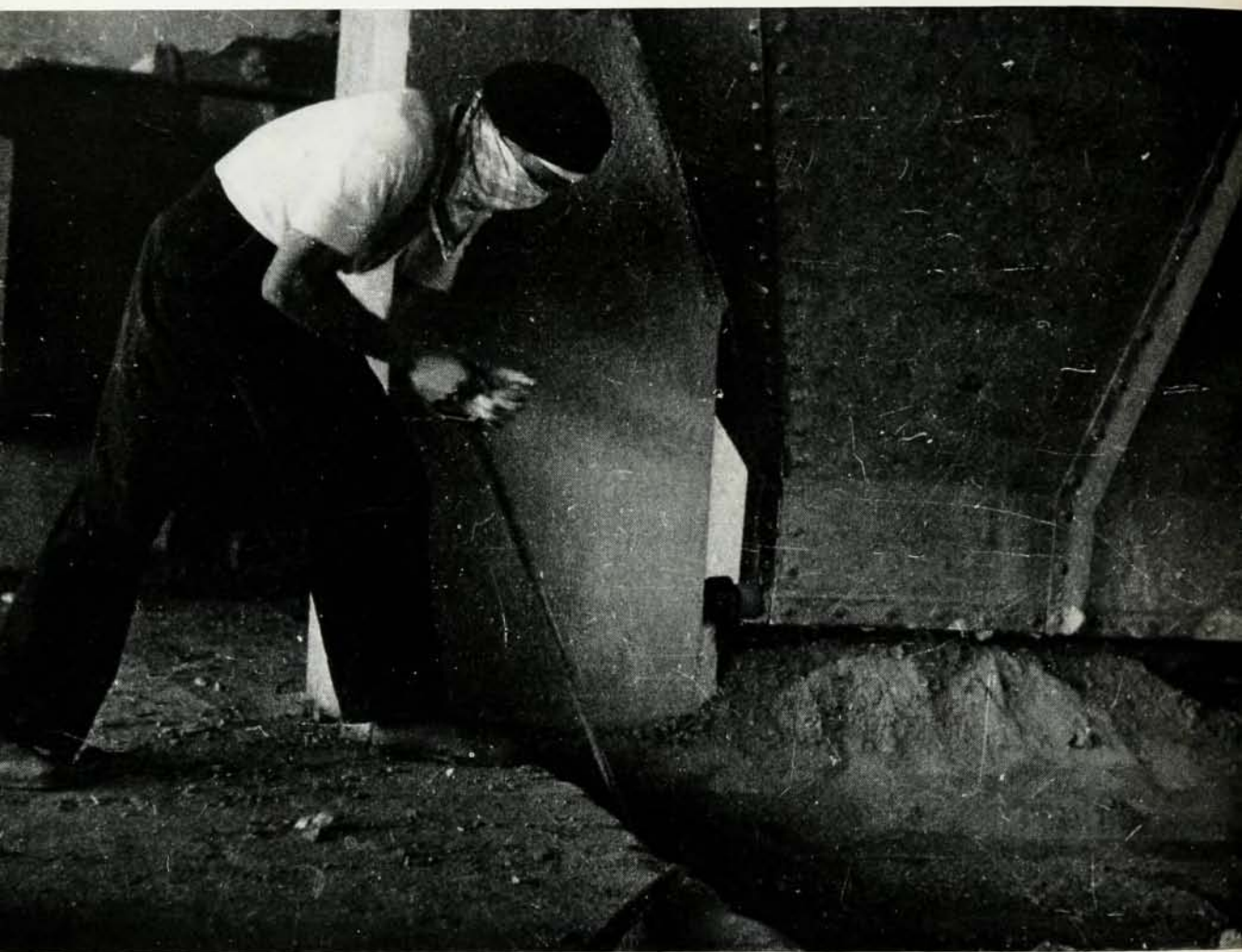


MERCURY



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Working cinnabar ore in the mercury mine at Almadén, in Spain, during the Civil War. The ore is heated to a high temperature, the mercury escaping as gas and coming down in drops as it is cooled to be collected in receptacles. The protection against the poisonous vapor is hardly adequate.

POISONING

by *Harriet L. Hardy*

Mercury is not treated with the respect it deserves, the author has found from her observation of general laboratory practice. *Physics Today* presents below its second in a series of articles dealing with common laboratory substances which must be handled with care.

Curiously ignorant and apathetic is the manner in which modern workers in many university, government, and industrial research laboratories approach the dangers of handling mercury. Fortunately, most laboratory-scale operations are intermittent enough to give a distinct factor of safety, but mercury's great toxicity, and the ease with which it gains entry to the body, means that interrupted exposures will not necessarily prevent toxic effects. The possibility of acute mercury poisoning from laboratory accidents and the likelihood of storing unknown amounts of mercury over the years, with resultant chronic poisoning, are very real. Mercury poisoning, or mercurialism, has been

known since Roman times. This does not make it less dangerous now.

Accepting from experience the fact that mercury, a heavy metal, is toxic, the most impressive single fact in this regard is that the element vaporizes readily even at the temperature at which water freezes. In workrooms, the presence of mercury in open vessels will result in a concentration in the local air of the so-called maximum allowable con-

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Alchemist's kitchen.
Copper engraving by
H. Cock after a
drawing by
Peter Bruegel.
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centration at room temperature. This point must be given emphasis because the vapor pressure of mercury has been used erroneously in discussion as proof that mercury does not volatilize and hence is not dangerous. Since mercury does vaporize so readily, the use of heat in any operation involving the element increases the danger of toxic effects promptly and manifoldly. The facts are illustrated by the following:

Maximum allowable concentration of mercury
is 0.1 mgm. Hg/m³

Temperature in °C	Vapor Pressure in mm (Hg)	Milligrams of Hg/m ³
20	0.0013	15.2
30	0.0029	33.9
40	0.0060	70.0

The next most useful thing to know is that mercury may be absorbed by inhalation, through the unbroken skin, and when swallowed. For many years advantage has been taken of the ability of mercury compounds to penetrate the skin in treating syphilis by rubbing mercury bichloride and cyanide compounds of mercury into affected areas. Dentists have suffered chronic mercury poisoning because of the custom of making amalgams ready for final use by rubbing the material forcibly in the palm of the hand. The toxicity of mercury taken by mouth is popular knowledge because of the use

of the bichloride in committing suicide. The time-honored medicinal use of calomel (mercurous chloride) has been practically abandoned because therapeutic dose and toxic dose are too nearly the same.

The physical properties of mercury and the ease with which the element and its compounds gain access to the body make it difficult to control its toxic effects.

The Danbury Shakes

The recorded history of mercury poisoning is very ancient. Slaves and convicts were used in mercury mines in Roman times and Dr. Hamilton, in *Industrial Toxicology*, writes that Justinian considered a sentence to work in the mercury mines equivalent to a death sentence. There are mines, yielding cinnabar (mercuric sulphide) which is not so hazardous, and quicksilver, in Spain, Austria, Italy, and the United States (California and Texas). Only in modern times have technical improvements cut down the danger of mercury mining.

Early alchemists considered the metal a substance of great consequence (being one of the five basic elements of which all matter supposedly was formed) and brewed it and stewed it at great length. By the middle of the sixteenth century, mercury was used

widely as a therapeutic agent, both in its various compounds and in the free state, finely divided or in vapor.

The treatment of fur to make felt hats is another ancient source of mercury intoxication. Mercury nitrate was introduced into the process of making felt hats by the French at an unknown date, probably in the seventeenth century, as a trade secret, so that the process is still called by them "secrétage." The Huguenots took the secret to England, where because the nitrate solution turns white fur a reddish brown color, the process is called "carrotting." From mercurialism in the hatters' trade has come the description of the effects on the nervous system embodied in Lewis Carroll's Mad Hatter in *Alice in Wonderland* and the expression, "Danbury shakes," referring to the Danbury, Connecticut felt hat industry. In 1941, Connecticut outlawed this source of mercury poisoning, and thirty other states have followed with restrictive regulations.

Mercury readily dissolves certain metals to form compounds known as amalgams, which have a variety of applications. Venetian glass artisans of the Renaissance period, for instance, introduced mirrors of glass backed with a tin and mercury amalgam, from which the mercury was driven off with heat. This was the source of acute mercury poisoning of a type seldom seen following the advent of mirrors backed with silver nitrate.

Mercury has many current uses. Mercury amal-

gam is used for extracting gold and silver from richer ores and in mining cinnabar, which is not toxic. Workers are exposed to mercury in the condensation process, usually close to the mines, where cinnabar is reduced at three and thirty-eight degrees to four hundred and twenty degrees centigrade, into metallic mercury and sulfur dioxide. Metallic mercury is used in making thermometers and barometers on a fairly large scale. Mercuric oxide and metallic mercury are used in making a new kind of dry battery. Solders for dry batteries contain mercury; and, since heat is involved, toxic effects from inhalation of mercury vapor may easily result. Dangers arise through using heat in repairing high frequency induction furnaces and mercury boilers with an acetylene torch. In the "constant potential" department of electrical works, when an alternating current is changed to direct current by passage through a large flask of mercury, the hazard of the volatilized metal is present. Mercury is used widely and carelessly in hospital, university, and industrial laboratories. In wartime, the manufacture and use of mercury fulminate for detonators is a likely source of toxic mercury effects. Organic mercury compounds are used as fungicides and in medicine. Their manufacture has resulted in mercurialism. An unusual source of toxic mercury manifestation is tattooing, which is done with a mercury compound.

Symptoms

The clinical signs and symptoms of toxic exposure to mercury may be conveniently classified as acute, subacute, and chronic, designating fairly closely the speed of onset and the violence of the disease in a given case. The dosage and the speed with which mercury is taken into the body are decisive factors. Thus bichloride of mercury taken with suicidal intent is purposely excessive and taken in a single dose produces violent reaction in kidneys and gastrointestinal tract. This is in contrast to the small amount of mercury absorbed through the skin and by inhalation when a dentist, making mercury amalgam fillings day after day for years, occasionally develops muscular tremors due to the chronic effect of mercury on the central nervous system.

Acute mercury poisoning may cause inflammation of the mouth, skin irritation in wide variety, gastrointestinal disturbances, and kidney damage. Inflammation of the mouth and its structures may result



Examining Mercury
Robert Capa—Pix

in excessive salivation and in the gums swelling and bleeding; in extreme instances the teeth may loosen and fall out, and occasionally a blue-black line, the so-called "mercury line" caused by deposited mercuric sulphide, is visible. Skin reactions to mercury may be various and are nonspecific. Gastrointestinal symptoms occur, as has been mentioned, when mercury is taken into the body in fairly large doses, chiefly when it is taken in by mouth. Since a large proportion of ingested mercury is lost from the body through the large intestine, related symptoms such as diarrhea and abdominal pain are to be expected. The remainder of a dose of mercury taken in and not retained is excreted in the urine, with the result that kidney damage is encountered to some degree in all but very slight exposures, varying from the mildest evidence of irritation to complete kidney shutdown and uremia and ultimate death.

The result of chronic exposure to mercury is usually some form of mouth inflammation and symptoms of central nervous system damage. It is the chronic form of mercurialism which is most commonly encountered in industrial exposures. Muscular tremors which may become very disabling are the result of chronic mercury poisoning. The famous "hatters' shakes" are increased by effort, affecting eyelids, tongue, and fingers first; and if mercury exposure continues, arms and legs. There are descriptions of workmen who cannot feed or dress themselves but can continue their customary work if they once reach their work bench. Because of the tremor of fingers and tongue, handwriting is distorted at an early stage and speech becomes hard to understand. These facts are frequently used to help in making a diagnosis of chronic mercurialism. If worker-patients are removed from mercury exposure before the disease has lasted too long, the shakes will disappear.

Psychic irritability, or erethism, as it has been called since the eighteenth century (from the Greek word meaning irritation), accompanies the muscular tremors of chronic mercury poisoning. Loss of memory, bad dreams, insomnia, depression, torpor, loss of self-confidence, increasing shyness, and great irritability are psychological symptoms encountered in well studied cases of this disease. Men have been obliged to give up their work because of inability to keep their temper when orders were given them.

It should be mentioned that accidental introduction of metallic mercury under the skin through

breakage of glass equipment has been known to result in muscular tremors. The tremors disappeared when the mercury was surgically removed.

Before leaving this discussion of the clinical classification of mercury poisoning, it is well to point out that great variation in the disease is encountered, depending on the type of exposure. Thus, in the manufacture of lead fulminate, skin reactions are chiefly seen; in the felt hat trade, psychic irritability and muscular tremors are the prominent symptoms; while in medicinal use or accidental misuse of mercury compounds, kidney damage is most likely. In addition, as in all disease due to bacterial, chemical, or physical insult, there is great variation in the reaction of individuals or even of groups, depending on factors not fully understood. Examples of such little understood factors are race and diet. Better described factors such as previous kidney disease or poor dental hygiene may determine the character of the clinical picture.

Treatment

The obvious treatment for all types of mercury poisoning is to prevent any further exposure. Since the metal is promptly and steadily excreted, symptoms will in time disappear, although cases are reported with tremors lasting up to thirty-odd years. Considerable dental and medical supervision may be necessary if mercury exposure has caused inflammation of the mouth and kidney damage. Although it has never been reported in anything except suicidal mercury bichloride poisoning, British Anti-Lewisite (BAL) should be mentioned as undoubtedly a specific for acute mercury poisoning. Anti-Lewisite was developed during World War II by the British to combat the effects of the war gas, Lewisite. The toxic action of mercury depends on its ability to combine with and block the functions of certain cellular chemical groups which are physiologically essential. Because BAL competes with these particular chemical groups of the cells for the heavy metal, the BAL replaces the mercury and a stable combination is formed which is rapidly excreted. This discovery has been so well established that every adequately equipped medical unit serving industrial or laboratory workers potentially exposed to toxic amounts of mercury now has BAL on hand for accidental acute poisoning. Because of the fact that the body stores mercury in certain cells of the body

which BAL cannot penetrate, chronic mercury poisoning has not be treated with this chemical.

Control

From the brief description of mercury poisoning given, it is clear that while deaths are few from occupational use of mercury, it is potentially disabling. The clinically detectable disease is well enough understood to be prevented, and with the experience accumulated and the skills at hand, there is little excuse for its occurrence. Engineering devices are used to keep the amount of mercury in the workers' zone close to the level of one-tenth of a milligram per cubic meter of air. The United States Public Health Service found that there was no evidence of mercurialism when laboratory workers (thirty-eight were examined) were exposed to levels of from four to seven-tenths of a milligram of mercury per cubic meter of air. Further studies by Public Health found fifty-nine cases of mercury poisoning among five hundred and thirty-four hatters in atmospheres of from two to five-tenths of a milligram of mercury per cubic meter of air. It is on this type of study that the American Standards Association bases its safe working level, at one-tenth of a milligram of mercury per cubic meter, where no cases of mercurialism will occur.

The air concentrations are conveniently studied by using the optical mercury detector produced by General Electric Company and used in the Public Health studies described. This apparatus can be carried about and readings are made directly. Ideally, an engineer with industrial hygiene training should interpret the meaning of the mercury air levels so obtained.

Renes and Seiffert made some wise recommendations after inspecting a group of laboratories, where they noted that mercury was handled in a shock-

ingly careless fashion. Floors should be scrubbed, they advise, with large amounts of soap and little water, then rinsed; cracks should be sealed by varnishing, and the floors should be waxed often; mechanical air exhausts should be used, and good housekeeping to prevent spillage is a must.

Medical control has been introduced in industry where mercury is a constant hazard and one difficult to control, as, for instance, in plants where barometers are made. Routine check-ups by a physician of mouth, skin, and kidney status, observation of early tremors by keeping a record of handwriting, regular urinalysis, and blood counts constitute this type of hazard control. Job rotation and care of any medical defects, supplementing engineering control to a safe level, can absolutely prevent mercury intoxication. Although it is a difficult procedure, quantitative analysis of urine for mercury can and should be made available for workers steadily exposed. Experience has demonstrated that amounts of mercury in the urine above twenty-five hundredths of a milligram per liter indicate that the individual is getting into his body, by inhalation, absorption through the skin, or ingestion, sufficient mercury to cause intoxication in most cases if continued. While air levels and urinary mercury excretion levels do not always correlate with clinical evidence of intoxication, they are, when well calculated and interpreted, concrete and responsible data that can be relied upon to prevent disease.

By this discursive résumé of available knowledge, it is hoped interest may be excited in the subject of occupational mercury intoxication. From the given facts, it is seen that mercury poisoning can be prevented. Those responsible for the practice current in American laboratories would therefore do well to inquire into the handling, by those working with them or under them, of this potentially dangerous and ubiquitous material.

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