

WELDING AND CUTTING

the welding machine. Permanent injuries, and several fatalities have been caused by neglecting to use the line-disconnecting switch before making adjustments. The use of single-pole primary circuit breakers and electronic contactors which leave one line to the welder "hot" makes this precaution imperative.

Current and timing controls are of two types, mechanical and electronic. If worn parts throw the mechanical control out of synchronism with the current and voltage waves, transients may cause severe damage to the equipment. Synchronism should be carefully maintained, particularly on high-power equipment. The electronic controls are placed in the primary circuit and involve high voltages which must be guarded by proper insulation, lockouts, and safety switches.

All electrical work should conform to applicable codes.

Cables

The high current of the primary circuits (up to 10,000 amp) in resistance welding does not permit the use of plugs except for control circuits, usually 120 volts or less. Power lead terminals should be securely and permanently attached with screws or bolts for the duration of service.

The magnitude of the secondary welding current is such that the cables for a portable welding machine must be heavy. Even with sizes from 200,000 to 1,000,000 circular mils, copper losses are high and in many instances water cooling is required, especially for high production portable, as well as multiple-spot station, welding machines. The length of these cables varies from 1 to 14 ft, the latter being the maximum considered reasonably economical. The covering for the cable used with a portable welding machine is thick, high tensile rubber.

Abuse of the cables for resistance welding is severe. The production requirements demand the utmost of the cable materials used, and even the best cables need frequent replacement during a production year. The cables are subjected to electrical pulsation, bending, and twisting. Electrical pulses at the rate of 3,600 per minute cause a continuous whipping of the two cables which leads to fatigue and eventual breakdown.

Strapping will check the movement of the

cables and will prevent excessive wear, kicking of the operator, and unnecessary muscular strain. The secondary voltage presents little shock hazard, since the maximum voltage is about 30 volts, but the operator can be hurt by a cable blowout caused by steam pressure from faulty water cooling circulation.

A periodic check for weak spots in the cable covering is good practice. The use of concentric welding cables is advised because they do not have the undesirable features of the pulsating cables. Portable welding machines, including the cables, should have proper weight balance to permit operation without undue strain to the operator.

Electrodes and holders

For resistance welding, copper or copper alloy electrodes are in general use. Made in various shapes for particular applications, they are, with few exceptions, water-cooled. Resistance-welding electrodes, unlike those used in arc welding, are not deposited on the work. However, the high current density and continuous application of mechanical force finally cause wear and necessitate re-dressing and replacement.

Electrodes are placed in holders connected to the secondary circuit. The welding pressure is also applied through the holders. Their designs cover a multitude of applications and vary considerably with the welding methods used. Electrode holders and electrodes should be water-cooled to minimize softening of the metal from heat and to reduce the chance of heat burns to the operator.

Machine installation

Installation of resistance welding equipment should conform to the *National Electrical Safety Code* and the *National Electrical Code*. Some items worthy of special attention are listed below.

- 1 The frame cabinets for welding machines and for auxiliary equipment should be grounded. The ground wire should be omitted, however, on AC power sources that are grounded or where the manufacturer does not recommend grounding. Where water-cooling is provided, the welding machine is considered adequately grounded when electrically connected to water pipes.
- 2 Control circuits should operate on low