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COPPER WELDING FOR MAXIMUM RF CONDUCTIVITY

E. F. McLaughlin

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E. F. McLaughlin

Lawrence Radiation Laboratory
University of California
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Tests of various copper weldments were made in connection with the proposed construction of copper-clad-steel vacuum tanks for the heavy-ion linear accelerator (HILAC). This accelerator operates at a frequency of 70 megacycles/second. At this frequency the rf resistance of copper is 2.2 milliohms per square, that of brass is 4.6 milliohms per square. A design requirement of the tanks was that the copper welds have an rf resistance less than that of brass. The purpose of the tests was to discover techniques of producing these welds at a minimum cost.

The weld samples were 4-in. squares of 1/2-in. copper-clad steel, the copper being a nominal 10% of the thickness. A strip of copper cladding was removed by chipping away a groove 1/16 × 3/4 × 4 in., simulating the area to be overlaid with copper in the actual weld. The copper was then replaced by several welding techniques. The samples were cleaned by brushing them with a powered rotary stainless steel brush. The rf resistance was measured with a device developed by Quentin Kerns and reported in UCRL-2946.†

These copper welds are customarily produced by the inert-gas-shielded nonconsumable-electrode arc-welding process (such as "Heliarc"), with copper (either pure or alloyed) added as filler material. This slow and expensive process can produce welds with a resistivity of 3.0 milliohms per square.

It was found that welds meeting the design requirement can be rapidly and cheaply produced by the inert-gas-shielded consumable-electrode arc-welding process (such as "Aireomatic"). The shielding gas may be either helium or argon, but argon is preferred because it is cheaper and reduces the spatter of the filler material. The best filler material was found to be Anaconda 372, a proprietary

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*Work done under auspices of U.S. Atomic Energy Commission.

†Quentin A. Kerns, Eddy-Current Bridge for Measurement of Skin Losses, UCRL-2946, April 11, 1955.

alloy of 98.85% copper, with the balance tin, manganese, and silicon. Welds of low resistivity can be obtained by using welding currents of about 275 amperes for a 1/16-inch-diameter electrode, which is somewhat higher than for conventional welding. Subsequent etching does not improve the conductivity of the weld. Grinding the welds is not necessary; they may be cleaned with a wire brush only.

The welding position has a pronounced effect on rf resistivity. In welding "uphill," the molten metal runs away from the arc. The arc strikes bare steel and contaminates the copper deposit with steel. By welding "downhill" this difficulty is avoided, since the molten metal runs under the arc and contamination is held to a minimum.

In practice it was relatively easy to obtain welds with a resistivity of 3.4 milliohms per square, which is much better than the design requirement imposed. Electrical tests on the HILAC vacuum tanks after they were completed showed that the "Q" of the tanks is slightly better than originally hoped for. A saving of between five and ten thousand dollars on the construction costs of these tanks was attributable to the use of the welding techniques described here.