ELectricity is used in industry to join together metal parts by welding. There are two principal methods of electric welding: arc welding and resistance welding. Air is normally a very good insulator and resists the passage of electricity through it; in fact, many thousands of volts may be needed to pass an electric spark through an air gap only several inches long. If, however, the air is “ionized,” or rendered conducting by metallic vapour, a much lower voltage will pass current through it, the resulting electrical discharge being called an arc. An arc can be described as a luminous discharge of current through a conducting gas and appears as a yellow or white light which burns at a few thousand degrees Centigrade. The arc welding plant utilises this high temperature to fuse together the metal parts. Arc welding is carried out by means of a generating or transforming plant capable of supplying current at about 70 to 100 volts, and either direct or alternating current can be used. A high current value is required for arc welding, varying from about 50 amperes for a small plant to several hundreds of amperes for a plant capable of welding together thick pieces of metal. A flexible cable from one terminal of the plant is clamped or bolted to one of the metal work pieces, whilst the other terminal is connected to an electrode holder which the operator manipulates with his hand. Various types of electrode can be gripped in this holder as required by the work in hand. In order to start the arc the operator touches the electrode on the work piece so that a “short circuit” path of low resistance is provided between the terminals of the welding plant; this allows a heavy current to flow from the electrode to the work piece. As the electrode is drawn away again, the gas on the electrode and weld piece becomes “ionized,” that is, the molecules of air become electrically charged and move rapidly at high velocity, conducting electricity from the electrode to the work piece. The electricity thus produced continues to flow in the air across the arc. An arc of about 4 to 5 inches long is used with a carbon electrode; if the arc is too short the metal is liable to “bore” and absorb carbon; whilst if the arc is too long the metal may become oxidised.

The next stage in the evolution of arc welding was the introduction of metal electrodes, which are used with either direct or alternating current. With such electrodes no added metal is necessary, as the electrodes are of suitable composition and the metal is gradually projected direct into the weld. Later on covered metal electrodes were introduced. One type of electrode has a wrapping of blue asbestos through which runs a fine aluminium wire. When the arc is struck the wrapping fuses to form a protective slag round the arc, which has a cleansing effect on the molten weld, that slag being easily removed when the weld has cooled.

**Atomic Hydrogen Welding**

A new form of arc welding, which has originated in America, is called Atomic Hydrogen Welding. A fairly long fan-shaped arc is produced between the tips of tungsten electrodes which are fed with alternating current. With such electrodes gas is blown through the arc and absorbs heat which causes the molecules of gas to become dissociated, or parted, into atoms. As the atomic hydrogen passes to the cooler regions it recombines into its molecular state, and in so doing releases the heat which it received from the arc during dissociation. A small zone of high temperature is produced at a spot about half an inch in front of the tungsten arc, this being used for welding with a filler rod of uncoated wire to provide the necessary added metal. An electric arc is inherently unstable, that is to say, it is not self-regulating. Suppose the operator is using a metallic electrode with an arc about three-sixteenths of an inch long and happens to bring the electrode within about one sixteenth of an inch of the work piece. If the supply voltage is steady the result will be that the arc current will increase due to the reduction of the arc, more metal will be melted and a greater quantity of metallic vapour produced, which will still further increase the arc current, and so on. In order to enable satisfactory welding work to be carried out with a direct current operator, it is necessary to use a supply plant which has what is called a “falling characteristic” to compensate for the arc instability. In other words, the plant is designed so that the voltage across the arc falls if the current should increase, and this tends to keep the arc current within limits.

**A.C. Working**

Alternating current welding plant is quite simple. A transformer, which is usually immersed in a tank of oil to keep it cool, is required to step down the supply voltage to about 100 volts, as most supply systems operate at a higher voltage. The transformer may have extra connections so that sixty or seventy-five volts may also be used. The voltage obtained from this transformer is fairly steady and does not vary much, with the load change, so it can be used to weld through a choke coil or reactor before reaching the electrode the desired regulating property is obtained. The choke coil is only suitable for alternating current. It has a laminated iron core which is magnetised by alternating current passed through a coil of wire round the core; when the coil current increases, due to a shortened arc, an opposing or reactive voltage is generated in the coil which reduces the voltage available at the arc. The choke can be regulated so that it is suitable for various welding loads. This may be done in one of three ways: by sliding the iron core further into the coil to reduce the arc voltage, and vice versa; whilst in another type of choke it is effective by using a switch on various terminals to control the number of turns of the coil which are connected in circuit.

**D.C. Operation**

A quite different type of plant is required for use with direct current. Arc welding could be carried out from a steady direct current of about 100 volts if a resistance were connected in series between the supply and electrode to perform a similar purpose to the choke steel. As the arc voltage would be reduced with increased current to stabilise the arc. As most direct current supplies exceed 100 volts, however, it is usual to use a special type of direct current generator for arc welding; this can be driven by any sort of engine or electric motor. Such generators are designed with a particular type of field windings to provide the “dropping characteristic,” and this enables welding to be carried out without loss of power which would occur in a series resistance. The terminal voltage of a direct current dynamo, which is driven at a constant speed, is practically proportional to the magnetic strength of the field magnets. One type of welding dynamo has a shunt field winding, which maintains a constant field strength so long as the dynamo-