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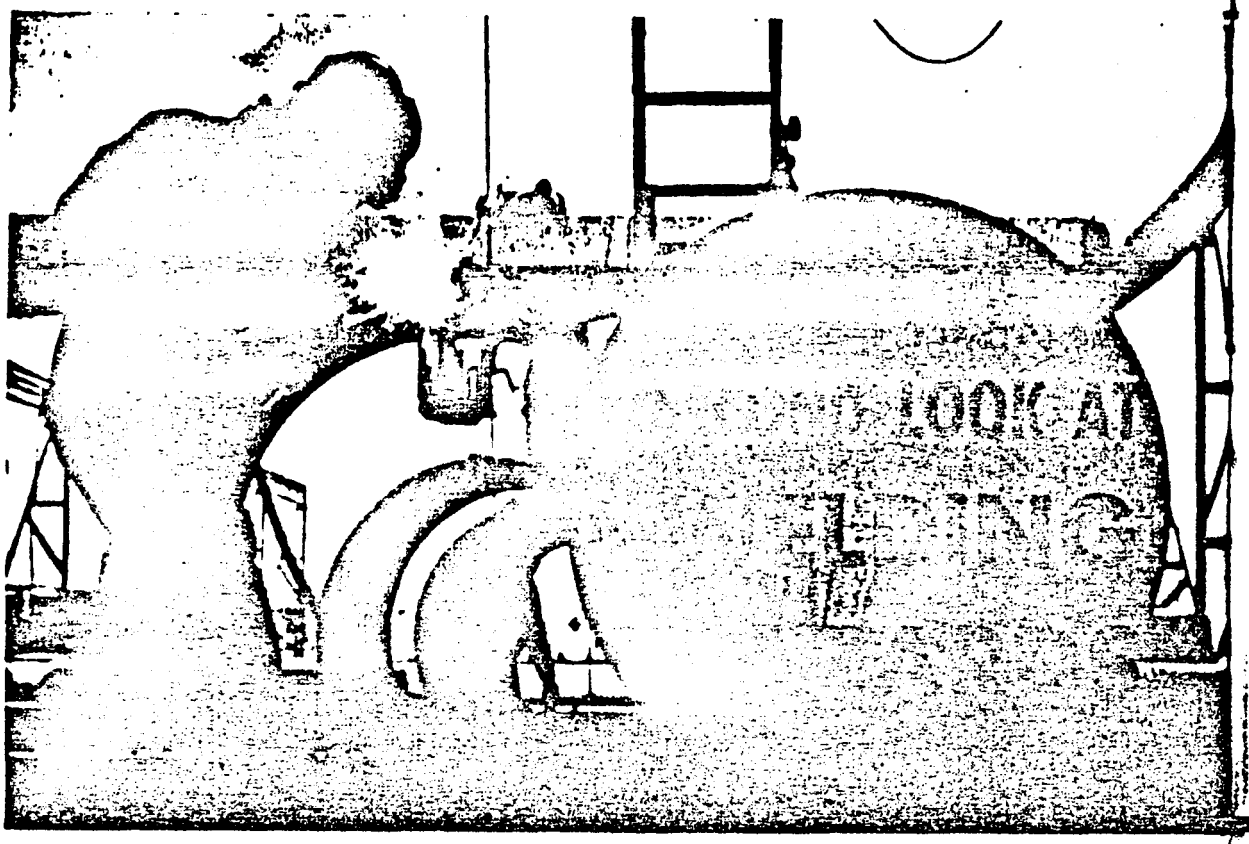

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ARC AND GAS welding is indispensable to industry for speedy production of a host of products that could not be efficiently produced by any other means. Not only is the technique invaluable for production work but for maintenance purposes it certainly is a godsend to the harried plant engineer confronted with some new breakdown problem each day. Paint is scaled off with ease, case hardening is done in a jiffy and large pipe is heated in place for those intricate bends required to fit into congested places.

While all this is on the profit side of the ledger, there is also some concern over the hazards presented. Badly kept gear can injure workers through electrical shock, flash burns to the eyes, and burns from spurting slugs in heavy cutting operations. Welding equipment therefore must be kept in good condition, and the inspector's job is twofold: He must make detailed, periodic visual inspections for defects; and he must see that the machines get an occasional trip to the shop for the more complete electrical check.

Perhaps the most important item on the list of welding equipment is the electrode holder. Some men are quite happy with an uninsulated holder, and argue that the insulation material is too fragile and therefore cannot be depended on. The fact is that the insulated holders can be depended on if handled carefully and inspected at frequent intervals. Statistics indicate that a large percentage of accidents are chargeable to uninsulated holders or those that were in a defective condition.

Most accidents of this type occur in cramped quarters where the welder's body is wet with perspiration and is in liberal contact with the work piece. Quite often any contact the operator may make with live, current-carrying parts through wet or bare hands will not harm him seriously. But the shock he receives may cause him to react with such force and reckless abandon that he is injured in other ways. The common expression "kick like a mule" is no exaggerated expression. For direct current does act like that.

The most vulnerable feature of electrode holders is the head, protruding beyond the ring or collar of the insulating material just above the hand. That portion lacks insulation. As the worker changes rods, he may readily make contact with bare metal. If he should roll on the holder, or carry it over his shoulder as so many men do, the live part may come in contact with the neck or face.

Grounding Hazards

One type of arc welding carelessness that recurs frequently is the utter disregard for good ground or negative return connections to the generator. Literally miles of good 3-conductor power cord to electrically driven tools have been ruined

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FOR C

By PAUL C. ZIEMKE

Eye protection always gets first attention in welding safety. Let's look at some of the other, less obvious hazards:

- The Electrode Holder
- Grounding of Equipment
- Storage of Cylinders
- Fire Hazards
- Dust and Fume Hazards

because the welder used a makeshift high-resistance ground on the work piece. The heavy weld current, seeking a low resistance path, courses over the third (ground) wire of the electrical tool to burn off the drill bit point and practically "cook" the insulation into a total loss.

Field welders, too, develop serious fire hazards by neglecting to bring in a ground wire to every job. An all-too-common, yet dangerous, practice is connecting the generator to an outside hydrant or building sill-cock for the ground return circuit. Welding is then attempted in any part of the building on the general premise that there is sufficient metallic interconnection between water, gas, and metal sewer lines, plus the metal structure of the building, to form a low resistance path back to the generator. That this is not always true is borne out from the number of mysterious fires that develop in service tunnels, attics and basements where arcing occurs because of the inadequate physical connection between the aforementioned services. Use of the structural steel frame of a building for grounding should be attempted only under the direction of competent electrical supervision.

Finally, there is the lazy man who knows just enough about the modern 3-phase lighting service to utilize the installation for his own benefit. Like the individual who coupled his negative return to the fire hydrant, this fellow connects his negative cable to the neutral wire of the 230–115 volt lighting service and then expects to move about the building anywhere with trailing positive cable to perform weld jobs wherever the occasion demands. This is a particularly dangerous practice since the heavy current may heat the splices and connections on the neutral wire to the point of failure.

What this man fails to take into consideration is the fact that the large, ample sized wire he couples onto in the building's service entrance does not of necessity extend all the way out to his weld site in the same size and capacity. The large size neutral wire extends only to the individual lighting distribution panels. From that point on, the wire size is drastically reduced in keeping with the type of service supplied. The average "home run" wire leading to lights and receptacles is practically a standard—#12 gauge. To weld on ventilating ducts, stacks and conduit racks under such conditions means that small conductors are annealed or burned off.

Create in the minds of the welders a healthy respect for electricity, even though the voltage is considered too low to be deadly. A paramount warning to operators should be to take special care in hot, humid weather and when welding in wet places. Almost without exception, fatal shocks occur in hot weather. The operator's physical condition and the condition of his clothing should be his guide.

Precautions for Welders

1. Use care in laying down your electrode holder so that it does not make contact with conducting material. 2. Carry the electrode holder in your hand, not crushed under the arm, or slung over the shoulder. 3. Don't carry the holder about with a rod in it. 4. Don't work alone in confined places where a bump on the head, or metal fumes may knock you out and help may be slow in getting to you. 5. Exercise particular care in high places where it is foolhardy to cling with one hand while welding with the other. Use standard staging material and don't stand on barrel heads or packing cases to reach a high place. 6. If you must work from a ladder erected in a doorway or aisle see that you have a helper at hand to guard against passing traffic. 7. Do wear the special chrome tanned leather jacket, and keep your pants bottoms out of your shoe tops or you will get a "hot foot" that won't be funny.

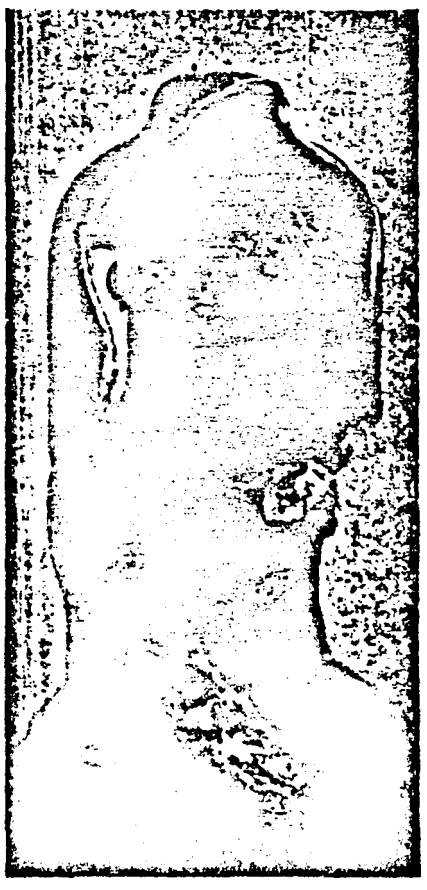
Fire Hazards

The Livonia fire of the General Motors Co. rated the biggest loss for a single production unit, all because of an error in planning the protection needed against flying slugs of hot metal. Portable extinguishers merely halted the fire momentarily, and then it raged speedily out of control before the arrival of the city fire fighters. In fact in most plants using much arc welding or gas cutting apparatus, the fire runs made to extinguish hot metal slug fires far outnumber those of any other cause.

Potential fire hazards should all be eliminated before welding or cutting is begun. There are many approaches to this. Probably one of the most effective procedures is the issuance of a welding and burning permit before work can commence. The operator asks for this permit from the department head for whom the work is to be performed. It is he who is best informed on the hazards peculiar to his department and therefore is best qualified to make all arrangements to have combustibles blanketed or moved, floors watered down if of wood, and all flammable gas producing equipment shut down and vented. If the nature of the installation warrants it, the depart-

ment head must appoint a reliable monitor to watch the operation for the full time the work is in progress. Armed with a suitable extinguisher he should remain at the welding site about a half hour afterwards to watch for any vagrant slugs that escaped his notice while the work proceeded. Failure to do that resulted in a 2 million dollar fire that raged for two days in a warehouse.

Oxygen and acetylene hose should be inspected and pressure tested every 60 days and no one but the authorized shop individuals should make up the connectors of the suitable right and left hand threads. Patching is ruled out at any time. Tape, no matter how well applied, never made an acceptable seal. It merely covers up a bad situation that leaks gas to fill a room with an explosive mixture, or permits the hose to catch fire as the leaking jet of acetylene contacts a spark. Usually, it's only a matter of seconds before the jetting flame burns through the adjoining oxygen hose and then the welder had better sprint fast for the



Oxygen cylinder that exploded because of exposure to heat and softening of lead seal.

regulator valves. The burning rubber and the incomplete combustion of the acetylene can literally fill up a room with floating carbon, like a "black" snow storm.

In one Tennessee plant the oxygen hose burst with such violence that it caused the rupture of an ear drum. The rigger who was cutting structural steel had run the pressure on the regulator up too high and was using the torch valve to control the pressure in balance with his acetylene supply. In another instance, a gauge exploded violently blowing out all the windows from the little repair shop, and peppering the workman with fine bits of pulverized glass from the gauge bezel. The cause? Someone unfamiliar with the hazard of the reaction between oxygen and oil had used the standard shop gauge for calibrating the controls on a hydraulically powered elevator. The very legible inscription on the white face of the dial —"USE NO OIL"—apparently meant exactly nothing to that benighted soul. But for the shielding effect offered by the bulk of the oxygen cylinder, the shopman would have been killed by the flying shrapnel shot out from the exploded gauge.

Rupture Disks and Fusible Links

One of the accompanying pictures shows the need for proper storage for all compressed gases, especially the fuel gases. The cylinder had been stored on the westerly side of a warehouse where the full rays of the summer sun beat down on it all the day long. Later, the cylinder was brought indoors to the small storage room adjacent to the shop. At the new location no overexposures to heat occurred, yet suddenly the storage room door was torn from its hinges, carrying with it the door frame stops and the strike plate. A close examination of the cylinder by experts in the field of compressed gases revealed what appears to be a logical sequence of events. The exposure to high solar heat on the outdoor platform had so softened the fusible lead plug on the safety cap that the lead extruded from the recess against the rupture disk. This slow movement of the lead caused the disk to flex and partially fail, yet the oxygen was still obstructed by the lead seal and hence did not escape to the atmosphere. However, at some moment when the cylinder stood chained to its stanchion in the auxiliary warehouse one extruded portion of the lead seal let go and the rupture disk then failed completely, producing a jetting stream of oxygen downward on the ferrous metal threads of the protective metal cap and its associated swaged-on collar.

At 2,300 lbs. pressure the escaping oxygen reacted speedily with the excellent reactive material formed by the admixture of fine rust particles and the residual fatty materials left after years of smearing the valve threads with soap suds to check for tightness of gauges and fittings. The speed and effectiveness of the reaction is indicated by the fact that an area the size of a silver dollar was heated to incandescence through three thicknesses of metal. The weakened metal was then forced upward with the violence of a small volcano to splatter oxidized ferrous metal over the upper warehouse wall surface where several incipient fires were kindled on wood cross members. A fire was also kindled on the wood plank which formed part of the chaining arrangement at midpoint of the cylinder's length. This fire bears out the theory that the first reaction occurred as the jetting oxygen burned through the cap and collar, and so softened the cylinder wall that it failed under pressure.

A check with experienced warehousemen discloses the fact that on many occasions they find cylinders completely exhausted as the result of this slow heating and softening of the lead seal above the rupture disk. The copper disk then develops a minute opening where its outer edge bears against the sharp shoulder of the valve tee to permit a slow, sometimes completely noiseless, release of the 400 cu. ft. of gas. While the Interstate Commerce Commission requires these two protective features on all cylinders to safeguard

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Look at Welding
ntinued from page 24)

iem against violent rupture in cases of fire or other exposures to unwarranted high temperatures, the user of compressed gases should not trust to luck too long lest a serious accident occur. One can imagine the calamity that would have resulted if this cylinder had ruptured when connected to an oxygen tent providing some patient the life saving features of oxygen therapy.

Dusts may be defined as solid particles of matter which are ordinarily produced by grinding, crushing, drilling or blasting, plus the chipping or brushing of welds. These materials may be carried about the welding shop and into other work areas unless point-of-operation or first class general ventilation is provided. The size of the particles varies from what is called ultra-microscopic to those which are visible. From a hygiene standpoint, the significant particle size of dust ranges from a fraction of a micron to 10 microns. (A micron is 1/25,000 of an inch). The most frequently encountered dusts in industrial shops are of inorganic minerals.

Fumes may be defined as solid particles which are formed by processes similar to combustion, condensation and sublimation. The most common types of fumes encountered in industry are usually caused by the oxidation of metal, such as the oxides of lead or zinc. Particle size is usually smaller than that of dust and ranges below one micron. In contrast to dusts, fume particles tend to join together very easily. Many people erroneously speak of fumes when they mean vapors of liquid materials, such as acid solutions, organic solvents, and the like. Fumes are usually found where molten metals such as lead, zinc, and cadmium are being processed or used in industrial operations. Welding may produce fumes of the metals which are being welded or fumes and gases from the variegated coatings of weld rods.

It should be remembered that metals may produce both dusts and fumes, according to the nature of the operation and the state of the materials when processed. For example, among the heavy metals, such as lead, dust may be of equal or greater importance than fumes as a causative factor in disease. Other mineral dusts and metallic dusts that are also considered of etiological importance are: (a) toxic and/or irritant dusts (from heavy metals and their salts, such as arsenic, lead, manganese), and (b) fibrosis-producing dusts, such as free silica and asbestos.

Exposure to a potentially harmful material is not necessarily a health hazard. It depends on the state of the material. Whether it is an actual health hazard can only be determined by an industrial hygiene engineering survey, in which the amount and kind of exposure is rated, according to accepted standards of concentration, size, and quality of dusts and fumes. Many persons erroneously state that there is a "lead hazard," for example, when it is only known that contact is being made with lead.

The importance of air contamination will be evident when it is realized the pathologic effects produced by dusts and fumes are brought about almost entirely by inhalation. There is one outstanding exception, the absorption through the skin of lead in the form of tetraethyl lead, which is of course a fluid. No dusts, so far as is known, produce any systemic pathological conditions from skin absorption, and it is doubtful that any kind of true fume is absorbed by the skin.

From the etiologic point of view, particularly with reference to pathologic effects, the following outline shows how different types of substances among the dusts and fumes act on the various systems in the body to produce pathological effects. The lists are not complete; just typical examples are shown.

(a) General system poisoning: Arsenic, lead, mercury, vanadium.
(b) Substances acting on the gastro-intestinal system: Antimony,

cadmium, lead, mercury, zinc.

(c) Substances acting on the skeleton and joints: Lead, mercury, mesothorium, phosphorus, radium.

(d) Substances acting on organs of special sense: Arsenic, lead, manganese, mercury.

(e) Substances acting as fatal poisons: Lead, mercury.

(f) Substances acting on the genito-urinary system: Arsenic, lead, mercury, vanadium.

(g) Substances acting on the brain and nervous systems: Arsenic, lead, manganese.

The name, "Metal Fume Fever," is applied to the condition which results from breathing fairly heavy concentrations of freshly formed metallic oxide fumes, principally zinc and one of its alloys, brass, although the condition may result from the inhalation of other metallic oxide fumes. Metal fume fever is not a systemic poisoning, but it should be borne in mind that some of the metallic fumes that cause it, such as lead, cadmium, mercury, and manganese, may also cause systemic poisoning.

The symptoms come on some hours after exposure, usually after leaving work. The first sign is a dryness of the throat, which may be followed by a dry cough and a feeling of heaviness in the chest. Rise of temperature, accompanied by sweating, and leucocytosis and elevation of the pulse rate and the blood pressure follow, usually with chills. The symptoms ordinarily pass in 12 or 24 hours and the usual experience is that the employee returns to work the following day. A natural immunity is conferred on certain types of workers, but the immunity seems to be lost rapidly after removal from continuous exposure.

For ordinary conditions in which only limited dusts are encountered along with a fume condition, simple filter type respirators will protect the welder against the hazard of breathing these dusts and fumes. The filter is made of chemically treated filter paper or felt through which the air is inhaled.

The particular type of filter employed will depend upon the kind of contaminant present in the air. Since it takes less of the more toxic materials such as lead to affect the wearer than the harmful amounts of fibrosis producing dusts, a more efficient filter will have to be used against toxic dusts than against fibrosis producing and nuisance dusts.

The United States Bureau of Mines tests respiratory protective devices against various air contaminants under carefully controlled conditions. Devices meeting its tests receive that Bureau's official approval, and this is indicated by approval numbers on the device and a reproduction of the certificate on the package. Equipment approved by the U. S. Bureau of Mines for the particular contaminant or class of contaminants in the air should be used.

Pictures by courtesy of: Top—Kaiser Services; Bottom—U. S. Atomic Energy Commission.