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THE SPRAYER-DUSTER AS A TOOL FOR FOREST FIRE CONTROL

D. G. FRASER

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ABSTRACT

A back-packed, air-blast-type machine designed to apply herbicides and insecticides, was tested as a forest fire control device using dry-powder extinguishants. Filled with ABC-type dry powder the machine extinguished fires burning in small test cribs of pine slash, but could not — perhaps because of low capacity — control a fire in a section of a red pine plantation. Test results suggest the possibility of controlling crown fires with dry chemical extinguishants. (The machine also quickly dried unlined forestry hose.)

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THE SPRAYER-DUSTER AS A TOOL FOR FOREST FIRE CONTROL

by

D.G. Fraser[1]

INTRODUCTION

Various types of air-blast sprayer-dusters for dispersing herbicides, insecticides, and other chemicals are available. One of these, the Solo sprayer-duster, a back-packed machine, has been tested at the Petawawa Forest Experiment Station as a fire suppression tool and other purposes.

The Ontario Department of Lands and Forests used this type of machine experimentally in the control of fires burning in grass and other light fuels. The machine was employed successfully to direct a blast of air at the leading edge of the fire, blowing the flames back onto the burned fuel and snuffing them out.

German experience (Kortge, 1961) indicated that a large dusting machine using a dry powder chemical extinguishant was a useful piece of fire control equipment. The Solo's ability to deliver a high volume of dust with a high-velocity air stream indicated that the machine could be used to project dry chemical extinguishant onto a fire. In areas where water for fire fighting is lacking or scarce, the easily transported dry chemical might have logistic advantages. Field tests using the machine and various dry chemical extinguishants were conducted at the Petawawa Forest Experiment Station during the 1962, 1963 and 1964 fire seasons.

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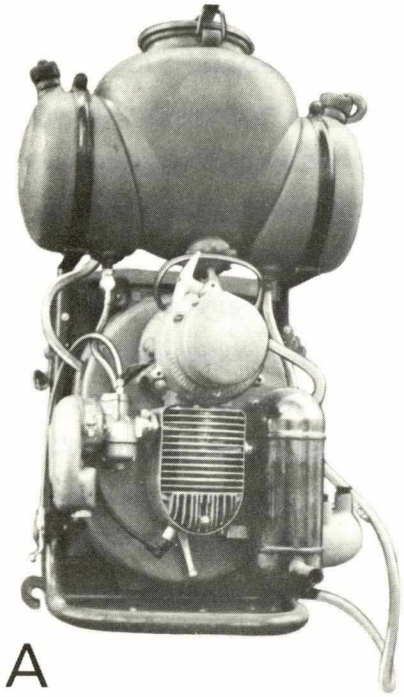
[1]Research Officer, Department of Forestry and Rural Development of Canada, Forest Fire Research Institute, Ottawa.

DESCRIPTION OF MACHINE

The Solo sprayer-duster (Figure 1) consists of a high-efficiency blower driven by a 2-cycle, air-cooled gasoline engine. The blower is connected to the jet pipe, or nozzle, by a flexible hose. The solution or dust to be applied is propelled and atomized by an air blast with a nozzle velocity of about 225 miles per hour. Before entering the blower the air is drawn past the cylinder of the motor, thus providing adequate engine cooling. The unit is mounted on a back-carrying frame cushioned by two rubber elements. The front of the carrying frame is fitted with an inflatable air-cushion which absorbs any remaining vibration and evenly distributes the weight over the operator's back. Canvas shoulder straps with snap-on hooks are provided for carrying the unit. Extensive use has been made of aluminum alloy and plastic in the construction of the unit and as a result, even when the gasoline and spray tanks are filled, the total weight is only 42 pounds.

The sprayer rides comfortably on the operator's back and is not tiring to carry for extended periods. All moving parts are enclosed and the only hazard to the operator is the danger of a burn from the engine muffler. He must place the machine on the ground to start the engine and if it should swing sideways as he pulls it up onto his back his elbow may come in contact with the muffler. One experience of this is sufficient to ensure safe practice in the future. The operating manual recommends having a shoulder-height stand so the user can get the machine on his back easily with no danger. This is not always possible in forest operations but if the operator holds his right arm high when pulling the unit onto his back there is no danger of a burn.

The primary use of this type of equipment is for applying herbicides and it is most useful for controlling growth on fire access roads and fire lanes. Since the herbicide is mixed with air rather than water in this type of application there is



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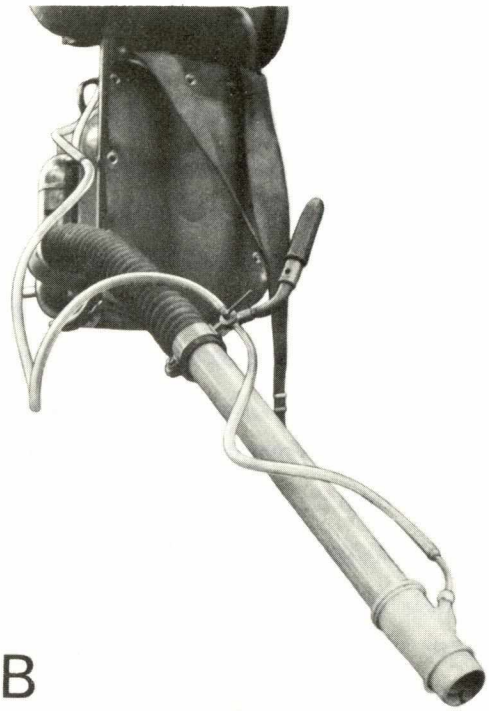

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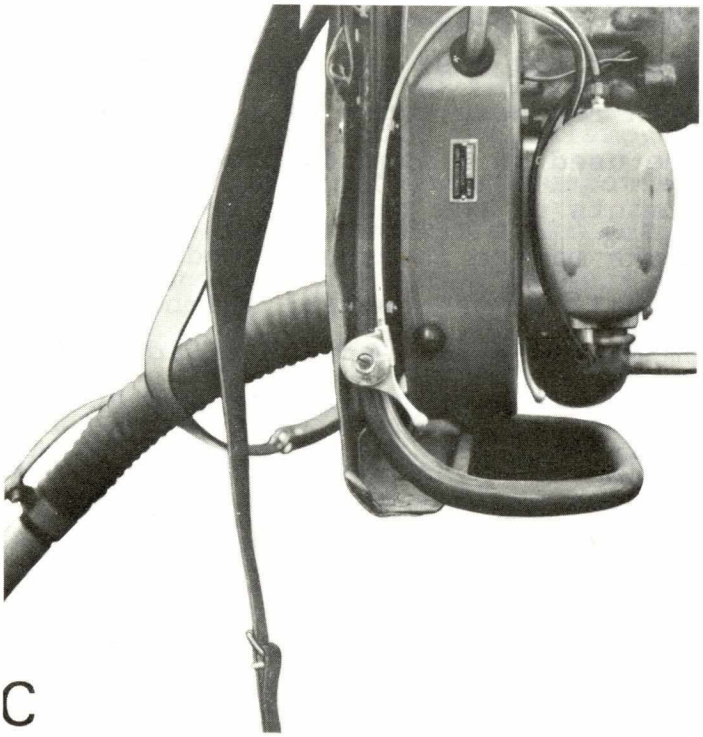

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Figure 1.

SOLO SPRAYER-DUSTER

A. Engine, fuel and chemical tanks.

B. Discharge pipe and nozzle with feed tube for liquid spray or "wet dust" technique.

C. Side view showing throttle location.

a considerable saving in transportation costs. A highly concentrated herbicide solution may be used. This technique reduces the amount of liquid required; in one case approximately ¼ pint of full-strength herbicide was used to treat the same area that would require 20 gallons of a water-mixed solution.

The model used in the tests has a plastic 3-compartment tank holding engine fuel and the chemicals to be sprayed. The central compartment holds 5 pounds of powder. The brushes of a mechanical agitator incorporated into the lower portion of the central compartment feed the powder into the tank outlet. A cable-controlled metering valve in the outlet regulates the amount of powder passing through the system. The powder flows through a hose into a fitting on the blower outlet where it enters the air stream. By varying the speed of the engine the concentration of the dust and the distance it is projected can be altered. The combination of engine speed and the metering system makes possible a wide variety of dust concentrations. The third compartment may be used to hold water or other liquid which can be mixed with the dust at the nozzle. This technique of "wet dusting" reduces drift of the dust and makes possible the use of a "sticker" solution for some types of herbicides.

If the unit is to be used as a liquid sprayer, both the central and third compartments of the tank can be used to hold spray solutions. The tanks may be interconnected by removing two small plugs in the wall of the central chamber, or, if desired, two separate chemicals can be used and mixed at the nozzle. The central compartment has a tight-fitting lid and when the blower is operating, a small portion of the air stream is diverted into the chamber ensuring that the liquid or dust is positively expelled through the nozzle even though the latter is held above the level of the liquid in the tank.

The unit has been used for three fire seasons without development of mechanical troubles. When the operating and maintenance instructions are followed, one or two pulls of the

recoil starter will start the motor. When operating above one-quarter throttle, the blower produces a loud high-pitched whine which makes it difficult for the operator to receive verbal instruction; throttling down renders it possible to converse with him. The throttle control is mounted on the side of the carrying frame and is somewhat awkward to reach.

A flame-throwing attachment is also available. As a flame-thrower its only advantage over regular back-firing torches is the strong blast of air entrained with the flame. This is particularly useful if damp fuels are to be ignited, as a good draft can be created.

In addition to the fire suppression tests the Solo was also used to provide an emergency method of rapidly drying unlined linen fire hose. The blast of warm air from the nozzle was directed through a 100-foot length of hose stretched out full length on dry ground. The hose dried in approximately five minutes.

DRY CHEMICAL EXTINGUISHANTS

Gay-Lussac in 1821, and a number of investigators since then, have noted that flames will not propagate through a gaseous mixture containing suspended particles of various inorganic powdered chemicals (Fraser, 1962). The effect of these powders appears to depend largely on their dispersion through the fire area.

There are two main types of dry chemical powders used for fire extinguishment. The type which has long been available, usually finely powdered sodium bicarbonate plus talc to improve its flowing characteristics, is effective on Class B and C fires (oil, gas and electrical) and is now frequently referred to as BC-type powder. The new All-purpose or ABC-type powders are effective on fires in Class A fuels (wood and paper) as well as the Class B and C fuels. The chemical formulations used in the ABC-type may be quite complex and they sometimes contain chemi-

cals which provide a marked cooling effect on the burning fuels.

With wood fuels, combustion may be present in two forms; the flaming state where distilled gases from the fuels burn in the air, and the glowing combustion state where heat is liberated from the glowing wood embers. The cooling effect of the ABC powders is of particular importance in controlling the second type of combustion. Tests of the ABC chemicals in building fires have indicated that they are eight times as effective as plain water, weight for weight, in controlling fire (Anon., 1962). Experiments on small fires in the open air at the Petawawa Forest Experiment Station indicated that this type of dry chemical was from two to four times as effective as water in controlling fire in forest fuels (Fraser, 1964).

DRY CHEMICAL TESTS

The Solo was tested using two brands of the ordinary BC-type dry chemical; a combination of the BC-type and ammonium sulphamate both as a dry powder and as a liquid using a "wet dust" technique; a combination of BC-type and powdered borate; and three brands of ABC powder. Water, applied by an ordinary back-pack pump was used as a standard for comparison. Results of the tests are summarized in Table 1.

Two types of fire tests were used to evaluate the different chemical compounds: 18-inch circular fuel cribs of dry pine (*P. strobus*) slash, with pieces up to 1.0-inch diameter, built on mineral soil, and cribs 10 feet long, 18 inches wide and 18 inches high also made of dead pine branches with pieces of larger diameter than in the circular cribs and constructed on a base of white pine duff. All cribs were ignited with the aid of a few ounces of chain-saw fuel to ensure rapid ignition. The fire was allowed to burn until the wood in the crib was fully involved in the fire and glowing combustion was present. At this point attempts were made to suppress the fire with dry chemical powder blown from the Solo. In most cases the flames

TABLE 1. RESULTS OF FIRE TESTS

Chemical	Quantity Used to Extinguish 18" crib	10' crib	Remarks
BC Powders	4 lb.	Not controlled	Several applications, 18" crib not completely extinguished
BC Powder Plus Ammonium Sulphamate(dry)	1 lb.*	--	18" crib not completely extinguished
BC Powder Plus Ammonium Sulphamate(wet)	1 lb.	--	18" crib not completely extinguished
BC Powder Plus Borate	--	--	5 pounds would not extinguish 18" crib
ABC Powder Brand X	$\frac{1}{4}$ lb.	$1\frac{1}{4}$ lb.	Some powder wasted on 18" crib. 10' crib smouldered for some time
ABC Powder Brand Y	$\frac{1}{4}$ lb.	2 lb.	10' crib controlled but not completely extinguished
ABC Powder Brand Z	$\frac{1}{2}$ lb.	$1\frac{1}{2}$ lb.	Similar to Brand Y
Water Spray	Not measured	13 lb.	10' crib fire controlled with about 9 lb., completely extinguished with 13 lb.

*All figures represent the average of two or more trials except BC powder/ ammonium sulphamate. Here one test was with dry sulphamate and the second with liquid sulphamate in a "wet dust" application.

were quenched or greatly inhibited during the period the pile of fuel was enveloped in a cloud of powder. However, when the nozzle was directed toward the base of the fire the air blast tended to fan the embers and increase fire intensity at that point.

Following the crib test, trials of some of the more promising chemicals were made on the edge of prescribed burns in young red pine (*P. resinosa*) plantations.

RESULTS OF TESTS

Although the BC-type powders tended to quench the flames rapidly, the unburned wood reignited from glowing embers as soon as the application was stopped. Some four pounds of this type of powder was not sufficient to extinguish a fire in the 18-inch circular cribs.

The addition of small amounts of ammonium sulphamate to the BC powder increased its effectiveness. The best mixture seemed to be one pound of ammonium sulphamate to five pounds of BC powder. When this was used on an 18-inch crib the flames were quenched and the pile of wood remained smouldering for several minutes before reigniting. A second application of powder to the crib produced similar results with a slightly longer period of smouldering before reignition. One pound of the 5:1 mixture was sufficient to provide this degree of control for fires in the 18-inch circular cribs. The control obtained when the ammonium sulphamate was added as a liquid mist, using the "wet dust" technique, was about the same. However, the mixtures of powdered ammonium sulphamate and dry chemical powder could not be stored for more than a few hours without caking because of the hygroscopic properties of the sulphamate. Because its extinguishing potential was not outstanding, no further tests were conducted with this mixture.

The mixtures of BC-type powder and powdered sodium calcium borate were less effective than the BC-type powder used

alone. Five pounds of a half-and-half mixture would check the flames but did not extinguish even the 18-inch crib fires.

The three different brands of ABC powders controlled the fires in both circular and 10-foot cribs. The quantity of chemical used varied from ¼ lb. to 2 lb. There were differences between the three brands of powder tested. Brand X appeared to have the greatest cooling effect on the embers. Slightly more than one pound was dusted over a 10-foot crib, the flames were quenched but reappeared when dusting stopped, especially in areas where the air stream had increased the intensity of the glowing embers. All flames died out within three minutes without any additional application of extinguishant and within five minutes, although smoke was still rising from the wood, the heat being radiated was much less than would be expected. No further control effort was taken on this fire and one hour later the ashes were checked but no embers or warm spots could be detected (Figure 2).

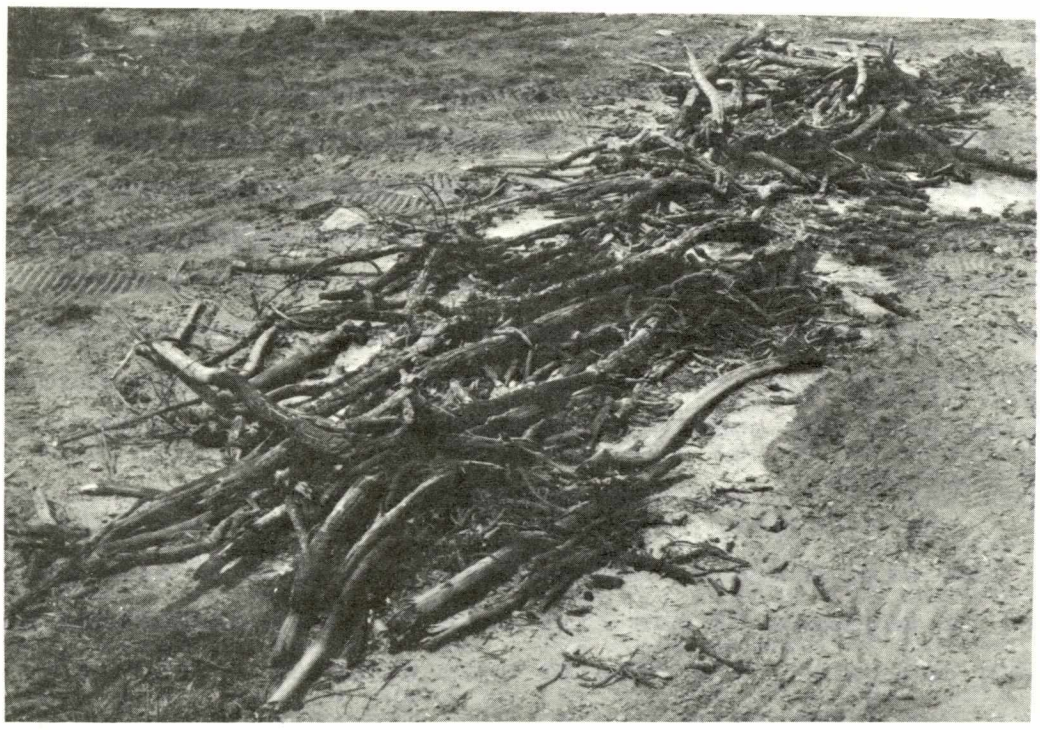

Figure 2. Crib after fire extinguished showing unburned fuel.

With Brand Y, two successive dustings of about one pound of powder each were required to control fire in the 10-foot cribs. Once again the embers smouldered for some time, but no further control action was taken until the conclusion of the tests, about an hour and a half later. By that time, there were many pieces of partly burned wood left in the crib but the volume of embers had decreased and the fire showed no sign of increasing in intensity although a steady breeze had been blowing. However, it could not be considered "safe", and the remaining embers were soaked with water. The results with Brand Z of the ABC chemical were similar to those experienced with Brand Y, although slightly less powder was used. The cooling effect of these two was noticeably less rapid than that of Brand X.

As a comparison, tests were made using a water spray to extinguish 10-foot crib fires. The water was applied with an ordinary forestry back-pack hand pump. The tank was weighed before and after the test to determine the quantity of water required for extinguishment. One application of water controlled the fire but numerous glowing embers remained and the crib gave every indication of bursting into flame again once the water evaporated. A second application was made 30 seconds later to completely extinguish all embers. Care was taken to apply the water sparingly on the second application to avoid waste. The operator felt much less water was used on the second or mop-up application but the tank was not weighed between operations. The water used for complete extinguishment averaged 13 pounds per 10-foot crib.

As a further test, the Solo, charged first with Brand X and then with Brand Z, ABC powders, was used to attempt the control of segments of the fire line on small prescribed burns in young red pine. The results were somewhat difficult to assess. The fires were burning with moderate intensity in a thick layer of needles and small dead branches. The burns were

about one-quarter acre in size and the fire advanced at a rate of about 10 feet per minute, propelled by a light breeze. Suppression was attempted on the downwind side of the plot. Unfortunately, the cloud of dust did not instantly extinguish the quarter-acre fire. The flames on a small section of the fire front could be suppressed and the fire checked as the operator moved along the line, but the fire would immediately re-enter the checked area from the sides after the operator moved away. By concentrating on a small segment, about 10 feet of the line, it was possible to bring the fire under control and extinguish it in that area. One could be sure of complete extinguishment only after the flames of the fire on each flank of the controlled area had burned to the cleared fireguard and died down.

Although this would appear to be a rather poor performance it should be remembered that approximately 2.5 pounds of powder were used to achieve this degree of control. It is doubtful if a quarter-gallon of water (the equivalent weight) applied as a spray would have secured the same area of active fire line. Unfortunately a direct comparison between water and dry chemical could not be made on this fire. It might be noted, however, that some 300 gallons of water were used on mop-up after the fire had burned the prescribed area and had stopped at the prepared fire line.

CONCLUSIONS

When used on fires burning in typical forest conditions with continuous fuel beds the Solo is not an adequate or effective piece of fire suppression equipment. It has two drawbacks: its capacity is too small, and the air blast from the nozzle tends to increase fire intensity within the powder-delivery range of the machine. The five pounds of powder the Solo tank will hold is equal to the weight of a half-gallon of water. Even though the powder is about eight times as effective an extinguishant as water, weight for weight, one charge in

the Solo would be no better than four gallons of water or one back-pack tankful and this quantity of water would not go very far in the control of even a quarter-acre fire.

As a fire fighting tool, the Solo might be useful in combatting fires burning in grass and light fuels. The air blast from the machine can be used to literally blow out the fire — forcing the flames back into the burned fuel area. The addition of an ABC dry chemical would not likely increase its effectiveness for this purpose.

To assess the fire extinguishing effectiveness of the various dry chemical extinguishants would require a much more elaborate experiment than the simple tests described here, but there is no doubt that the ABC types are more effective than water on the basis of weight. They thus have some logistic advantages in fire fighting but require some means of application other than the Solo. As mentioned previously their extinguishing action is that of breaking the chain reaction of combustion. Thus they are very effective in fires in liquid hydrocarbon fuels such as oil or gasoline. With this type of fire, although the flame temperature may be high, the fuel has an ignition point well below the kindling temperature of wood. If the flames can be removed momentarily, the fuel itself, because of evaporation, tends to cool below its ignition temperature and the fire will remain out.

With this in mind, it is interesting to speculate on the effect of dry chemical powder on the control of crown fires. Although the volume and arrangement of the fuel at the tree-tops is usually not such that it will support glowing combustion independently, the flames may leap from tree to tree in advance of the ground fire which supplies the initial source of heat and ignition. This is somewhat similar to the behaviour of a fire set in wet slash — the fire may flash over oil-soaked but damp slash and consume very little of the wood. The possibilities of controlling crown fires by discharging dry chemical

powders into the tree crowns, perhaps by utilizing the downdraft of a helicopter, are interesting.

When a fire is burning in forest fuels on the ground, the quantity and arrangement of fuels are usually such that after the initial ignition period is over, glowing combustion is present and the embers provide sufficient heat to kindle unburned wood. A fire of this nature is difficult to control. The various ABC formulations contain glow inhibitors that exert an antipyrogenic effect at the surface of the burning wood. Unlike the fires in oil and gasoline, the heat retained by the wood fuel after the first quenching of the flame is sufficient to re-ignite the wood. The effectiveness of the ABC powders, therefore, is largely dependent upon the efficiency of the glow inhibitors and the speed with which the cooling effect of the chemical takes place.

Although unmodified versions of the Solo or similar sprayer-dusters do not appear promising as fire control devices utilizing dry chemicals, the efficacy of the chemicals themselves suggests other possibilities. It might be possible to utilize the air blast of a Solo or similar blower to dispense dry chemicals from a tank truck, even through a hose line. Dropping dry chemical from aircraft instead of water is another possibility. One helicopter firm is considering such a technique to combat fires in aircraft crashes which occur near an airfield. Here, as in forest fire control, speed in initial attack is vital.

SOMMAIRE

Le vaporisateur-saupoudroir "Solo" a été conçu pour l'application d'insecticides et d'herbicides à des fins agricoles. Il projette les substances chimiques au moyen d'un puissant jet d'air. L'appareil comprend un souffleur actionné par un petit moteur à essence, des réservoirs qui contiennent le produit chimique soit liquide ou en poudre, ainsi qu'un boyau flexible et une lance qui sert à diriger le jet d'air. On peut varier la quantité de produit chimique injecté dans le jet d'air grâce à un dispositif de réglage contrôlé par câble.

Le ministère des Terres et Forêts de l'Ontario a fait l'essai de cet appareil dans la lutte contre des incendies de combustibles légers. L'appareil fut utilisé pour diriger un jet d'air vers le flanc principal de l'incendie, repoussant ainsi les flammes vers la partie brûlée où elles étaient vite étouffées. Une expérience tentée en Allemagne (Kortge, 1961) avait démontré qu'un saupoudroir plus gros utilisant une poudre chimique ignifuge sèche pourrait éteindre de petits feux de forêt. Des épreuves ont été effectuées à la station d'expérimentation forestière de Petawawa utilisant l'appareil "Solo" chargé de produit chimique ignifuge sec. Les résultats de cet essai sont présentés en résumé au tableau 1.

La poudre de type ABC, dite tout-usage, a éteint des feux d'essai allumés dans de petits tas de déchets d'abatage de pin desséchés. D'autre part, le produit chimique sec de type régulier BC s'est avéré inefficace lorsque appliqué à l'aide de l'appareil "Solo". Bien que les résultats d'autres essais (Anon., 1962; Fraser, 1964) aient indiqué que les poudres de type ABC étaient jusqu'à huit fois plus efficaces que l'eau pour éteindre les incendies, le "Solo" chargé de poudre ABC n'a pas été efficace lorsqu'il fut utilisé dans la lutte contre un feu dirigé dans une plantation de pin rouge.

L'usage de la poudre ABC augmentera peut-être l'efficacité de l'appareil à éteindre les petits incendies se

propageant dans des combustibles légers. La capacité limitée du "Solo" (5 lb.) comporte cependant un désavantage. Le jet d'air s'échappant de la lance a tendance à activer le feu et à en accroître l'intensité.

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