

### **The Dangerousness of Mercury Vapor**

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When I am making the decision to report without hesitation to a wider circle about my personal problems, which ordinarily wouldn't concern others and would not be worthy of publication, I am driven by the intense desire to warn emphatically all those who have to deal with metallic mercury about the dangers of this unstable metal, and to save them from the horrible experiences which have spoiled a great part of my life. Today I can speak about them freely because luckily they have been concluded, and they are behind me with sufficient distance.

The insidious horror of mercury is not nearly sufficiently well known and is being taken note of too little in those places where one is particularly threatened by it, in chemical and physical laboratories.

For nearly 25 years I have suffered from ailments, which, in the beginning, arose only occasionally, then gradually got worse and worse and finally increased to unbearable proportions so that I disparingly doubted my ability to continue to work scientifically. The cause was understood neither by me nor many outstanding physicians. They thought that it was possible that it could be found in the especially narrow built of the nasal passages and an unusual irritability of the nasal mucosa. Because of this, I underwent decades of treatments of the nose with cauterizations, burnings, massages, electrification, and bloody operations. Without success. Two years ago--a few of my colleagues fell ill with similar symptoms--it was accidentally discovered that it had to do with an insidious poisoning by mercury vapor. In my chemical work, which involves testing of volatile substances by the "vacuum method," which uses mercury-tubs, -pumps, -manometers, and -valves<sup>1)</sup>, I had been in constant contact with mercury for 25 years.

Today there is no doubt about the diagnosis any more because all my symptoms, although not gone completely, have more or less been diminished<sup>2)</sup>, after having avoided inhaling mercury vapors for the last two years without the use of any other healing methods.

First I am describing the difficulties as they developed in me over time. They are identical to an insidious mercury poisoning in every detail. I was able to convince myself of this through my colleagues and other peers, who suffered and still suffer from mercury vapor poisoning. Some of them, it is noted, were not cognizant of the origin of their difficulties. Many pertinent symptoms have, up to now, been insufficiently described. At any rate, insidious mercury vapor poisoning has not received the attention it deserves.

With me the situation began with slight intermittent headaches and mild drowsiness, which increased gradually, over the years, to constant nervous restlessness and "jitteriness." Head-

pressure impaired the ability to think. It worsened and finally became an almost uninterrupted vexing headache (sits mostly over the eyes). I had strong vertigo, which was occasionally connected with visual disturbances (unclear and double vision). Soon the upper air passages were involved as well. This started with a slight transient nose cold. This was followed by a constant "stuffy nose," which later turned into severe nose, throat and sinus infections. They were followed, one by one, almost without interruption, by pussy, often bloody, mucosal discharge and scabbing, frequent sore throats and ear aches connected to auditory loss and loss of smell (some sense of smell remained; e.g. cyanic acid). There was a distaste for tobacco smoke. During the last years prior to recognition of the poisoning, there were added signs: a strong flow of saliva, a sour, insipid taste in the mouth, infections of the eyes and oral mucosa. There were little blisters, sensitive and sore areas on the tongue, the palate, the gums and the insides of the lips and cheeks. There was reddening of the gums and slight bleeding while brushing the teeth. There were toothaches, receding of the gums and formation of "pockets" and temporary loosening of individual teeth. The mouth and tooth signs revealed themselves only (in part they only reached their peak months after recognition of the poisoning) because, since my youth, I have been taking good care of my teeth (among other things nightly long rinses with 1 and 1/2% hydrogen peroxyde solution and sodium bicarbonate). If this hadn't been the case, I might possibly have become aware of the cause of my problems through mouth infections.

Other signs were: Mental weariness and exhaustion, lack of inclination and inability to perform any, particularly mental, work, and increased need for sleep. There were tremors of the spread-out fingers and also sometimes the eyelids. There was pain in various locations of the body, tearing in the back and limbs, and pressure in the liver area. At times, there were disturbances of stomach and intestinal activity, loss of appetite, sudden bladder pressure, isolated bouts of diarrhea, which occurred without other possible causes. There were sudden blistering rashes, e.g. on the insides of the arms and thighs.

The most depressing accompanying sign relating to mental work was the diminishment of memory. My memory, which had previously been excellent, left more and more to be desired and became worse and worse until, two years ago, I suffered from nearly complete memory loss.

Only with the help of extensive notes and great effort was I able to put together a scientific paper or deliver a lecture. I forgot the telephone number on the way from the telephone book to the telephone. I forgot everything that I had once learned by heart. I forgot the content of the book or theater play I had just read or seen as well as my own work, which had been published. It was impossible for me to remember numbers and names. Often even the names of good acquaintances were lost. Specifically, I lost the ability for arithmetic and mathematical figuring. Also my chess playing ability suffered. The impairment of memory, particularly that of people memory and the worsening ability to do arithmetic, seem to be signs peculiar to insidious mercury vapor poisoning. This showed itself in blatant form in my co-workers and other people whom I got to know who had been under the influence of mercury for a longer period of time. Soon after all of us in the laboratory had found out what was wrong with us, we sat down together to put down on paper a completed piece of work where we had to do a lot of mathematics. None of us was able to add up columns of ten to twenty multi-digit numbers without making mistakes.

While my physical ability, e.g. mountain climbing, did not seem to have been weakened, the ability to work mentally suffered a little, although not in as devastating a fashion as had been the case with memory. Added to that were depression, and a vexing inner restlessness, which later also caused restless sleep. By nature companionable and loving life, I withdrew moodily into myself, shied away from the public, stayed away from people and social activity, and unlearned the joy in art and nature. Humor became rusty. Obstacles, which formerly I would have overlooked smilingly (and am overlooking again today), seemed insurmountable. Scientific work caused great effort. I forced myself to go to the laboratory without being able to get anything useful accomplished in spite of all efforts. Thought came laboriously and pedantically. I had to deny myself working on solutions to questions beyond the nearest tasks at hand. The lecture that used to be a pleasure became a torture. The preparations for a lecture, the writing of a dissertation, or merely a simple letter caused unending effort in styling the material and wrestling with the language. Not seldom did it happen that I misspelled words or left out letters. It was not nice to be aware of these shortcomings, not to know their cause, not to know a way to their elimination, and to have to fear further deterioration.

All attempts to improve the situation went awry. Staying in the mountains for many weeks did not help. I felt hardly less ill than in Berlin. The nose treatments and operations sometimes brought short-lived, yet never lasting relief. It was peculiar that all mental difficulties disappeared for hours when the physician treated certain areas of the mucosa of the upper nose with cocaine. When the right spot was hit, headache and vertigo disappeared sometimes in a few minutes; memory, inclination to work, and good mood reappeared, but, sadly, only as fleeting guests. Sometimes I made use of this possibility to call them up before a lecture, an important meeting etc.

As already indicated, my colleagues in the laboratory, my assistants, doctorants [PhD Candidates], and female lab workers had already suffered for some time from all kinds of problems: Fatigue without recognizable cause, worsened memory, mild headaches and drowsiness, occasional digestive disturbances, limb aches, slight mouth inflammation, nose colds [runny nose], sinusitis etc. The difficulties expressed themselves differently from person to person, whereby they came to light foremost in the areas of lowest resistance. All of them showed fatigue and diminished ability to perform mental tasks [work]. But nobody had the idea that the cause of it could be the same for all of us. Only the convergence of several lucky/unlucky circumstances finally opened our eyes.

In 1921, out of frugality, we had switched off the much more expensive power consuming electrical ventilation system of the Kaiser-Wilhelm-Institute for Chemistry. Since the middle of 1923, two of my colleagues, an assistant and a Spanish guest, were working on gas density measurements, which required maintaining a constant temperature, and for this reason kept the windows and doors closed if possible. The work had to be done by the spring of 1924 because my assistant wanted to go into industry, and the Spanish colleague wanted to return home. The work was performed hastily so that our ordinarily scrupulous cleanliness suffered in every room. Spilled mercury remained unattended, and much of it lay under tripods, in cracks and slits between the floor boards and on tables. Thus the conditions presented themselves that, instead of the slow insidious mercury poisoning, the more easily recognizable acute mercury poisoning became apparent. The assistant fell ill more seriously, not only with headaches, mental fatigue

etc., but also with stronger bodily deterioration; with tooth abscesses and such. His brother, a physician, suspected that the symptom complex pointed to mercury poisoning. The experienced poison researcher L. Lewin [Louis Lewin, 1850-1929] whom we consulted checked out all laboratory personnel and declared that, based on his experience, he was certain that all of us were suffering from mercury poisoning. Indeed the test showed (according to the procedure described in the following memorandum) mercury in the air of the workrooms as well as in the urine of all involved. The mercury content of the air in the individual rooms was quite varied: Depending on the results of the specimens it showed thousandth or hundredth of mg, i.e. only a small fraction of what the air under saturation with mercury vapor can accommodate. At room temperature, taking .001 mm mercury saturation pressure as its base value, this figures to be about 12 mg per cubic meter. Since man breathes in about 1/2 cubic meter air per hour, and the inhaled mercury apparently<sup>3)</sup> is retained for the most part in the lungs, it would require a very extended period of time in mercury saturated air to suffer from acute mercury poisoning. However it takes a long time after inhaling mercury containing air before the poisoning becomes obvious. For one or more years the signs may be limited to fatigue and slow diminution of mental performance and memory. Thus the already mentioned Spanish colleague, for example, showed outward signs of inflammation of the oral cavity only at the very end of the year he stayed in our laboratory. The symptoms reached their climax months after he had left us, and after he was removed from the influence of mercury. He had noticed the mental effects much earlier without being able to explain the cause. "For me, it was," he said, "as if I was getting dumber and dumber in Germany." And I had to make similar observations with my remaining co-workers. Thus all my PhD candidates had difficulty withstanding the rigors of the doctor's exams. The PhD candidates and assistants recovered after a few years, once they had left the laboratory without being aware of the mercury poisoning. As for me, the effects of the minute amounts of mercury increased over the course of decades as described in the following narrative.

Particularly significant for insidious mercury poisoning is a noticeable coming and going of symptoms. Following a few days or weeks of improved well-being comes, sometimes setting in suddenly, a time of increased ill health. This also happens in the form of frequent relapses during the recovery period. As soon as my illness had reached its pinnacle, there were, as a rule, one or two tolerable days. Then the saliva flow, runny nose, and sinusitis, starting from the nose down to the throat and sliding down to the bronchi, increased again. There were tooth inflammations, highest fatigability and drowsiness, vexing headache, often also tearing and diarrhea. Headache, drowsiness and memory loss are connected to the irritation of the nerves leading to the upper part of the nose seen in the already mentioned effect of cocaine application on the nasal mucosa.

Apparently there are many similarities between insidious mercury poisoning and the better known lead poisoning. The [latter] is more thoroughly researched because it happens more often in industry. It, too, concerns mainly the nervous system and shows the same waxing and waning of the symptom complex<sup>4)</sup>. "After a period of health the poison can suddenly, without cause, display its effects again by evoking an attack of lead colic or other symptoms. This phenomenon can only be explained by the poison having been encapsulated for a long time in a place in the body to which, suddenly, the circulation has access again..."<sup>5)</sup>. According to F. Schuetz and H. Bernhardt<sup>6)</sup> lead deposits itself preferably in the spleen, gall bladder, and brain, and is primarily excreted with the bile, possibly also through the colon wall. The kidneys, in this case, are less involved in the acute and chronic course of poisoning. Mercury seems to act similarly. After one

year of excluding mercury as the cause of mercury poisoning, it could not be detected in my urine, in spite of the fact that there were still very strong signs of illness. The saliva, however, still contained mercury<sup>7)</sup>.

After we had recognized the source of our illness, our first worry was how to protect ourselves from mercury in the future. The first thing, of course, was to remove carefully everything on tables, in drawers, slits, cracks and joints, and under damaged areas of the linoleum flooring, whereby a modified "vacuum cleaner" (consisting of suction connection, suction bottle with a long rubber hose in front of which was attached a cut-burner type widened glass nozzle) served us well. We had the linoleum repaired. All cracks in the work tables were eliminated. The dangerous corners between floors and the so-called scrub molding were rounded off (putty, painted with oil paint) so that they were more easily accessible for cleaning. Wherever tripods stood for a longer period of time, the joints between tripod and table tops were also closed off with putty. All open mercury surfaces on tubs, manometer holders etc. were covered as completely as possible with fit-cut cellophane plates. We avoided eating in the work rooms or saving food and took especially good care cleaning our hands (particularly brushing our finger nails) after handling mercury. We also paid good attention so that no mercury fell into pockets and folds of the work coats. Moreover we gave full attention to the airing out of the work rooms by testing the success with air analyses (Compare the following memorandum). It was soon apparent that the reinstallation of the strong house ventilation system (very strong ventilators in the attic suck the air out through hoods; fresh air enters from channels through flaps above the doors) was not nearly sufficient enough to make the air mercury free. The situation in our laboratory is inopportune in that we are working with particularly many mercury apparatuses whereby open mercury surfaces and occasional sprinkling of mercury is not altogether avoidable. An added factor is that the work rooms in the very modern and well-built and furnished Kaiser-Wilhelm-Institut for Chemistry are so large (several hundred cubic meters air space) that the air does not get renewed fast enough by the ventilation system. In this regard smaller rooms may be advantageous because, naturally, the same ventilation works better and causes faster replacement of the air<sup>8)</sup>. Sufficiently airing ventilation, in this case, as it turned out, is obtainable only through constantly opening windows and creating a draft (regulated by temperature, windspeed, and - direction). At the same time the ventilation system is at work. Because it rests at night, the laboratory is being supplied with fresh air through opening the windows wide. This measure is repeated at noon. Thus we have succeeded in keeping the laboratory air so clean that traces are detectable only in small quantities, and we can continue working with our mercury apparatuses without having to fear new health problems.

Whenever one deals with mercury one should devote great care to the testing and cleanliness of the air. One should check the airstream situation in the work space<sup>9)</sup> and provide for as much fresh air as possible. It goes without saying that all work with mercury, if at all possible, should be performed under hoods<sup>10)</sup>. That is the only way that protects from damage with certainty. These precautions are necessary even if one has to choose the path through the Scylla of mercury poisoning and the Charybdis of a cold. A chemical removal of mercury cannot be obtained according to our experiences. It had been suggested to distribute sulfur powder or zinc dust in the work place. We also tried large foil flags that were hung in long rows from the ceiling. Although tin foil amalgamates quickly if you put it into a closed container next to mercury, it failed in this case: The mercury content in the air did not lessen noticeably; one tin flag (33 X 100cm area;

weighing 57g), which had hung for 11 months over a mercury apparatus, was weighed afterwards. It contained only .005 mg mercury.

The recovery from insidious mercury poisoning, after the removal of the poison source, takes place very slowly. Professor Lewin predicted this, and the development of our wellbeing confirmed this. The time period is visibly connected to the duration of the poisoning, and possibly also to how old you are. My co-workers who had left the laboratory were, thankfully, rid of their problems in the course of 1 - 2 years and have fully recovered the freshness of their thinking ability and memory. Nevertheless, even they had to suffer for a long time from relapses not only of mental but also of physical nature (particularly mouth inflammation). Some assistants and female lab workers continued to work here where they, unfortunately, cannot operate without mercury. Even today, after two years, they are still suffering from clearly visible, but steadily diminishing, after-effects of the poisoning. As for me, who was exposed to the damaging influences for over 20 years, the recovery apparently is taking the longest. All in all, I recovered the ability to work. I had only occasional relapses (headaches, drowsiness and mild mouth inflammation). Considering the course of the recovery up to now, I do not doubt, however, that my last co-workers and I will lose our symptoms completely. It seems that you have to count on it to take years to excrete the mercury again that took years to build up in the body. In this regard the following case has been educational to me recently, which at the same time proves that it is irrelevant for the course of insidious mercury poisoning whether the poison gets into the body via the lungs or through the skin<sup>11)</sup>

A medical assistant who had applied mercury salve therapy on his patients fell ill in 1905 with those symptoms (moodiness, headache, vertigo), which gradually got worse (fatigue, unbearable headache, oral inflammation, loosening and loss of teeth, constant runny nose, sinusitis, sore throat, ringing in the ears, hearing and vision disturbances). Only in 1911 was the situation recognized as mercury poisoning. The man stopped applying the salve therapy, but still needed many years before he lost his symptoms. After 1914, when he went to war he suffered from headaches and drowsiness. Today as a fifty-five-year-old he is again the picture of health and quite youthful.

It seems that an existing mercury intoxication preconditions a special sensitivity vis-a-vis renewed exposure from mercury vapor. Some of us who, at our work, and also during occasional mistakes with ventilation, had come in contact again with more mercury, noticed this soon because of the stronger symptomatology after the relapses. That is not surprising because, as the long development period of the insidious illness shows, a certain borderline value has to be reached before noticeable symptoms appear. The borderline value is certainly exceeded for a long time, even during recovery, so that each added amount of mercury worsens your wellbeing at once.

On doctor's orders we tried to hasten the recovery in various ways through use of diuretics and emetics, through hot baths and prolonged use of small amounts of sodium iodide. I do not get the impression that healing was particularly accelerated. The iodide has the reputation of bringing the metal into soluble form from insoluble organic mercury compounds. This is the form in which the mercury is probably anchored in the body. As far as I am concerned, there was no proof that significantly more mercury was excreted after addition of iodide. No progress was to

be expected from diuretics, as already mentioned, since the mercury excretion in the urine had stopped relatively soon altogether. The healing arts are sadly lacking in medicines that detoxify mercury in the body <sup>12)</sup>.

Exercise in fresh air is still best suited to make the subjective symptoms less noticeable. With milder headaches and vertigo Novalgin has been proven worthwhile as a palliative. All in all, it has to be left to time to become master over this destroyer of peace. For me even a four-week long stay in the high mountains and an ocean voyage to southerly latitudes brought hardly any progress, (which normally occurs with unaffected people), although, naturally, the mental relaxation helped the nerves.

Why were our illnesses not recognized sooner as being mercury poisoning? I have often asked myself this question, not without self-accusations. The first signs, those that preceded the oral signs of slow mercury poisoning, are hardly known by the medical profession.<sup>13)</sup> They consist only of fatigue, lowering of thinking and memory skills, slight headaches and drowsiness and rare occasional diarrhea. In the same way, it was little known until now that the nose and remaining breathing passages are being compromised in the form of a runny nose and sinusitis. But exactly these symptoms brought me and the physicians who treated me on the wrong track, and have been misleading in other cases that I have come to know about. Thus one of my assistants was treated for a long time for a sinus infection before the true cause came to light. By the way, balanced judgment of the bad situation becomes impaired in those who are affected exactly because of the existing drowsiness: "Quem Mercurius perdere vult, dementat prius!" [Whom Mercury wants to destroy, he first robs of his mind!]

At this time I would like to warn about a little known source of insidious mercury poisoning: It is amalgam tooth fillings. Professor Lewin suggested to me at once, when he noticed mercury poisoning in me, to replace all amalgam fillings--of which I had a considerable number in my mouth since early youth--with other fillings. Telling me this, he recalled a case of a university colleague who was at the edge of mental and physical collapse when the cause was found just in time. It was found in the numerous amalgam fillings stemming from the time when he was young. After their removal slow recovery followed.<sup>14)</sup>

Dentists used to prefer copper and cadmium amalgams and now often use the so-called silver amalgams for tooth fillings because these amalgams are easy to work with and fill out the cavities well. Silver amalgam is superior to the earlier named amalgams, which corrode and rot over time. However it, too, releases mercury at room temperature as the following assays<sup>15)</sup> proved to us:

We enclosed silver amalgam samples in an evacuated glass tube, which was bent [in the middle] at a ninety-degree angle with the ends melted shut. The horizontal tube shank with the amalgam piece was kept warm at 30-35 degrees C; the other shank serving as a receptacle, was cooled with ice or liquid air. We then measured the mercury that had sublimated in the receptacle in all cases.

- I. Amalgam piece carefully made for this purpose by dentist in the state-of-the-art method from metal powder and mercury: .801 g. Enclosed by melting into glass tube 24 hours after manufacture. Warmed [30-35 degrees] for 23 days. Receptacle in ice. Distilled mercury = 11.2 mg

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- II. Same as above: .810 g. Kept for three weeks to make hardening as complete as possible. Only after that period of time was it enclosed by melting into glass tube. Warmed [30-35 degrees] for 12 days. Receptacle in liquid air. Distilled mercury = 15.3 mg
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- III. Amalgam piece made by taking care using as little mercury as possible: 1.000 g. As in II. was kept in the open for three weeks. Warmed [30-35 degrees] for 9 days. Receptacle in ice. Distilled mercury = 8.2 mg
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- IV. Amalgam filling, which had been in a tooth for years and had fallen out: .894 g. Warmed [30-35 degrees] for 14 days. Receptacle in liquid air. Distilled mercury = 29.4 mg

Without doubt, the fillings that were used here in the laboratory would have allowed mercury to evaporate from the mouth as well and supplied the inhaled air with a small amount of mercury, which, in the long run, has to be harmful. The old copper and cadmium amalgams are likely to be even more harmful.

For some time, one of my faculty colleagues had been suffering from occasional headaches and drowsiness the cause of which he couldn't explain. After he had an old amalgam filling removed, which had caused a slight infection near the tooth in question, his symptoms disappeared gradually. After its removal the filling showed itself as crumbly and laced with mercury droplets, throughout.

Dental medicine should do without the application of amalgam as means for filling teeth altogether or, at least, wherever at all possible. There is no doubt that many complaints such as fatigue, memory weakness, oral inflammation, diarrhea, lack of appetite, chronic runny nose and sinusitis are sometimes caused by mercury that has been directed to the body from amalgam fillings, maybe only in small quantities, but constantly. The physicians should give this fact the most serious attention. Then it will probably become apparent that the frivolous introduction of amalgams as tooth filling device was a nasty sin against humanity.

Insidious mercury poisonings are certainly much more common than ordinarily thought. This is true particularly for chemists and physicists who so often have to work with it. The great danger here is being noted much too little, and the true cause of symptoms and illness is often not recognized. In literature you find almost nothing about this.<sup>16)</sup> Since the discovery of our misfortune I have found out about a dozen certain cases of insidious mercury poisoning, just in the circle of my acquaintances. They almost always have the same symptoms. Often the correct cause was missed and therefore the correct treatment was missed as well. An important example is that of a foreign colleague who had been working with mercury apparatus' for a long time. When he visited me and I asked him whether he had ever felt any mercury poisoning, he decidedly said that he had not. Upon further questioning about his health he then admitted: "I am in bad shape. For years I have been suffering from neurasthenia and had to stay away from the



laboratory from time to time." The doctors had tried all kinds of things with him. They had treated him for stomach, intestinal, and ribcage disease with a special diet etc. In reality what he had been dealing with was full-blown mercury poisoning without doubt.

One unknowing victim of mercury poisoning has probably been Faraday. In the last two to three decades of his life, which came to an end in his late seventies, he was bothered increasingly by health problems, which made his scientific work more and more difficult, and which played a significant role in his letters and descriptions of his life. They were diagnosed by physicians as neurasthenia and early onset arteriosclerosis. They consisted of, at times, strong mental and physical fatigue, "irritable weakness," headaches, vertigo, "rheumatism" and, more than anything else, constant increasing memory loss.<sup>17)</sup>

Faraday, being spared serious "bodily" illnesses, was even in old age a strong hiker and swimmer. But he avoided people for the last third of his life. Scientific work, including his lectures, were continued with long interruptions into the last decade of his life. It is heart rending to read in the great researcher's letters that he went to see his physician friend so often to complain to him about vertigo and headache, that he couldn't remember names, that he was losing the connections with his colleagues, that he was forgetting his own work and notes, that he was forgetting his letter writing, and that he didn't know any more how to write words. "The affected organ is my head. The result is loss of memory and clarity and vertigo." All these symptoms make it most likely that Faraday suffered from an insidious mercury poisoning from the vapors used in the laboratory. It makes you shudder to think how, in all likelihood, this rich intellect could have been freed from this suffering, and what gifts he could have given to science if the cause of his illness could have been recognized and remedied.

Maybe--Professor Jaensch (Marburg) brings this to my attention--the mysterious sickness the mathematician, physicist, and philosopher, Blaise Pascal (1623-1661), succumbed to when he was still young was mercury poisoning. Pascal worked with mercury in his well-known barometer research. His suffering from sustained headaches, vertigo, toothache, loss of appetite, and lasting bad colic complete the picture of advanced slow mercury poisoning.

No doubt mercury, the use of which sadly cannot be done away with in research, has done heavy damage to science in the past as it still does today in the way it curtailed the output of many a researcher. May this present-day warning help us pay better attention and avoid the dangers of this insidious metal.

Please view the bibliography in the original article: [Die Gefaehrlichkeit des Quecksilberdampfes, von Alfred Stock \(1926\)](#)