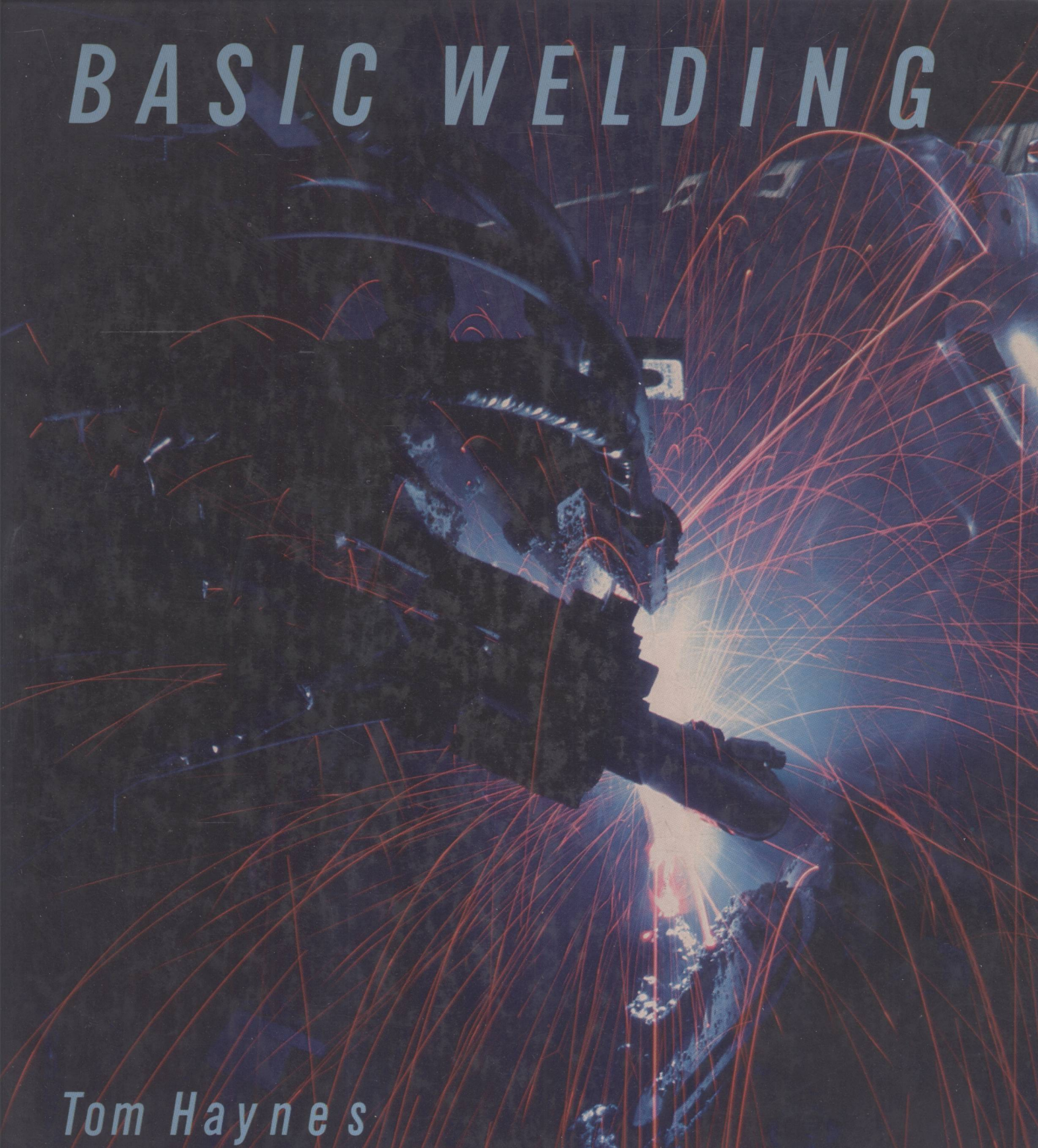
BASIC WELDING



Tom Haynes

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Tom Haynes

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BASIC WELDING

I wish to dedicate this book to my wife, Marjorie, for her patience and support during the writing of this book, and for everything else.

I would also like to thank the following members of the staff of McGraw-Hill Ryerson. To Joerg Klauck, for his confidence and support from inception, Brian Henderson, for his help and guidance, and Norma Christensen for her help in keeping track of all the pieces.

I would also like to thank my typist, Verna Kuzyuk, for the excellent work she did.

Tom Haynes, 1987

INTRODUCTION

There are many textbooks on welding and allied processes, but there are few that are designed specifically for welding courses. They are either too advanced or too simple.

This text is designed to cover most of the work in basic welding courses, and in the many other areas in schools, colleges, and universities that cover welding as a part of their course of studies.

It is essential that those learning a practical skill should also understand clearly the theoretical basis of the subject. In this way they more readily appreciate the reasons for doing certain operations, or for doing them in a particular way, and the consequences of not following the proper procedure. In addition, the student should understand the "why" of processes as well as the "how" of practical work.

Each year, complex and sophisticated welding advances are made, and the need for knowing more about these processes increases.

There are very few areas where welding, in one of its many forms, does not contribute to the ease and quality of construction. Changes in industrial demand for special alloys require the welding engineer and chemists, metallurgists, etc., to design processes, electrodes, fluxes, and procedures to produce high strength welds in these alloys for domestic, automotive, industrial, civil, marine, and space applications.

The contents of this text are divided into units that contain a topic or a series of related topics that will fit most course outlines. In addition to Unit 1 on safety, the subject is also dealt with in other units where applicable.

The welding industry is beginning the process of converting to the metric system, and its plan is simply to convert existing sizes and quantities from Imperial to metric. Both systems of measure have been included in the text. This will help the student who has been taught the metric system but will, for a number of years, have to work with equipment graduated in the "old system," and read technical information from various sources that is not in metric.

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U · N · I · T 1

SAFETY

Safety is an aspect of any occupation which cannot be overstressed. No matter what the area of work, there are certain dangers. The student should be aware of them and know how they can be avoided.

Do not rely on others — check your own area and equipment before you start.

GENERAL SHOP PRECAUTIONS

1. Hold back long hair, under control, when using spindle-type machines such as drills, etc., and when using flames.
2. Wear goggles when grinding, welding, chipping, or working overhead.
3. Do not work on electrical equipment unless it is unplugged or isolated at the switchboard and labelled.
4. Do not work beside stoves or welding benches with disposible lighters in your pocket.
5. Take care when handling sharp or long objects which may cause injury.
6. Make sure work is not hot before grasping it. If you leave hot work on your bench or floor, mark it "hot."
7. Use tongs or pliers to carry work, not gloves, since they may burn through, which may damage you as well as the gloves.
8. Turn off all equipment when finished — do not leave operating equipment unattended.
9. Be aware of the location of firefighting equipment and how and where to use it.

GAS WELDING

1. Check for gas leakage before lighting the torch.
2. Turn off all valves when not in use.
3. Do not leave a burning torch unattended.
4. Have a good exhaust system operating.
5. Wear goggles to protect your eyes. Use a #5 filter for general welding.
6. Wear protective gloves, apron, etc.
7. Do not use oxygen from the torch to "blow down" with (it increases combustibility of clothes).
8. Do not use copper on acetylene pipelines — it can cause an explosion.
9. Do not use oil or greases on gas pipelines — they may cause an explosion.
10. Do not breathe oxygen from the torch — it is dangerous.
11. Take care when handling the torch — flame temperature approximately 3250°C.
12. Protect hair from heat and sparks.
13. Do not look at arc welding using gas welding goggles or sunglasses.
14. Use a spark lighter to light the torch, not matches, or another torch.
15. Do not turn around quickly with a lighted torch in your hand.

ARC WELDING

1. Do not ground yourself (connect yourself into the circuit).
2. Make sure insulated parts are in good condition.

3. Avoid wet conditions — even perspiration can cause a greater risk of shock.
4. Turn off equipment when finished, or when moving it from place to place.
5. Wear a welding helmet when arc welding. Use a #10 filter for normal welding.
6. Have a good exhaust system operating.
7. Wear a filter mask or respirator if necessary.
8. Wear protective equipment such as leather gloves, apron, etc.
9. Place protective screens around the welding area to protect others.
10. Take care when handling arc welding equipment — chance of shock and burns.
11. Remove electrodes from holder when finished, and hang up the holder.
12. Keep the weld area clear to prevent tripping or grounding.

FIRE HAZARDS

1. Welding and gas cutting can splash or spray sparks and hot metal great distances.
2. Check the area for dangerous situations before starting, and have someone watching.
3. Welding or cutting on a dividing wall may burn or damage materials on the other side, so check the area.
4. Keep hose and cylinders clear of sparks or hot metal from cutting and welding.

USED CONTAINERS

1. If these have contained flammable substances or chemicals, do not weld them.
2. If a used container must be repaired, take it to a specialist; do not attempt to repair it yourself.

Welding on this type of container can cause an explosion or the release of toxic fumes. Even containers left open for long periods or blown out with air are not safe.

The specialist will steam out or chemically neutralize the contents, and then fill the container with water, inert gas, nitrogen, or carbon dioxide, with the repair area at the top, before attempting to weld it.

CYLINDER STORAGE AND USE

1. Oxygen and some other gases may be compressed to 17 240 kPa (2500 psi), so care must be taken when handling them. DO NOT DROP THEM!
2. Do not use gas cylinders as rollers or supports.
3. Do not move them about without the protective cap, unless they are in a proper cylinder truck.
4. Oxygen and acetylene cylinders must not be stored in the same area.
5. Full and empty cylinders should be kept separate.
6. Storage spaces must be ventilated.
7. Cylinders not in use or in trucks should be chained so that they will not fall.
8. Do not lift or sling cylinders by the safety cap.
9. Keep cylinders away from welding and cutting processes.
10. Keep cylinders away from extreme heat, electrical outlets, etc.
11. Do not use undue force on the valves, and check them for leakage when in use.
12. If a cylinder is damaged or leaking and it will not stop when the valve gland is tightened, remove it to a safe, open space. Fence off the area and post "no smoking" — or "naked light" sign, open the valve gently to release the gas, and notify the supplier at once.

QUESTIONS

1. List as many precautions as you can, from memory, under the following headings: (a) explosive conditions, (b) fumes, (c) personal protection, (d) care of gas cylinders, (e) storage of cylinders, (f) heat and sparks, (g) effects of gases, (h) cylinder use, (i) arc radiations, (j) shock hazards, (k) used containers, (l) safe shop habits.

U · N · I · T 2

BASIC EQUIPMENT

PROTECTIVE EQUIPMENT

When gas welding, the operator may be subjected to heat, sparks, and the bright light from the process. It is important that the welder is protected from these hazards by making use of the equipment made available.

Welding Goggles: The light which comes from the flame and white hot metal can cause eye strain and discomfort. In addition, although the sparks given off under normal welding and cutting conditions are small, those which may be produced by **backfire** are large and extremely dangerous, and could cause serious eye damage.

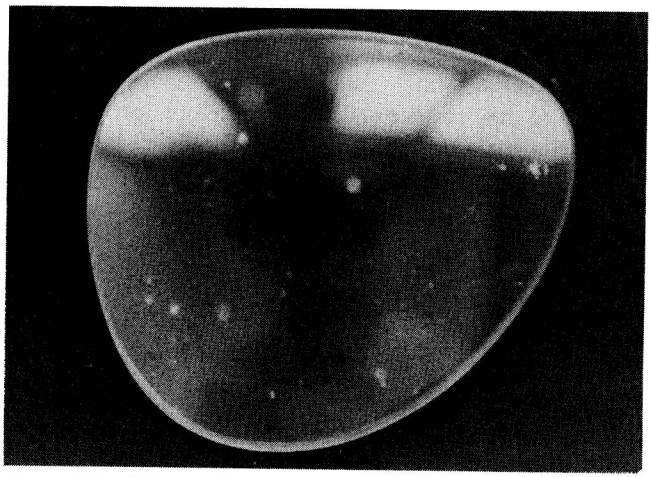


Figure 2.1 Effects of spatter on lens, due to backfire.

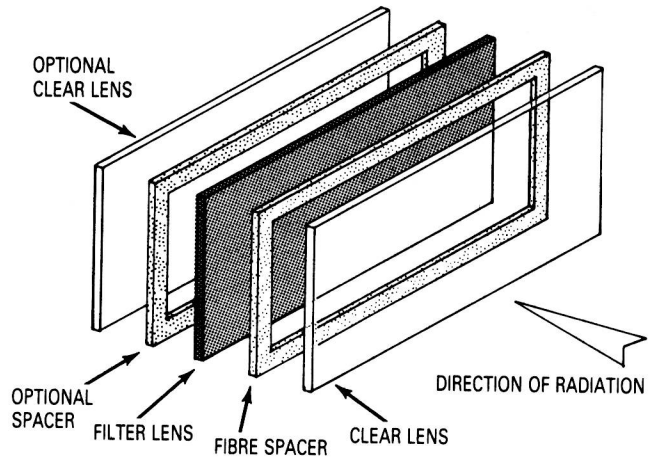
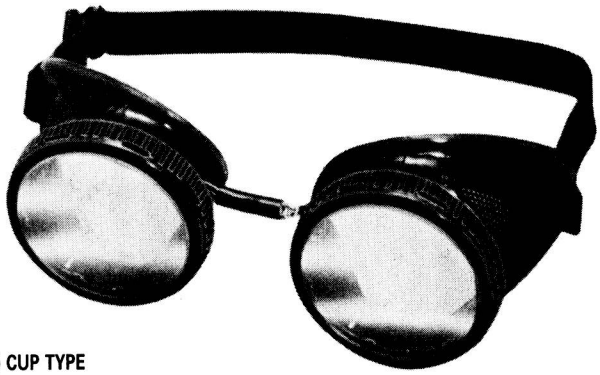


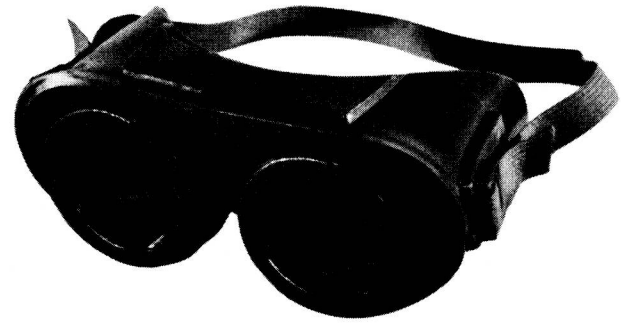
Figure 2.2 Lens assembly.

The goggles vary greatly in design and material but are normally made of plastic and designed to hold a suitable **filter lens** and **cover plate** (Figure 2.2). An elastic head band is fitted and can be adjusted to suit requirements (Figure 2.3).

The filter lens is of optical quality and may be solid, green, or blue tinted glass or of a laminated design. Since the lens is expensive, it is usually protected by a disposible clear glass or plastic **cover plate** which can be discarded

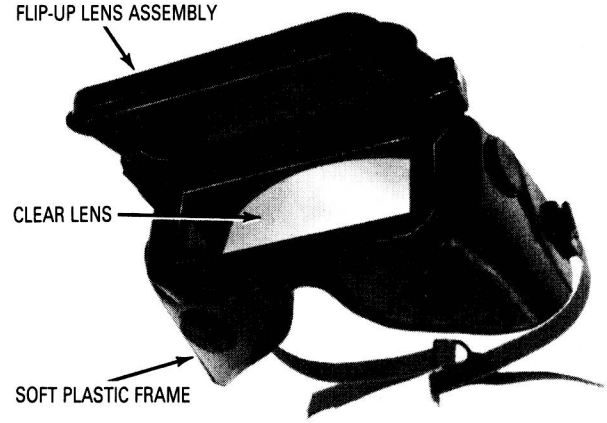


(A) CUP TYPE



(B) COVER GOGGLES

(C) "FIXED FRONT" PLATE TYPE



(D) "FLIP FRONT" COVER GOGGLES (PLATE-TYPE LENS)

Figure 2.3 Goggles

Courtesy of L-TEC Welding and Cutting Systems

when damaged by spatter, etc. A fibre spacer may be placed between the clear and filter lenses.

For normal gas welding and cutting, a #5 lens is suitable, but for heavy gas welding and cutting a #6 may be more suitable.

Goggles may be of the "cup" design which holds 50 mm (2 in.) lenses (Figure 2.3 A,B) and covers, or the one-piece type holding a 50 × 108 mm (2 in. × 4 1/4 in.) lens and cover (Figure 2.3 C,D). These may also have a "flip-up" lens unit to allow normal viewing through a clear lens.

Gloves: To protect hands from heat and sparks, gloves or gauntlets of leather or other non-flammable material should be worn. For light welding, many welders dispense with them because of difficulty in handling the filler metal and torch valves, etc. (Figure 2.4).

Apron: Wear a leather apron, especially if welding in position or if sitting while welding. This will reduce the chance of burns to the operator and his or her clothing.

Caps: Some welders wear caps or "beanies" to prevent burns to the head and to keep the hair clean. These are of great value when welding overhead or in the case of a backfire.

GENERAL EQUIPMENT

Spark (friction) lighters: Since it is dangerous to try to light the torch with matches, other torches, or disposable lighters, the welder should use a flint-type spark lighter. The **lighter** (Figure 2.5) is about 90 mm (6 in.) long, which

Courtesy of Fibre-Metal Canada Ltd.

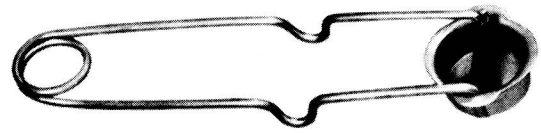
Figure 2.4 Welder's gloves.

keeps the fingers well away from the flame. Flints are replaceable at low cost. (Reports of injuries to operators due to explosion of disposable lighters include one death.)

Wrenches: It is important that the correct size and type of wrench is used on all fittings, tips, and tip retaining nuts, etc. (Figure 2.6). This prevents damage to parts which are not easily replaced, which may necessitate sending the part away for repair.

QUESTIONS

1. Describe how and why eyes are protected during gas welding.



Courtesy of L-TEC Welding and Cutting Systems

Figure 2.5 Friction (spark) lighter.

Figure 2.6 Wrenches.

2. Explain the lens assembly for gas welding goggles.
3. Why should gloves be worn during welding?
4. Of what kind of material are welding gloves made?
5. Describe other protective equipment which may be worn while gas welding.
6. What is a friction lighter, and why should it be used?
7. Why should a welder not light his torch with matches, or another flame?
8. Why should disposable butane lighters not be used near welding processes?

U · N · I · T 3

GASES

TYPES OF GASES USED IN WELDING

The gases used in gas welding and cutting processes are normally **oxygen**, with **acetylene**; but **MAPP**, **propane**, **natural** (town) **gas**, and **hydrogen** are sometimes used for flame cutting and heating.

OXYGEN

(Symbol O, usually O_2). This gas is normally found in a free state as the molecule O_2. It is present in the earth's crust in rocks as 47%, it constitutes 85.8% of the oceans, and about 21% of air. As a gas it is colourless, tasteless, odourless, and non-toxic, and supports life and combustion.

Oxygen may be obtained in the pure state by (a) chemical reaction to release it from a high oxygen compound; (b) by electrolysis — or passing electricity through an electrolyte (a mixture of water and acid), causing the water (H_2O) to break down into hydrogen and oxygen which may be collected separately; (c) by breaking down the mixture of air, which is called **fractional distillation** and is the commercial method of production.

FRACTIONAL DISTILLATION (LIQUID AIR) PROCESS

1. Air is cleaned, dried, then cooled and compressed until it becomes liquid at about $-200°C$.
2. The liquid air is passed through a complicated process which in effect "boils off" each gas from the liquid air, each gas separating at its particular boiling point:

   Nitrogen at $-196°C$ (approximately 78%)
   Argon at $-193°C$ (approximately 1%)
   Oxygen at $-186°C$ (approximately 21%)

   There are also traces of **carbon dioxide**, **neon**, **helium**, **krypton**, and **xenon**, which make up about 0.04% of the air in total.
3. Each gas is led off as it is produced, and stored in the liquid or gas forms.

Oxygen is used for many applications, such as the production of many useful compounds in the chemical industry, **liquid oxygen** (LOX) for the propulsion units for space and military rockets, **medical oxygen** for hospitals and rescue services, **oxygen-helium** mixtures for deep sea diving, to prevent the "bends," and most important, for us to breathe.

When oxygen comes into contact with most substances, they combine to produce **oxides**. This does not happen with the inert gases. Metals are easily oxidized, and in some cases produce a useful, protective oxide as in the case of aluminum, and chromium alloys, such as stainless steel. In most other cases it is not helpful and in the case of iron and steel it is very destructive, as can be seen by rusting cars and other steel constructions.

Rapid oxidation is usually accompanied by the generation of heat, as in **combustion**, or burning. In gas welding this is valuable in producing an extremely hot flame, and in gas cutting where, in addition to the hot flame, the oxygen is

used to cut the steel. In welding, oxidation is used in a special process called **Thermit welding** where the extreme heat produced by a chemical reaction melts the parts to be joined.

ACETYLENE

Acetylene (C_2H_2), also known as ethyne, is a colourless, tasteless, and in the pure state, an odourless, slightly toxic gas, which has been used as an anesthetic. The reason that the acetylene used in welding has a strong odour is that it contains impurities, which do not effect the welding process.
Production: Although acetylene may be produced in other ways, such as passing hydrogen through a carbon arc, the commercial method is by the reaction of water with calcium carbide. The reaction or production equation is shown below:

$$CaC_2 + H_2O = C_2H_2 + CaO$$

or

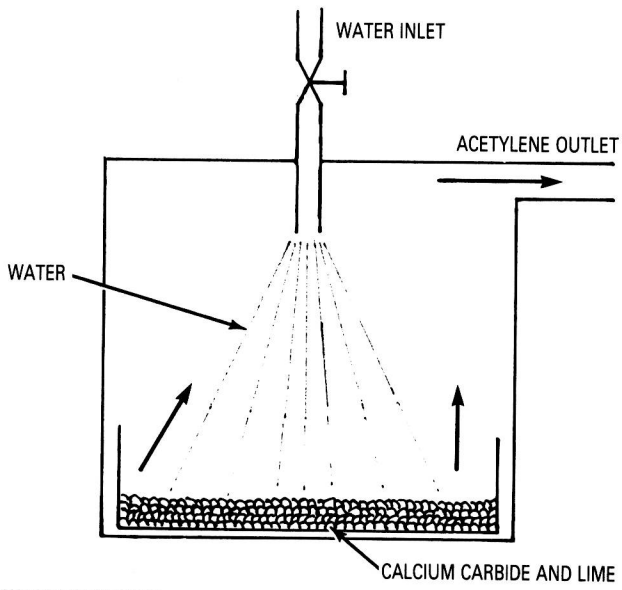
$$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$$

calcium carbide + water = acetylene + lime (hydrated)

CaO is lime and $Ca(OH)_2$ is hydrated lime.

GAS GENERATORS

There are two basic methods of production, which are shown in simple form in Figure 3.1.



(A) WATER TO CARBIDE

Figure 3.1 Acetylene generators.

The actual units, or **generators**, may be low pressure or medium pressure according to design, although most modern generators are medium pressure.

Low pressure or bell-type generators produce acetylene at up to 14 kPa (2 psi) and are somewhat like the large gas storage units in some cities. They may feed a pipeline where only low pressure or injector-type torches are employed.

Medium pressure generators produce acetylene at up to 100 kPa (15 psi) and may feed one torch or a pipeline system, where either low pressure or equal pressure torches may be used.

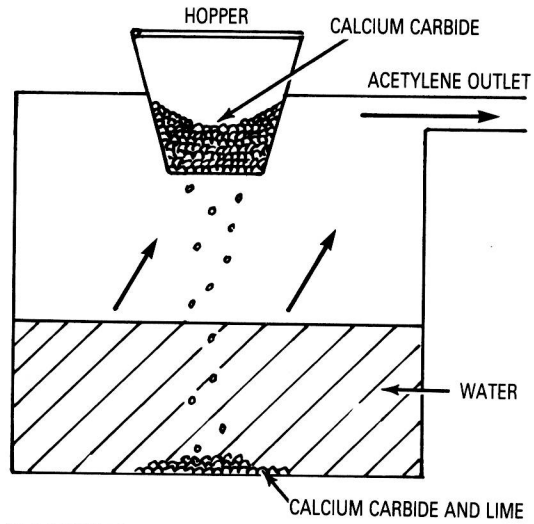
Acetylene obtained and used from a generator is called **generated gas**, but when it is taken from the generator and stored under pressure, dissolved in acetone, and supplied in steel cylinders, it is called **dissolved acetylene**. This is the most common method of obtaining acetylene.

USES OF ACETYLENE

Apart from welding processes, acetylene is used as fuel for emergency lighting units where electricity is not available. In addition, it is used in the manufacture of many kinds of plastic.

EXPLOSIVE RANGE

Acetylene is the most explosive gas used in industry, and may explode in a range of 3 to 80% in air. It will also react



(B) CARBIDE TO WATER

with copper and brasses with more than 70% copper to form an impact explosive, copper acetylide. Combined with oxygen, it produces the hottest flame (3250°C).

To complete the list of dangers which may be encountered with acetylene, it is very unstable in the free form, and the compound may break down, or decompose, under pressure. Although the disassociation pressure is 164 kPa (23.8 psi), it is not to be used at more than 100 kPa (15 psi) in the free state.

QUESTIONS

1. List five gases used in welding and allied processes.
2. State the properties of oxygen.
3. What are the three methods of producing oxygen?
4. State the three steps in producing oxygen commercially.
5. List the three main gases in the air, and give their boiling points and approximate percentages.
6. State three uses for oxygen, other than welding and cutting.
7. Why does oxygen give a hotter flame with a fuel than air does?
8. State the chemical symbol or formula for oxygen and acetylene.
9. How is acetylene produced?
10. State the simple form of the production equation for acetylene.
11. What are the two basic methods of producing acetylene?
12. What is an acetylene generator?
13. Why does acetylene have a strong odour?
14. What is the explosive range of acetylene in air?
15. Why should acetylene not be used at more than 100 kPa (15 psi)?