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Western Flying

WELDING MAGNESIUM

The recently developed heliarc process opens new aircraft possibilities

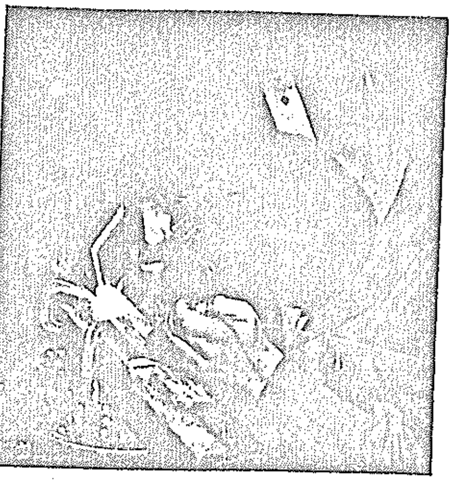
THE use of a new material for aircraft construction, a material which is available in inexhaustible quantities, has been made possible by a new method of arc welding developed during two years of research by Northrop Aircraft, Inc. Known as "heliarc welding," this new process permits the welding of magnesium sheets, extrusions and tubing into structures which are lighter, simpler and stiffer than has been heretofore possible in conventional duralumin construction.

The men chiefly responsible for this contribution to the aviation industry and the war effort of H. V. Pavlecka, chief of research at Northrop, and Russ Meredith, welding engineer. Together with other men in the Northrop organization, they have developed heliarc welding which now is being made available to all war industries.

The use of magnesium welded structures eliminates the hundreds of thousands of rivets that go into the conventional plane. Rivet heads on the fuselage and wings, even though countersunk, produce resistance to passage through the air, or "parasite drag." At high speeds a substantial portion of the engine power is used to overcome this parasite resistance. In the future, welded magnesium aircraft can be finished just as smoothly as a fine automobile, presenting to the airflow a perfectly uniform and rigid surface.

While magnesium has been used for some time in the aircraft industry for engine parts, wheels and accessories it has never before been used extensively as a primary construction material because of the difficulties in fabricating. The Northrop "Heliarc" welding process makes possible the all-magnesium plane with its many advantages.

Magnesium is the most abundant metal on the earth and in the ocean. Indeed, about 15 per cent of all the dissolved solid matter in the sea consists of magnesium chloride and magnesium sulfate —enough to cover all the land areas of the earth to a depth of 60 or 70 feet or 9,000,000,000 pounds per cubic mile. The mother liquors from the brine of salt wells are always rich both in magnesium salts and bromides. Nearly all the silicate rocks of the earth's crust contain notable quantities of magnesium. Some of these are of commercial importance; examples are talc, soapstone, and asbestos, cement and marble. The cost of magnesium alloys at the present

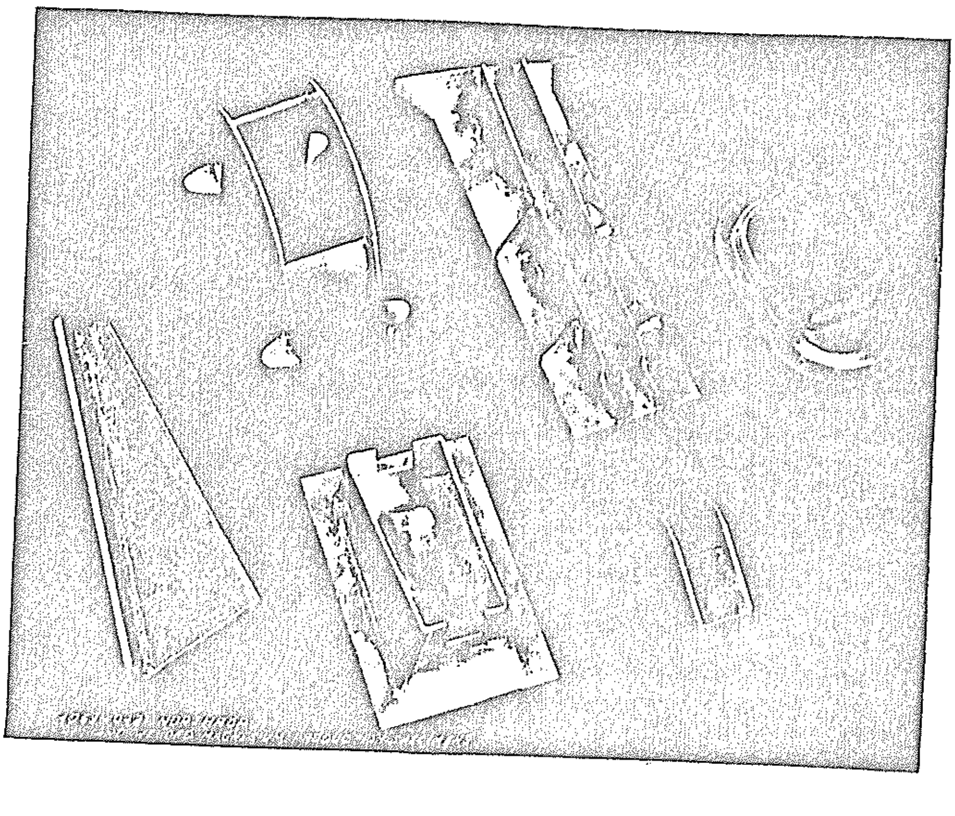


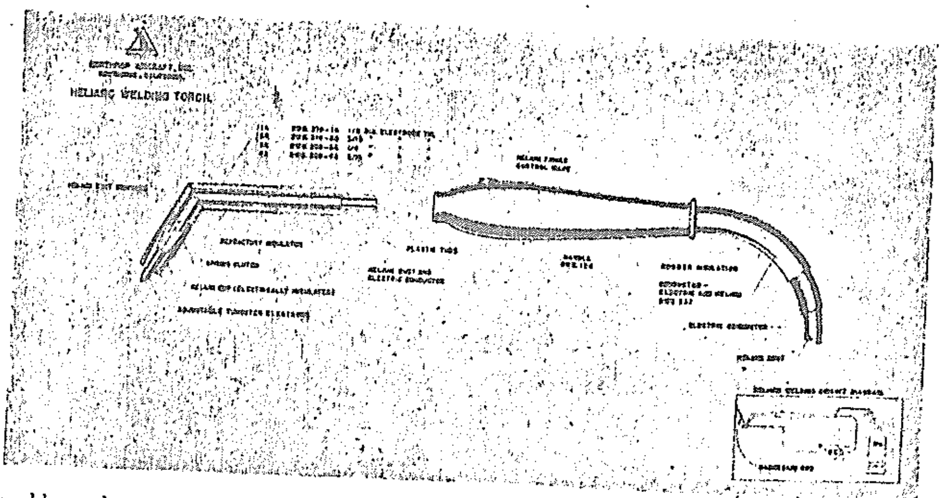
time is greater than aluminum alloys. However, because of new magnesium plants under construction and increased production in the plants now in operation, magnesium alloys will be cheaper than aluminum alloys in a very short time. 24,000 kilowatt hours are required to produce a ton of aluminum from Bauxite and only 18,300 kilowatt hours are required to produce a ton of magnesium, which has 54 per cent more volume. Magnesium alloy will shortly be the most plentiful alloy if it is not at the present time. The world's largest deposits of Brusite, a magnesium bearing ore are in Montana, Washington and British Columbia.

Contrary to popular belief, magnesium alloys are not inflammable when properly processed; in fact they are more resistant to direct flames than aluminum alloys. Although magnesium alloys are 35 per cent lighter than aluminum alloys and 21 per cent of the weight of steel per unit volume, their weight strength ratio is comparable to aluminum alloys, and they possess the design property of stiffness and rigidity that cannot be obtained in other alloys. With these properties of magnesium alloys in mind, together with the rapid production method of attachment and aerodynamic advantages which Heliarc welding presents, the future use of magnesium alloys for the fabrication of structures, especially in aircraft, should be greatly enhanced.

Magnesium castings containing foundry defects have been repaired with this process and welds equal to or stronger than the surrounding metal have been obtained. The weld metal is much more dense than that of the surrounding cast and far less susceptible to corrosion. Almost any thickness of cast metal that can be poured may be readily welded with this process.

A welding rod of the same alloy as the parent metal is usually used for castings and wrought alloys. The weld ingot appears to have better corrosion-resistant properties than the parent metal in salt spray tests. The weld bead appears to be cathodic to the adjoining metal, which causes minor pitting of the original metal adjacent to the





weld under severely corrosive conditions.

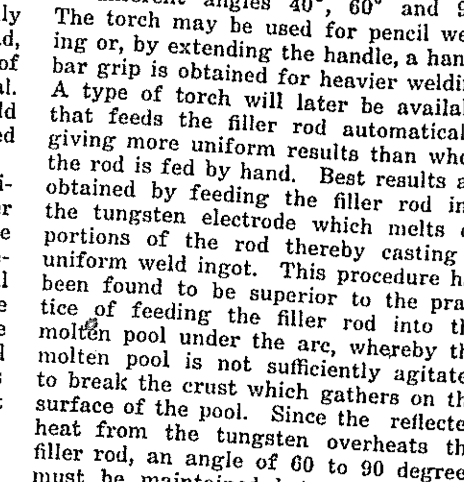
The tungsten electrode is very slowly alloyed with the weld metal and naturally in a period of time the tungsten electrode must be replaced. No noticeable increase in the corrosion rate of heliarc welds in magnesium alloys because of the presence of tungsten has been noticed.

Heliarc weld ingots have in general an extremely fine grain with practically no enlargement adjacent to the bead, indicating that there is a minimum of heating effects on the adjacent metal. This accounts for the very good weld efficiencies obtained on heliarc welded alloys.

Dowmetal J-IH magnesium alloy, heliarc welded, has approximately 95 per cent of the parent metal strength in the weld area. However, at present the design safety factor for welded dowmetal J-IH assemblies is 75 per cent of the strength of the parent metal. These strength values are based on butt welded joints. Fillet, lap, edge or corner welds are weaker than the butt welded joint and must be stressed accordingly.

Heliarc welding has proven to be a successful medium of attachment for magnesium, stainless steel, brass, inconel, monel and some of the carbon steel alloys. Research work is now in progress to extend its use to aluminum and other carbon steel alloys not heretofore heliarc welded. In the heliarc welding process, a shield of helium gas envelops the molten metal. Because helium gas is an inert gas, it prevents oxidation and eliminates the use of a flux and the danger of entrapped flux in the weld ingot that would promote corrosion. The arc in this process is produced directly between a tungsten electrode and the base metal rather than between two tungsten electrodes as is the practice in atomic hydrogen welding.

The Northrop Heliarc welding torch is equipped with a helium valve that is opened just prior to the striking of the arc between the tungsten and the parent metal which feeds helium through the torch to the weld. Helium has over five times the specific heat of air and when in motion prevents heat accumulation around the weld thereby keeping it cooler and giving a better fusion and penetration with less distortion than other welding processes. The arc is struck by a light brushing action and quickly drawn back from the metal. Northrop Aircraft, Inc. has designed heliarc torches which will shortly be available to the industry. The torches are of two sizes to handle 1/16″ to ⅛″ electrode and 3/16″ to ¼″ electrode respectively and may be supplied with tips of different angles 40°, 60° and 90°. The torch may be used for pencil welding or, by extending the handle, a handle bar grip is obtained for heavier welding. A type of torch will later be available that feeds the filler rod automatically, giving more uniform results than where the rod is fed by hand. Best results are obtained by feeding the filler rod into the tungsten electrode which melts off portions of the rod thereby casting a uniform weld ingot. This procedure has been found to be superior to the practice of feeding the filler rod into the molten pool under the arc, whereby the molten pool is not sufficiently agitated to break the crust which gathers on the surface of the pool. Since the reflected heat from the tungsten overheats the filler rod, an angle of 60 to 90 degrees must be maintained between the filler rod and the electrode. The tungsten electrode varies in size from 1/16″ to ¼″, depending upon the thickness of metal welded and the heat required. The torch must be held as near the weld as possible to obtain maximum benefit from the helium for the prevention of oxidation.



Micro photograph of grain structure of weld. Weld ingot (darker portion) made of Dowmetal "J" alloy rod blended with Dowmetal "J" parent metal (lighter portion).

Also an arc length of 0.060″ maximum should be maintained. Poor penetration or gas holes may result by using too long an arc. On those alloys that have a tendency to be hot short, a rapid welding speed is recommended, approximately three feet per minute, to eliminate the danger of cracking.

A conventional arc welding machine with direct current generator having a 150 ampere output is desirable. However, higher output machines which operate at less than 300 amperes may be used providing lower amperes may be obtained. An upright machine is preferable in that it is easier to attach a helium tank to such a unit. Separate amperage and voltage regulators must be provided and the machines should have a continuous sequence of five increments of current control. The average life of a 200 cu. ft. helium tank is about thirty-five hours of continuous welding with a medium-sized torch. Fairly pure helium gas is required. Normally helium as purchased from the Government plant is sufficiently pure to cause no difficulty. Additional gases in helium such as carbon dioxide, hydrogen, nitrogen and the hydrocarbons may cause pronounced defects. Hydrogen produces bad porosity. Oxygen films the metal causing poor coalescence and inclusions. The presence of 7 per cent nitrogen in the helium reduces the welding speed to about two-thirds that obtained when only 1 per cent is present. All of these gases if present, may be removed, however, by passing the helium through filtering mediums.

This method of arc welding has provided an important new tool for the fabrication of structures from alloys such as magnesium and stainless steel. Any type of joint which has been commonly used for welding ferrous metals, may be employed on magnesium and stainless steel.

Stainless steel has heretofore been the most difficult alloy to weld and could only be satisfactorily arc welded by the use of atomic hydrogen, and then only in thicker sections. By the heliarc welding process, thicknesses of less than .010″ may be very easily welded. In the heliarc welding of stabilized stainless steel the extent of carbide precipitation is very low as compared to other methods of welding which greatly increases its fatigue factor. The medical profession would do well to consider this process for the arc welding of stainless steel braces in bone surgery where spotwelding and other means of attachment have not been so successful.

In the heliarc welding of magnesium structures a tungsten electrode is used with reversed polarity making the magnesium the anode. For ferrous and copper alloys, a carbon electrode is used and the welded structure is the cathode. Craters are eliminated in reverse polarity welding.

For the high temperature melting and heat resisting alloys heliarc welding has proved successful where other welding methods failed. Heliarc welding gives the greatest penetration of any known welding process.