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Scientific Adventuring and Misadventures

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Scientific Adventuring and Misadventures

by

Dr. Thomas L. Shipman

and

Roy Reider

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SCIENTIFIC ADVENTURING AND MISADVENTURES

by

Dr. Thomas L. Shipman and Roy Reider

FOREWORD

This talk was given as a banquet speech at the AEC and Contractors Safety and Fire Protection Meeting, Argonne National Laboratory, September 19, 1967, by Roy Reider, Safety Director, Los Alamos Scientific Laboratory. It is distributed as a report because of the interest shown.

This starts off with the "A-Student." There is little doubt any more that it is the "A" student of high school age who gets involved in more chemical laboratory accidents than the poorer student. It is equally clear that sheer intellect alone does not account for this misadventure differential. It appears that girls of equal academic standing do not get into difficulty as frequently as the boys. The best explanation for this difference is that experimental science is an adventure form. Not only are these bright kids, boys primarily, experimenting near the limits of their knowledge but also they are eager for dramatic things to happen. Later we will discuss this problem without confining it to youths.

Today's students can do more sophisticated experiments. A tragic accident of

this sort occurred several years ago when a 16 year old leading chemistry student made private plans for marking July 4th. Using calcium carbide and water he generated acetylene. The acetylene was passed through a solution of silver nitrate with ammonium hydroxide added to control the pH. The precipitate formed was silver acetylide, a unique and useless explosive compound of extraordinary sensitivity whose products of decomposition are entirely solids, elemental silver and carbon. The precipitate was filtered and moved out of the home laboratory on filter paper in a glass container. In the appropriately isolated location some elemental potassium was placed on the moist silver acetylide. The sharp explosion pulverized the glass depositing an infinite number of particles of glass, carbon and silver in the face,

hands and eyes. Present visual ability is limited to perception of light and dark.

An answer to similar problems has preoccupied man from the beginning of recorded history: Does one impose absolute restraint? Does one shake the head, wag the finger? The Old Testament suggested in Proverbs 22:6, "Train up a child in the way he should go, And even when he is old he will not depart from it." And in Proverbs 23:13, "Withhold not correction from the child."

We recognize the problem is not unique to young people. It is merely that the moral responsibility is greater. Our official responsibility is not age-limited, so any form of scientific adventuring requires our attention and best efforts.

A grave misadventure in a pseudo-science inquiry occurred at Los Alamos in 1946 in an experiment to find a suitable location for a reactor exhaust stack. Several people, engineers and technicians, wanted to study wind currents by observing smoke dissipation. Out of a formulary reference book they obtained a relative proportion mixture of a variety of ingredients. The list of materials and the quantities used may strain credibility but it is true:

Sugar.....2-1/2 pounds
Potassium chlorate.....3 pounds
Magnesium metal chips...1/4 pound
Barium nitrate.....1/4 pound
Red phosphorous.....1 pound

The phosphorous was being added to the other material when the incident, described as an "explosion," occurred. One man died soon afterwards, two were blinded. Three of the men planning the work were university graduates. Fabricated smoke bombs were available and it was affirmed

subsequently that the men were notified of this. Accepting this as true one must believe that adventure was being sought rather than an understanding of wind currents.

The valiant experimenters of the late 18th and early 19th century depended almost exclusively on personal observation. They had little instrumentation. These natural philosophers insisted on touching, smelling, tasting, and self-experimentation. The following letter to a scientific journal is only slightly reworded for brevity:

"Dublin, 1814

Carbon monoxide was discovered in 1801; it is combustible, burning with a blue flame, incapable of supporting life.

The experiments of Davy on the respiration of nitrous oxide in 1800 dissipated apprehensions of fatality from the inhalation of compound gases, and demonstrated that many gases, before considered as destructive to vitality, might be breathed with safety.

Desirous of witnessing the effects of carbon monoxide when respired, with a view to analogy to nitrous oxide, I was tempted to inhale it copiously. The consequence was nearly fatal. I made three or four hearty inspirations of the gas, having first exhausted my lungs of common air. The effects were a sudden deprivation of sense and volition. I fell supine on the floor for half an hour, apparently lifeless, pulsation nearly extinct. Several medical gentlemen being present, various means were employed for my restoration, without

success. The introduction of oxygen gas by compression into the lungs was suggested, the effects of which were dramatic. A rapid return of animation ensued, though accompanied by convulsive agitations, head-ache, and quick irregular pulsation, and, for some time after mental recovery, total blindness, extreme sickness and vertigo, with alternations of heat and shivering cold, were painfully experienced.

I very much regret the confusion arising from fear of my death so disturbed everyone that no accurate determination was made of the quantity of gas respired. The experiment is rather too hazardous for repetition. Nevertheless, the extraordinary efficacy of oxygen gas in cases of suspended animation produced by suffocating gases is fairly deducible. I hope the results of this experiment may be of practical utility in those cases which are often so awfully fatal. It is the decided opinion of the professional gentlemen present on this occasion, that the free use of the oxygen* gas was solely instrumental in restoring me to life.

Mr. Higgins himself had nearly once fallen a victim to a similar experiment with sulphuretted hydrogen, the effects of which, after recovering from a death-like insensibility, were painful and

oppressive for many days.

I am your obedient servant,
Samuel Witter"

The Swedish chemist, Scheele, who discovered hydrofluoric acid and started fluorine chemistry had a bad, but typical, habit of sniffing and tasting any new substances he found. He died at the early age of 44, after many years as an invalid.

It is not certain exactly when Franklin flew his kite but he should have had some idea of risk although perhaps not the degree. It is clear that his kite experiment followed the "sentry box experiment." In the "sentry box experiment" a long, grounded rod reached 30 feet above the house top; the experimenter sat in a sentry box, dry and insulated, within the house, and stretched out to the long rod a shorter hand-held rod heavily coated with wax at the handle. Electric sparks were then drawn off the long rod. When Franklin reported his kite experiment about 1752 he said, "When rain has wet the kite and twine so that it can conduct the electric fire freely, you will find it stream out plentifully from the key on the approach of your knuckle."

Shortly after this (1753) an experimenter, Richmann, was electrocuted in St. Petersburg. He was, however, trying to measure quantitatively the electricity in a lightning discharge using an ungrounded test rod. This was the first fatal accident to occur during an electrical experiment and it was widely discussed throughout the world.

In more recent times an attempt was made to utilize the high potentials developed in the atmosphere during electrical storms. Two German investigators in 1932 stretched an insulated cable across a

*Note here Witter's perception on the effectiveness of pressurized oxygen for asphyxia.

valley between two peaks in the Alps; from this cable a conducting cable supporting a terminal was suspended. During thunderstorms high potentials would develop between this terminal and a grounded terminal on the valley floor; sparks several hundred feet long were obtained. Plans had been made to install a discharge tube for the acceleration of particles, but experiments were abandoned when one man was killed.

The early scientific investigators were motivated towards safety almost exclusively from the leverage of self-preservation. This self-motivation for preventing accidents depended primarily on understanding what kind of accidents could occur and what were their consequences. If this knowledge of accidents is speculative or just not known then the risk is higher.

But modern investigators are also motivated by direction. Support for scientific programs, increasingly large and complex, imposes a directed prudence. Safety standards with almost the force and effect of law appear from all directions.

Yet, adventuring in science is by no means a problem only of past generations.

In the exciting work of the early 1960's Bartlett of the University of British Columbia and a co-worker were developing compounds of the noble gases. Only 0.39 gram of XeF_4 were dissolved in water and then evaporated under vacuum at room temperature. The remaining white solid exploded, shattering the glass vessel which was being closely observed by the experimenters. Serious eye injuries were inflicted on both investigators.

At an AEC affiliated laboratory early in 1967, an employee was interested

in the optical behavior of liquefied gases as they cross their critical temperatures. Carbon dioxide was liquefied in a heavy-walled glass capillary tube by cold trapping with liquid nitrogen. The filled tube was sealed off. It was then to be transferred into a pipe-fitting safety container while still cold and allowed to warm up. This entire assembly was to be cycled several times from 0° to 50°C to overpressure test the glass. This would have been followed by cooling down to -80°C , after which the pressurized capillary would be set behind a safety glass barrier so that a strong light could be projected to allow observation of the interface as the temperature was raised and lowered across the critical point. The critical point for CO_2 is 31.1°C and 73 atmospheres.

This plan was interrupted by a ringing telephone just at the point where the capsule had been sealed, removed from the liquid nitrogen, and placed on a wad of paper in which it was to be wrapped before insertion into the safety container. The experimenter answered the phone. An unspecified few minutes later he returned and picked up the capsule and wad of paper to put them in the pipe-fitting. Just then the capsule, about the size of the top of a fountain pen, blew up with a sharp report, reducing the glass to sand-sized particles. He was wearing safety glasses so no serious or disabling injuries occurred although he had about 100 cuts about the face and hands.

It is sometimes difficult to decide when adventure stops and scientific investigation begins, or vice versa. In March, 1927, Captain H. D. Gray, of what was then the Army Air Corps, ascended to 28,910 feet in a free balloon for an American altitude

record. Two months later, May 4, Gray reached a world record height of 42,470 feet, but he was forced to bail out, so that record was not official. Six months after that Gray ascended to the identical altitude of his May flight, 42,470 feet but did not survive the flight.

Daring investigations of the sea depths have interested scientists and adventurers alike. The dividing line is blurred. A marine biologist, Limbaugh of California, failed to come out of a long cave penetration in an undersea-underground river in France. A young Swiss mathematician, Keller, tried to forward diving techniques by experimenting with light gas and O_2 mixtures. He reached a simulated depth pressure of 810 feet for about 30 seconds, followed by a 49 minute decompression. By 1961 he had actually dived 700 feet. But at 1000 feet an accident occurred resulting in the death of a co-worker and a rescuer.

A modern, public or private, well-supported scientific laboratory would not long endure such a haphazard approach to experimentation that safety cannot be reasonably assured. Yet without compromise to the safety of personnel, property, and programs one can avoid unnecessary restrictions. The significance of absolute restraint is not difficult to recognize. Conversely, it is not clear that science requires a free assumption of risk for progress. What is abundantly clear is that modern society will no longer permit the application of new knowledge without regard to human and esthetic consequence.

Any new employee with academic experience only may need the kind of attention he may not have had from his professors. He will now be faced with multiple

safety rules, with a requirement for a review of proposed procedures. While professional health and safety people cannot stand at the elbow of every new employee, nor should this be their job, each new employee has a supervisor of some sort who must be made unequivocally responsible for the directed actions given the new man. He must be made quickly aware of the legal, social, ethical, and contractual responsibilities imposed on his principals from a variety of sources.

Perhaps our greatest challenge in this increasingly complex world is the real understanding of the nature and consequences of misadventures. Understanding is hardly enough. Dissemination by directive, by instruction, by example, by publication, continuously and imaginatively, should be one of our loftiest aims.

Now where do we fit into this? We certainly have a clear responsibility to keep bodies and souls intact. We are, however, in a difficult spot. Certainly we do not want to be guilty of stifling ingenuity and inventiveness simply by saying "No." There is an unfortunate tendency for those engaged in the broad field of industrial safety to acquire the reputation of being obstructionists.

First of all we must accept the fact that our mission is to help rather than to hinder. We must so conduct ourselves professionally that we maintain the confidence of every supervisor. He must know that we are friends of a particular ability who are anxious to help him get his job done, that we are the proper people to come to for advice in advance of the fact, not after trouble has raised its ugly head. It is the supervisor who must impress on his charges the fact that safety

engineers, industrial hygienists, health physicists, and physicians are not his natural-born enemies. They are interested in helping him accomplish whatever it is he wants to do, assuming that his supervisor is in agreement.

All we should ask is that these bright young men work in a prudent manner, with all that this implies. More often than not this prudence will involve seeking advice and assistance from someone else. This all adds up to developing good habits of work, habits that will insure greater chances of productivity and success. What better way

can we protect the investment which is in part our responsibility.

Make no mistake, this is not an easy assignment. It calls for a high degree of technical competence coupled with a high degree of ability to demonstrate this competence. But keep in mind the words of Laënnec, the physician who invented the stethoscope: "Do not fear to repeat what has been said. Men need the truth dinned into their ears many times and from all sides. The first makes them prick up their ears, the second registers, and the third enters."