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Diagnosis of Explosions

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pick. It is absolutely necessary to have a properly fitting key to effect a release.

Strait jackets are difficult to escape from. The modern types with zipper fasteners are almost, if not actually, impossible to get out of. Houdini did escape from strait jackets that were in use at the time he was performing and the only trick involved was to swell out his chest and stiffen his arms prior to being bound up, and then relax and go to work—and work it was, for he would be quite exhausted by the time he had accomplished his release.

There are in use today, in the United States, leg shackles of the same general design that were used by the early Egyptians, i. e., two curved irons to lock around the ankles. These ancients used a pointed bit of steel to spike the eyes of the curved portions together, while in Georgia today, their road-gang shackles are riveted together! Feature yourself being riveted to a pair of steel leg shackles for a period of years!

A few months ago an Oklahoma Sheriff passed through Kansas City with three prisoners. They were locked together with a long chain affair. This was wound around each prisoner's neck and locked with a pad-lock!

Not so long ago a prisoner in a Kansas Jail made a key from a broom handle and escaped from the jail house in a hurry. He left a note telling how the key was made! At Police headquarters in Kansas City there is a collection of several hundred different kinds of lock picks. A New York key firm sells a device with which anyone can readily ascertain the right tumblers to turn in any tumbler lock. I have seen a lock opened with a rubber bulb. The bulb was pressed quickly and turned gently until the lock opened! It has been said that the only lock that cannot be picked is in Yale!

In writing this article it was not my intention to disqualify any certain type of manacle or locking arrangement, but to set forth a few facts and to show in pictures some fettering devices of past and present times. Your attention is directed to the photographs under which the parentage of each device is set forth.

THE DIAGNOSIS OF EXPLOSIONS

Augustus H. Gill[1]

An explosion has taken place—what caused it? In many cases the answer is perfectly obvious: There are parts of an infernal

[1]Massachusetts Institute of Technology.

machine or bomb, a subterranean tank or pipe partly full of gasoline, a ruptured gasoline drum, a leaky bell-and-spigot joint in a gas main, or a fresh break. In other cases the explosion burned up the evidence, and the question arises: Do certain agencies leave peculiar marks or show distinctive phenomena?

The center of the explosion can usually be determined, as the wreckage radiates from it like the spokes of a wheel; this was noticed by Munroe in the gas explosion at the Capitol in Washington.[2] Explosions are caused by high explosives, gases, inflammable liquids, finely divided combustible solids, and the giving way of pressure vessels, as steam boilers, autoclaves and the like. The diagnosis of these last is a problem usually for the engineer rather than the chemist.

High explosives as dynamite, nitroglycerine and T. N. T., act by very suddenly setting free a huge volume of gas—expanded by the high temperature of the explosion. The wreckage from these explosions is very characteristic. The speed of the explosive wave is so great, some 26,200 ft. per second for nitroglycerine and 700 ft. per second for black powder, that wooden buildings are shattered, splintered, and literally split into kindling wood. The writer has seen, with wooden buildings, the clapboards ripped off and splintered, brickbats from the chimney blown through the house wall and several lath-and-plaster partitions, and 2" x 4" joists shot into the building like so many huge spears. In another case, pine sheathing was demolished and broken into arrow-like splinters which were driven into a signboard across the street like arrows into a straw target. A balloon shaped cloud of smoke was seen rising from the spot, dark colored from unburned carbon, a peculiar odor and even a bitter taste were said to be noticed.

In these cases there was no doubt of the cause being a high explosive rather than gas. The freshly broken gas main which was found, was the sequence rather than the cause of the explosion. Had it been a gas explosion, as was claimed, no black smoke would have been formed. Gas explosions being smokeless, any "smoke" would be entrained or stirred-up dust. There would have been little or no splintering, the speed of the gas wave being lower than in that of the high explosive.[3] The difference in the result is due to the speed and volume of explosive gas taking part. The parts are *pushed* apart *slowly*, compared with the *ripping* apart of the high explosive.

[2] J. A. C. S. *21*, 317.

[3] The speed of the explosion wave with hydrogen and air is 437 cm., about 14 ft. per second. J. Chem. Soc. *109*, 83-89 (1916).

It is as if a wooden box were beaten apart and to pieces by a mallet and by a charge of shot. No odor would be perceptible.

After a *gasoline explosion* the conditions are much the same as with a gas explosion. However, smoke is usually formed, and an odor of unburned, or partially burned gasoline often persistently clings to the wreckage; and the burning is at the *bottom* of rooms or enclosed spaces, as the gasoline is 3.5 times as heavy as air.

In a *gas explosion* the characteristics have been stated already in contrast to those already considered: there is no smoke, and no clinging odor of unburned fuel, and the burning is at the *top*, gas being 0.6 times as heavy as air. In a building of rough boards, or a cellar, the roughness of the ceiling boards and timbers, produced by the saw—the saw kerf—would be singed. Pressures in a closed bomb up to 90 lbs. per sq. in. have been noted.

With combustible solids the results of their explosion rival those of a high explosive. Munroe[3] cites the explosion at the Washburn flour mills in Minneapolis in 1878. This came from the ignition of the impalpable dust that floated in the air of the mill and settled everywhere throughout the milling room: the feed of one of the mills became interrupted causing it to send out a flame which scattered the dust and ignited the dust-laden atmosphere. The explosion which followed razed walls of solid masonry 6 feet thick at the base; sheets of corrugated iron roofing 2 ft. x 6 ft. were thrown two miles. Plate glass windows a quarter of a mile distant were blown out sash and all; flames and smoke estimated to have been carried 600-800 feet into the air; a wave 18 inches high was produced on the adjacent river.

When one considers that there is sufficient energy in the ordinary sack of flour to raise 2500 tons 100 feet into the air, the results of this explosion are not difficult to explain. This unfortunately was not an isolated case; a number of similar explosions have occurred since in various parts of the world.

The violence of dust explosions has been often remarked upon. Some of these dangerous dusts have given pressures up to 100 lbs. per sq. in., pressures nearly three times that being measured in others. The velocity of the wave with coal dust is from 2273 to 3300 ft. per second.

Dusts may be classified[4] as follows: (1) Those which ignite and propogate flame readily, the source of heat being comparatively small, as a match. Such are the carbohydrate dusts from sugar, starch, wheat-smut, etc., (2) Dusts which are readily ignited, but re-

[4]Brown, Ind. and Eng. Chem. 9, 269 (1917).
(1914).

quire a source of heat both of high temperature and long duration to propagate flame. Examples of these are horn and oil-seed dusts, such as castor and mustard. (3) Dusts which appear to be incapable of propagating flame, because slow burning, and do not form a cloud readily, as aluminum, spices, cotton and soya-bean dust. In this connection the fact should not be overlooked that 100 mesh celluloid powder can be classed as an explosive. A .38 bullet can be shot with it through 2⅜" of soft pine. At 11.1% nitrogen, celluloid contains some penta- or hexa-nitrate, which are gun cottons.

A puzzling situation was formerly caused by "Edison gas." It was discovered when the former Edison electric mains, consisting of two or three half-inch or larger, copper wires wound with rope, drawn inside a 3 in. iron pipe, filled with a mixture of linseed oil and asphalt, were uncovered in an excavation, and consequently overheated, that an inflammable gas developed. Gas company repair gangs have repeatedly been called to take care of a flame issuing from a pavement, only to find on digging down that it came from an *electric rather than from a gas main.* The mixture used will yield from a pound, 5-7 cu. ft. of a gas closely resembling illuminating gas. A gas of somewhat similar composition can be made from the grease contained in the present new lead-sheathed paper-insulated copper cables, and has in practice given rise to a severe explosion.

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