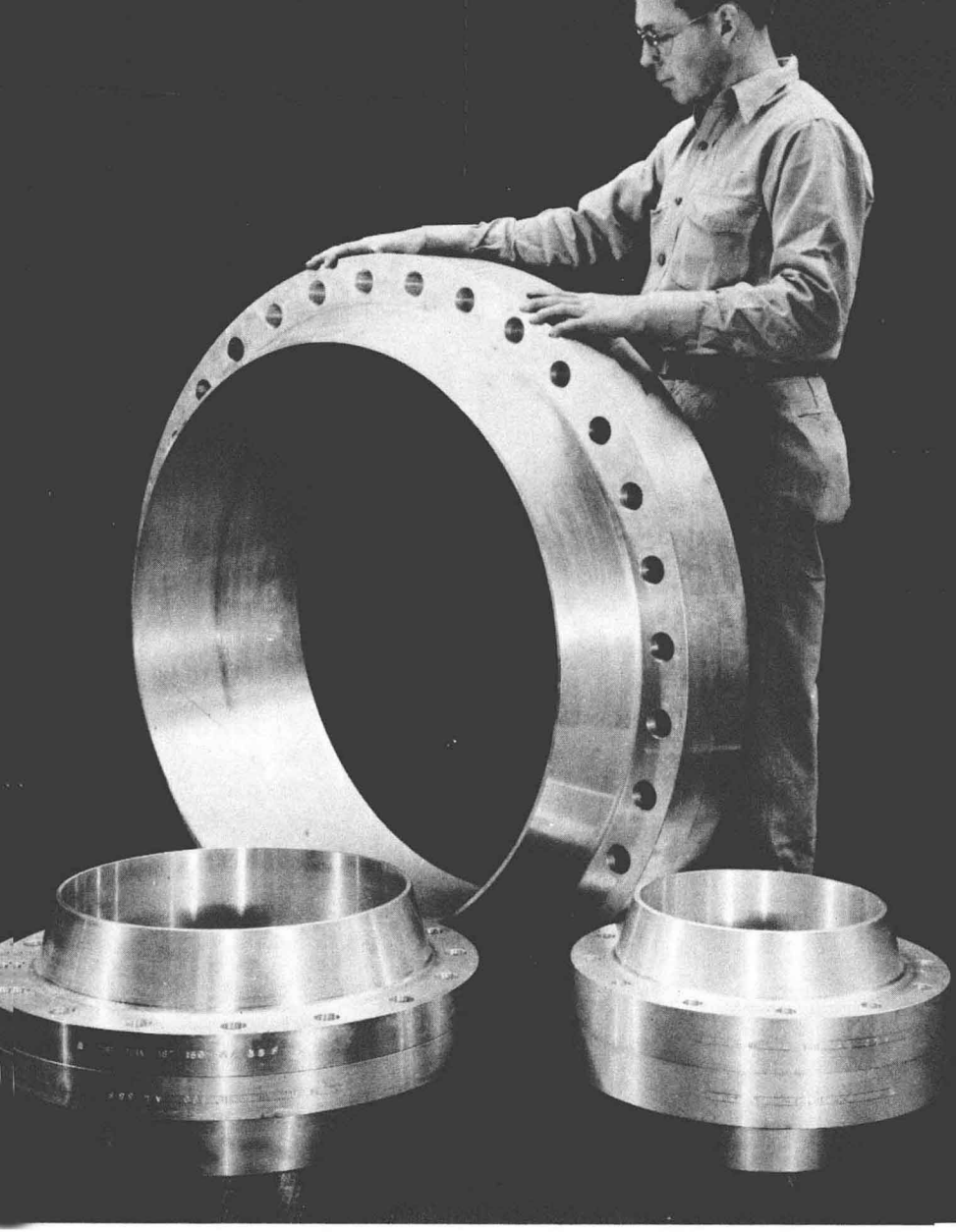
Now, new equipment and better techniques are available to bring more of the Alcoa aluminum alloys into the "readily weldable" category. At the same time, progress is still being made to speed up the operation, to eliminate unnecessary procedures, and to develop mechanized equipment for high-speed repetitive production. Because of continual process development, aluminum is now as easy to weld and as generally weldable as steel.



*A dump-truck body welded of aluminum stands up under abusive service conditions, and the weight it saves will make bigger loads possible every trip.*

Some of the advances involve arc welding—without flux—in an envelope of inert gas. Either a tungsten electrode or a consumable, aluminum alloy electrode is used. Resistance welding, too, continues to grow in importance. As the process becomes better understood it is applied more widely and successfully.

Gas welding was the pioneer method of welding aluminum and is used extensively today. Atomic hydrogen welding is employed for important aluminum welding jobs. A new method that involves no molten metal—pressure welding—may hold important commercial possibilities.



*Massive aluminum pieces, such as these pipe flanges, can be welded.*

*These aluminum utensils all have welded joints. Handles and bottom are welded on the tub, the handle on the milk can, leg brackets and handle sockets to the vegetable press, spouts on the coffee makers and coffee server, and the handle socket is welded to the frying pan.*

This book describes the various types of aluminum welding and provides technical and practical data. We hope the combination will be most useful.

Brazing—the companion method to welding—is the topic of *Brazing Alcoa Aluminum,* another book in this series.

### Where welding should be selected for making joints in aluminum

Before discussion of which welding method to choose, it may be helpful to outline briefly where welding itself offers greatest benefits. Here are some practical design considerations that may lead to the decision to weld a joint in aluminum instead of brazing, soldering, resin bonding, using rivets, bolts, special fasteners, or making other design provisions.

**Welds prevent leaks.** One of the easiest ways to make a permanent gas-tight or liquid-tight joint is by fusion welding or resistance seam welding. Hence, all kinds of aluminum tanks, pressure vessels, pipelines, containers, and the like are welded.

**Welds can be made in thick or thin metal.** Fusion welds can be made in material several inches thick without difficulty. Thin metal —less than 1/16 inch—is often fusion welded. Resistance welding is highly satisfactory down to foil gages. Bars, rods, wire and special extruded sections can be joined readily by fusion or flash welding.

The user has a wide choice of welding equipment and welding methods. He can set up to make one piece or tens of thousands. Simple, relatively inexpensive hand equipment will accommodate a wide variety of jobs—in the shop or field. On the other hand, modern aluminum welding methods lend themselves to complete automation. Jigs and assembly fixtures for simultaneous welding can turn out elaborate assemblies in mass production quantities.

**Speed and cost compete** with other joining methods when all-round performance is the basis for comparison. In each case, the actual cost depends on the kind of job and quantities involved.

**Welding is versatile.** Repair work, and maintenance, of course, are common occasions for welding aluminum. Equipment can be brought to the job.

## WELDING ALCOA ALUMINUM

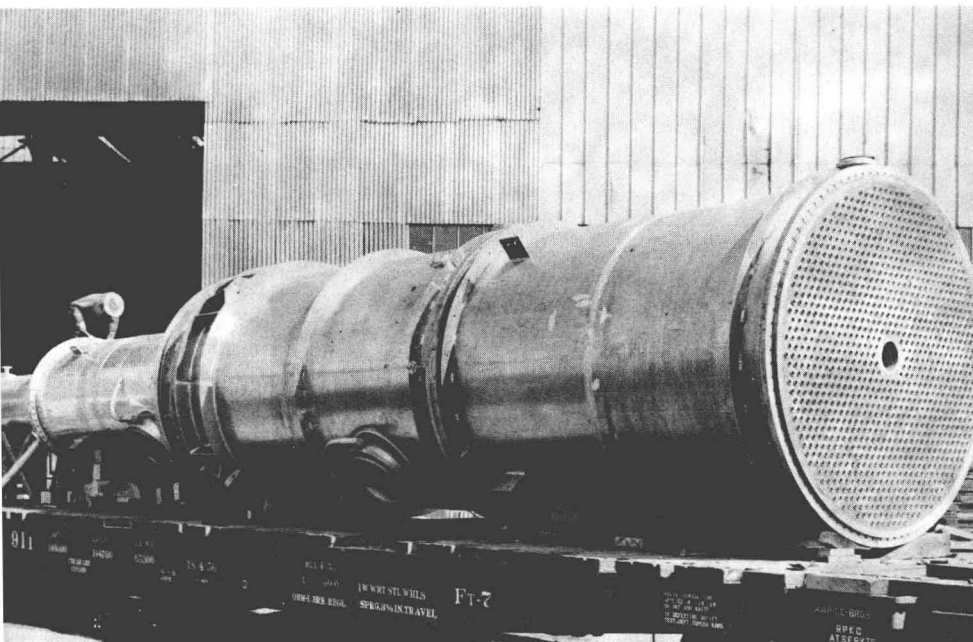
**Castings can be welded** as a production assembly method, as a foundry operation for minor modification and to correct defects, or as a repair procedure for restoring worn and broken parts to service.

**Resistance to corrosion is good** because both parent and weld metal are aluminum. Under severe conditions, special precautions can be taken to obtain satisfactory resistance to corrosion.

**Finished welds can be smooth.** Welding makes possible single-piece construction of complicated aluminum articles. A welded joint can be finished to match the parent metal. A ground and polished weld can be given an anodic finish along with other aluminum surfaces. Sometimes special procedures may be advisable to match colors.

**Welding saves material** and reduces the weight of many stressed assemblies. A butt weld is a symmetrical joint, and when finished smooth, it presents no stress-raising irregularities.

*This 53 foot long stripper column is an interesting application of welded aluminum used in the chemical industry. Metal thicknesses are from one-half inch through two inches.*



# 2

## Factors to consider when selecting a welding method

Aluminum can be welded by a number of processes. Many of these processes are used commercially. Each one has certain advantages. Here is a summary of the methods that are most likely to be of interest.

**Gas Welding** employs an oxyacetylene, oxyhydrogen or other fuel gas flame to melt parent metal—and usually filler metal—to make a weld.

**Metal arc** welding is the common process wherein the arc between a flux-coated electrode and the work heats both the electrode and the work, and deposits electrode metal to form a weld bead.

**Carbon arc** welding utilizes an arc between a carbon electrode and the work for heat. Added filler metal is usually provided.

**Atomic hydrogen** welding is done with a special torch that maintains an arc independently of the work. Heat is conveyed to the weld by molecular breakdown and recombination of hydrogen that flows through the arc.

**Inert gas tungsten** arc welding uses heat from an arc between the work and a nonconsumable tungsten electrode. The arc is enveloped by a stream of inert gas. No flux is needed.

**Inert gas consumable** electrode welding is metal arc welding that employs an automatically-fed, bare electrode. The arc is enveloped by a stream of inert gas. No flux is needed.

**Spot welding** is a resistance welding method that forms localized areas of cast metal between work pieces by combining the heat of resistance to electric current with the application of mechanical pressure.

**Seam welding** is a special form of spot welding in which a row of spots is made with precise control so that the welds can, if required, overlap to form a pressure-tight seam.

**Flash welding** applies heat by establishing an arc between the pieces to be joined. Then they are forced together at a predetermined rate to squeeze out the excess molten metal and to consolidate the joint.

**Pressure welding** is done by applying pressure to suitably prepared surfaces below the melting point of the parts.

**Percussion welding** is a method used for joining aluminum studs to sheet. Energy is stored in condensers and released as the stud approaches the sheet.

### Selection of method is based on many considerations

The conditions that influence a choice of method will be familiar to experienced welding engineers. Not necessarily in the order of importance they include:

—thickness and size of parts
—location and position of weld
—number of similar welds
—production rate required
—investment in welding equipment
—finish and appearance desired
—type of aluminum alloy

The choice of method sometimes depends upon the filler wire necessary to produce the desired results. Tables 31 and 32, page 175, describe the welding processes applicable for each filler metal and the alloy combinations with which each filler metal is commonly used.

**Thick sections** that require multiple passes to form a bead are best welded with an inert gas shielded arc using a consumable elec-

trode. Sections of moderate thickness—for example, between 1/16 and 3/16 inch—can be welded by any of the commercial processes. Resistance spot or seam welding is used successfully with metal thicknesses from foil up to 3/16 inch. Pieces up to 1/2 inch thick are being spot welded experimentally. See Table 1.

**Metal Thickness Ranges for Commercial Welding Practice**

*Table* **1**

| Welding Method | Minimum metal thickness, inch | | Maximum metal thickness, inch |
|---|---|---|---|
| | Experimental | Ordinary practice | |
| Inert gas shielded consumable electrode | .032 | .093 | ① |
| Inert gas shielded tungsten electrode | .025 | .051 | 1 |
| Gas | .025 | .051 | 1 |
| Atomic hydrogen | .025 | .051 | 1 |
| Metal arc | .064 | .125 | ① |
| Spot | — | foil | 3/16② |
| Seam | foil | .010 | 3/16 |

①No limit imposed by the welding process. While any practical thickness can be welded, most experience so far has been on pieces up to 3 inches thick.
②Experimental procedures have been developed for metal up to 1/2-inch thickness.

**Location** of welds will affect the choice of welding method, depending on whether work is done in shop or field and on the welding position for individual joints.

Gas welding equipment is highly portable. Resistance welding equipment, on the other hand, is usually permanently installed. Metal arc welding requires only a standard motor-driven dc welding generator. Inert gas shielded methods require a gas supply plus more elaborate welding machines.

Inert gas shielded arc welding can be carried out in all positions, including overhead. Other fusion methods depend on floating oxides out of the weld as slag, and they are limited to the downhand, horizontal, and—sometimes—vertical positions.

**The number of similar welds** to be made or the number of similar pieces to be handled influence tooling in general. Mass-production