BREAK THE FLAME CHAIN REACTION

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Since man first discovered how to start fires he has been trying to find better ways to put them out. Water, if properly applied, is effective but is not always readily available at the fire site and may be difficult to transport over the required distance. Many investigations have been made and others are in progress to discover some effective chemical fire suppressant.

The Department of Forestry has had some success in experimental control of fires with various combinations of dry chemicals. Although a report on these experiments is not yet available since the project is still under way, a review of the literature on chemical fire control reveals many interesting findings by various investigators.

One of the earliest studies was by Gay-Lussac in 1820, who investigated the "fireproofing" action of certain salts on cellulose. He divided the salts he found effective into two classes: those melting to form an oxygen-excluding coating, and those liberating inert gases to dilute the combustible gases.

In 1928, C. A. Thomas and C. A. Hochwalt in *Industrial and Engineering Chemistry* reported on a lengthy series of experiments using various salts to extinguish flames in gasoline. With a few minor exceptions every element capable of forming a water soluble salt was studied. The results of their experiments showed that the liberation of carbon dioxide was not the mechanism by which the chemicals extinguished fire. Rather, the extinguishing effectiveness increased with an increase in the atomic weight of the metal in the compound. With one or two minor exceptions only compounds containing alkali metals appeared to possess extinguishing ability; the radical to which the alkali metal was joined played an important part and, in general, the oxygen-bearing radicals were more effective.

J. G. Wright, Dominion Forest Service, in an unpublished note of September, 1931, described a demonstration of a fire extinguisher containing sodium carbonate, magnesium carbonate, calcium phosphate, and magnesium stearate. This extinguisher seemed very effective when used directly on oil fires and when used to form a narrow barrier in front of a running grass fire.

C. S. McCamy, H. Shoub, and T. G. Lee in a paper presented at the Sixth International Symposium on Combustion, New Haven, in 1957 recorded the results of a series of tests using various powders in a standard commercial extinguisher. In addition, one test was made with the extinguisher charged only with dry nitrogen and no powder. The result of their experiments indicated that the mechanisms of throttling, cooling, blowing out, smothering, and diluting are of minor importance in the action of dry powder extinguishers. They concluded that extinguishment was due to two mechanisms, shielding and chain-breaking the reaction of combustion. A series of measurements made of the optical properties of commercial dry chemicals dispersed in air seemed to show a trend towards increasing effectiveness with increasing particle weight. They concluded that the combination of fineness and dispersibility of powders

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had some correlation with their effectiveness. Salts of alkali metals appeared to be particularly effective.

In a paper delivered at the First International Symposium on Fire Research, Washington, D.C., 1959, T. G. Lee and A. S. Robertson of the National Bureau of Standards reported on a series of tests using sodium bicarbonate, potassium bicarbonate, potassium iodide, and potassium oxalate monohydrate to extinguish fire. A similar series of tests was tried using small glass beads as the extinguishing agent. The glass beads required a relatively high application rate, suggesting that a thermomechanism is not sufficient to explain flame extinction. It appears that both the chemical nature and the particle size of the powders influenced the application rate required for extinguishment.

This view was strengthened when a comparison was made between the data obtained at The National Bureau of Standards, and at the Naval Research Laboratories, as well as with those from British investigators. There was general agreement of the data from all these experiments.

In a paper presented at the N.F.S.A. Convention in Australia in 1959, G. J. Dole of the Monsanto Chemical Company pointed out that the burning of cellulose is a dichotomous reaction with a gaseous oxidation phase, termed flaming, and a solid combustion phase, known as glowing. These two simultaneous reactions are quite distinct and independent of each other. Therefore chemicals are termed either flame retardant or glow retardant, depending upon which reaction they inhibit. Not many of the fire retardant chemicals possess properties capable of affecting both types of combustion, but the phosphorous group is among the few possessing both qualities.

L. Scheichel in *Types, Mode of Action and Limits of Applicability of Dry Fire Extinguishing Powder*, U.S. Naval Research Laboratory Translation No. 654, discussed the new ABC powders which contain additives to suppress afterglow; these are effective against wood fires. In an anticatalytic and antioxidant effect, the dust particles of these chemicals furnish "walls" at which the chain reaction of combustion is terminated. The glow inhibitor exerts an antipyrogenic effect on the surface of burning solids. Thus, unlike earlier dry powder extinguishants, these are effective on wood fires. A typical formula for these powders contains sodium bicarbonate, ammonium sulphate, alkaline earth carbonate and may also contain urea-formaldehyde, phosphoric or boric acid and their compounds.

With the increasing interest in chemicals for fire control the remarks of K. Arnold, Director of the Pacific Southwest Forest and Range Experiment Station, Berkeley, California, have a prophetic ring. Addressing the Western Forest Fire Research Council in 1959 he said: "Recent research has outdated that old familiar fire triangle concept. In the light of new findings it must be refined to a square. In this new fire square, heat, fuel, and oxygen remain but another factor—the free-radical chemical chain reaction in the flame itself—is recognized as a fourth essential to the existence of fire. Consequently in fire extinguishment, an additional term must be added to the old fire fighting formula of 'remove the fuel, reduce the heat, or eliminate the oxygen'. Simply stated, it is 'break the flame chain reaction'. In this fourth term may lie the future key to forest fire control."

Forest fire research groups in at least three widely separated countries are currently trying to develop suitable means for taking advantage of the flame chain breaking principle in the suppression of forest fires.

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