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Potential Fire Hazards from Flammable Gases and Liquids in an Aircraft Cabin

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16. Abstract

This study was undertaken following an incident in which several individuals were arrested and convicted of carrying hazardous materials on board a commercial aircraft. The materials involved were butane torches, butane refill canisters, and canisters of compressed nitrous oxide. The purpose of the study was to determine the ignition potential and subsequent damage from these materials. Tests were conducted with butane leaking in lavatories and stow bins, the torch flame impinging on a refill canister and on a lavatory trash chute, butane spraying across an ignition source, ether spilled and ignited in a lavatory, and the nitrous oxide canisters exposed to heat.

The study concluded that these materials have the potential to produce extremely dangerous fire situations.

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EXECUTIVE SUMMARY

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The study concluded that these materials have the potential to produce extremely dangerous fire situations.

INTRODUCTION

PURPOSE.

The purpose of this study was to assess the potential fire hazards of flammable gases and liquids that could be brought on board aircraft.

BACKGROUND.

This study was undertaken following an incident in which several individuals were arrested on board a commercial aircraft for, among other things, possession of forbidden hazardous materials. The materials included butane torches, nine canisters containing 9 fluid ounces of butane used to refill the torches, and canisters of compressed nitrous oxide. The butane torches have a valve to control the flow of butane, a pushbutton spark ignitor, and a valve to control the air to the premixed flame. The maximum flame temperature is approximately 2500 degrees F and the torch is capable of up to 2 hours of burn time. These items were apparently brought on board the aircraft to facilitate illegal drug use. The materials were found on the individuals and in their carry-on baggage. Ether was not found in this incident, but the smell of ether was reported by cabin occupants. Since ether is sometimes associated with illegal drug use, it was included in the testing.

Title 49 CFR 172.101 contains a list of hazardous materials and their classifications. Butane is classified as a flammable gas and is prohibited from being transported on board passenger carrying aircraft. An exception to this is cigarette lighters containing not more than 2.3 fluid ounces of butane. Ether is classified as a flammable liquid and is also prohibited in any quantity. Nitrous oxide is classified as a nonflammable gas and up to 150 pounds is permitted to be transported on passenger-carrying aircraft. However, this refers to transporting as cargo and requires specific labeling and packaging.

Title 49 CFR 175.25 requires that notices be displayed in each location at an airport where the aircraft operator issues tickets, checks baggage, and maintains aircraft boarding areas. The notice must contain the following information:

"Federal Law forbids the carriage of hazardous materials aboard aircraft in your luggage or on your person.

"A violation can result in penalties of up to $25,000 and 5 years imprisonment.

"Hazardous materials include explosives, compressed gases, flammable liquids and solids, oxidizers, poisons, corrosives, and radioactive materials.

"Examples: paints, lighter fluid, fireworks, tear gas, oxygen bottles, and radio-pharmaceuticals.

"There are several exceptions for small quantities (up to 75 ounces total) of medicinal and toilet articles carried in your luggage and certain smoking materials carried on your person."

Although medicinal and toilet articles were not part of this study, further work is warranted in that area. Over the last several years, the fluorocarbon propellant in many aerosol cans has been replaced by butane and propane due to the environmental hazards associated with fluorocarbons. These types of aerosol containers could produce unforeseen fire hazards and, depending on the quantity, could be classified as hazardous materials that would be prohibited from being carried on board aircraft.

DISCUSSION

DESCRIPTION OF TESTS.

One test was conducted in a lavatory from an American Airlines DC-10. Oil burner electrodes were installed on the lavatory floor to provide a constant ignition source. The Halon 1301 "potty bottle" was not installed in this or any other test. A butane torch was placed next to the sink, the butane flow valve was opened fully, and the lavatory door was closed. The lavatory was monitored for approximately 30 minutes. The butane did not ignite.

Several tests were conducted in this same lavatory in which a 9-fluid-ounce butane refill canister was emptied into the lavatory. The electrodes on the floor were then energized. The butane ignited in all cases producing a large fireball and forcing the lavatory door open. In one of these tests the lavatory was filled with the paper products that would normally be present in flight. These included paper towels in the holder, toilet paper, and crumpled paper towels in the trash chute. In that test the paper was ignited by the burning butane which then spread to the inside walls of the lavatory. The fire could not be completely extinguished until all of the smoldering paper towels were removed from the holder and doused with water. Figure 1 is a graph of the temperatures recorded by thermocouples inside the lavatory at heights of 19 inches, 38 inches, and 57 inches. The data for each thermocouple were recorded at 1-second intervals. Figure 2 shows the propagation of the fireball. The photos were taken at a rate of 12 per second.

Another scenario that was examined involved exposing a butane refill canister to the flame from the butane torch. This was done on the countertop of the same lavatory that was described earlier. After approximately 1 minute of exposure, the refill canister exploded, producing a fireball and overpressure similar to the previous scenario. One test was conducted with the lavatory filled with paper products as described previously. The results were similar to the previous scenario with the paper and then the lavatory walls igniting. Once again the fire could not be completely extinguished until all of the paper towels were removed and doused with water.

One test was conducted in another American Airlines DC-10 lavatory in which the trash chute, paper towel holder, and toilet paper dispenser were filled with the paper products that would normally be present in flight. The trash chute was filled to capacity with paper towels overflowing out of the top of the chute. The butane torch was ignited, and the flame was placed against the trash at the top of the chute. The trash ignited, and the fire then spread to the lavatory walls and paper towels in their holder. The lavatory was completely engulfed in flames approximately 1 and 1/2 minutes after the start of the test. Carbon

dioxide and water were used to extinguish the fire. Figure 3 shows the progression of the fire in the lavatory. The photos were taken approximately once every 7 seconds.

One additional test was conducted in the lavatory. Approximately 1 fluid ounce of ether was poured onto the lavatory's metal countertop. The ether was then ignited with sparking electrodes. The ether burned for approximately 1.5 minutes. The lavatory walls just above the countertop continued to burn after the ether was consumed for approximately another minute before self-extinguishing. Figure 4 shows the propagation of flames from the burning ether.

The next test was conducted in an overhead stowage bin. Oil burner electrodes were installed in the top of the stowage bin to provide an ignition source. A 9-fluid-ounce refill canister of butane was emptied into the stowage bin, and the electrodes were energized. The butane ignited, forcing open the door to the bin and producing a large fireball. Several plastic parts of the stowage bin continued to burn after the fireball had subsided. These materials eventually self-extinguished. Figure 5 shows the propagation of the fireball. The photos were taken at a rate of 12 per second.

Another test was conducted using the butane refill canister and the oil burner electrodes. The electrodes were energized and the spray from the butane canister was directed across the electrodes. The butane ignited, producing a flame approximately 4 feet long. Figure 6 shows the flame produced from the ignited butane spray.

The last series of tests were conducted on the nitrous oxide canisters. A small pan of alcohol was ignited and the canister was placed approximately 3 inches above the surface of the burning alcohol. The pan of alcohol and the canister were placed inside a plexiglass box measuring 1 foot by 1 foot by 2 feet high. During the first test, the canister developed a small opening and leaked the contents. In the second and third tests the canisters burst violently, striking the 1/4 inch thick plexiglass box with enough force to cause it to shatter.

CONCLUSION

1. Butane torches, canisters of compressed butane and ether can produce extremely dangerous fire situations in aircraft.

2. Depending on quantity, aerosols cans with butane, or propane as the propellent are expected to produce similar hazardous fire situations and could be classified as prohibited hazardous materials.

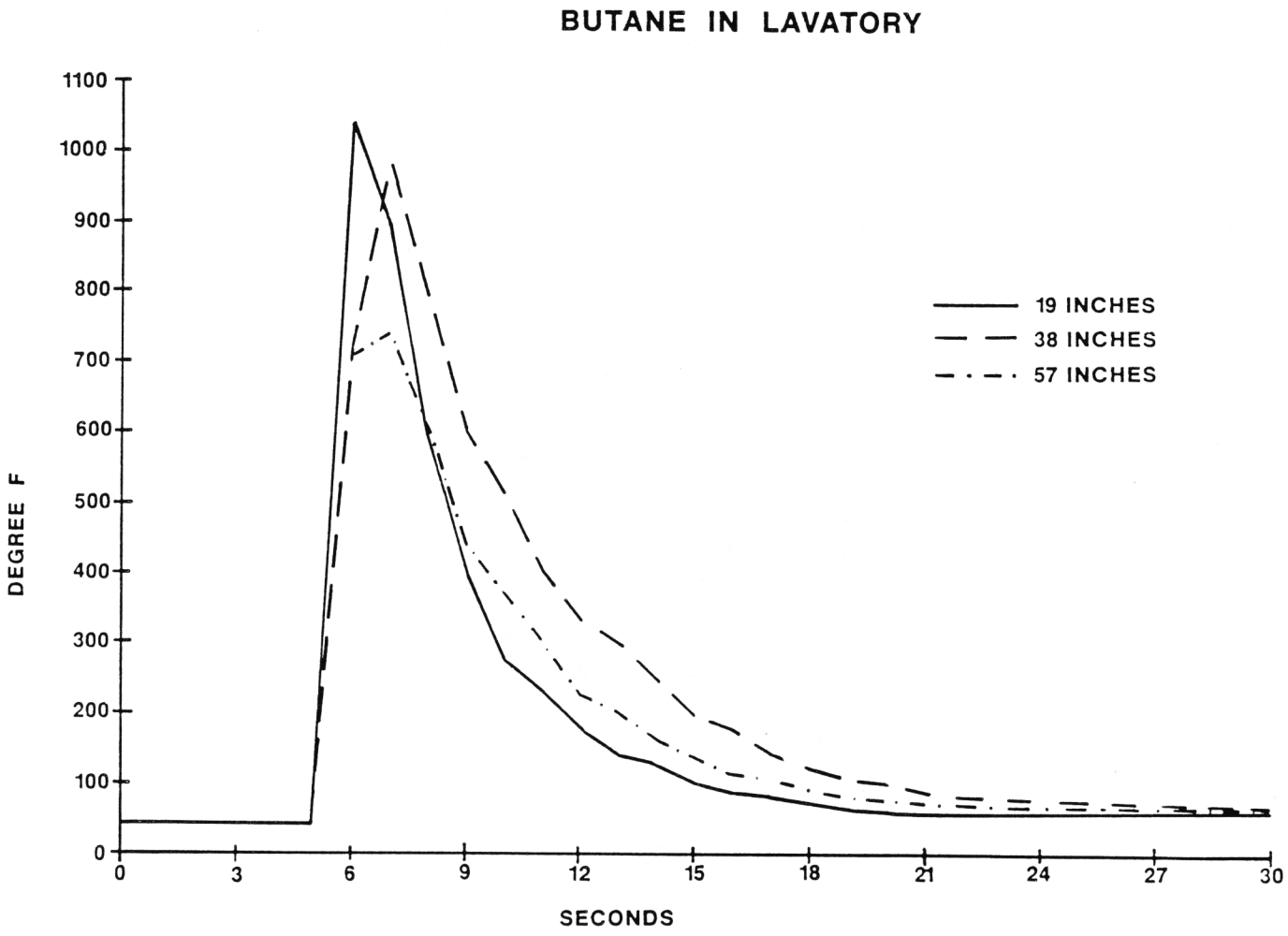


FIGURE 1. TEMPERATURES INSIDE LAVATORY

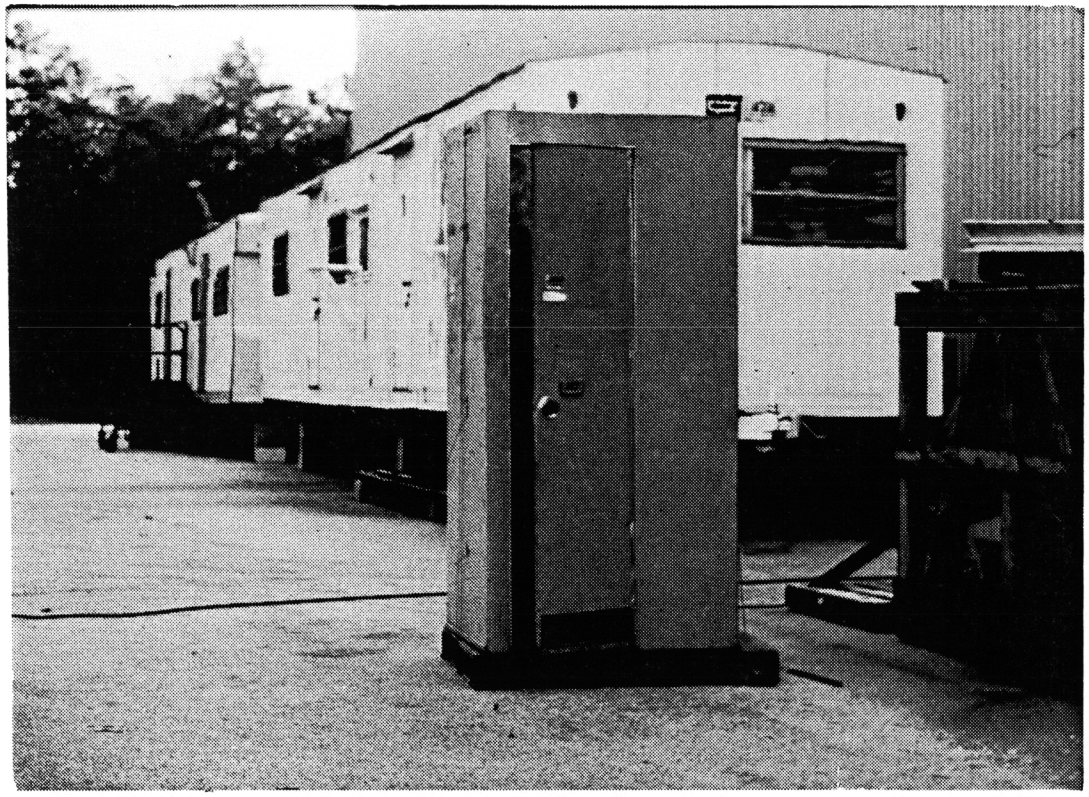


FIGURE 2. BUTANE IGNITED INSIDE LAVATORY (1 of 3 Sheets)

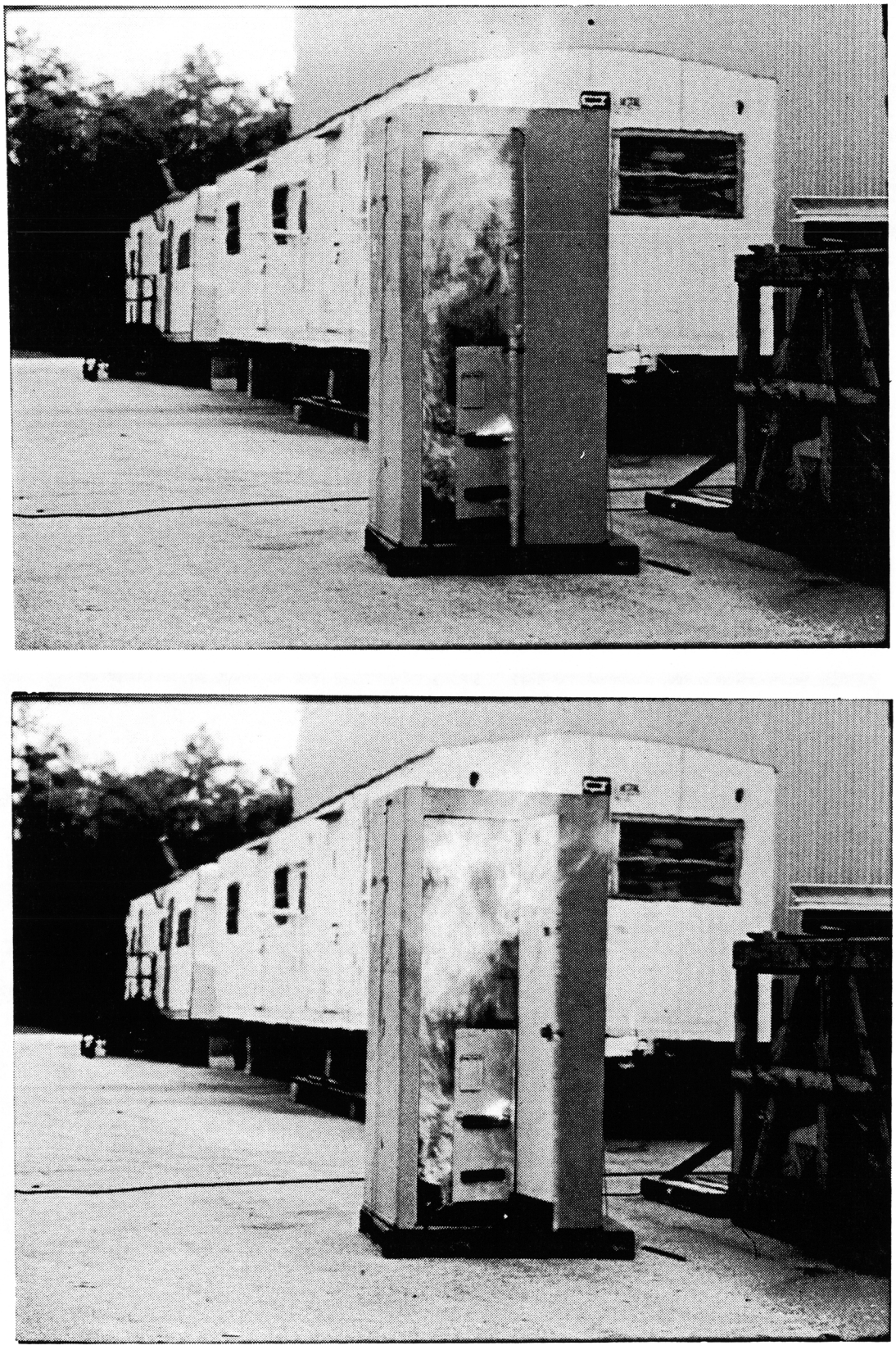
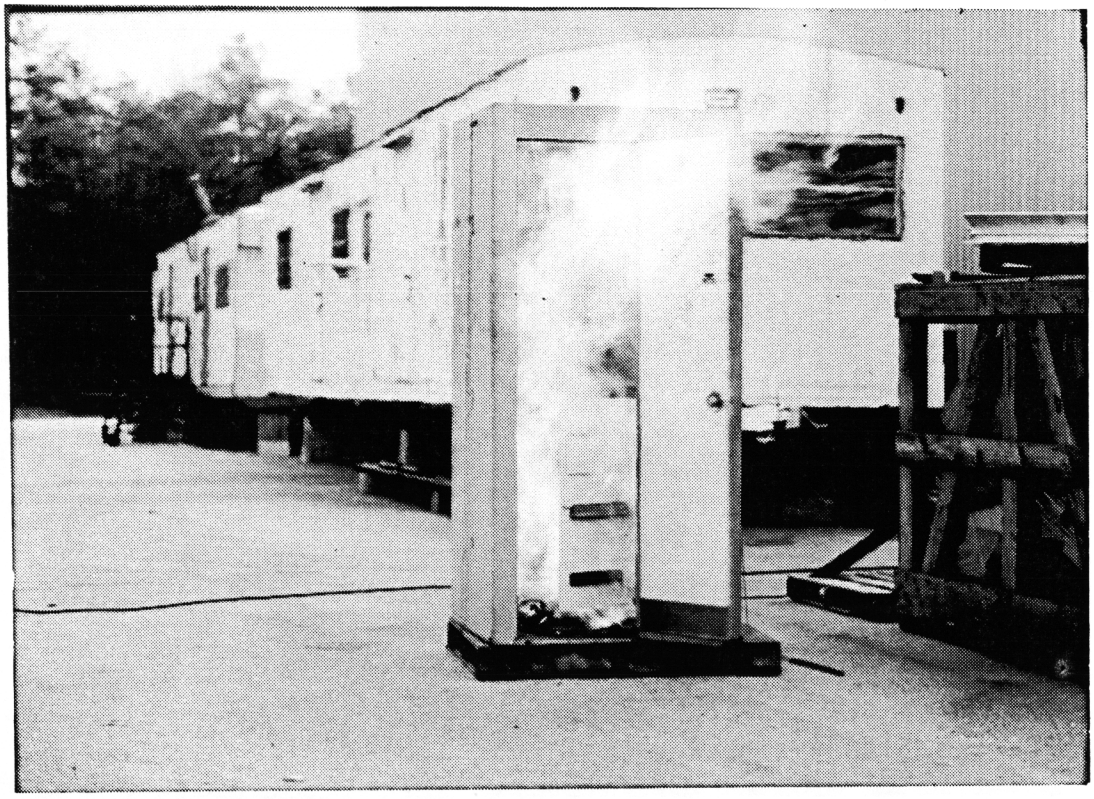


FIGURE 2. BUTANE IGNITED INSIDE LAVATORY (2 of 3 Sheets)



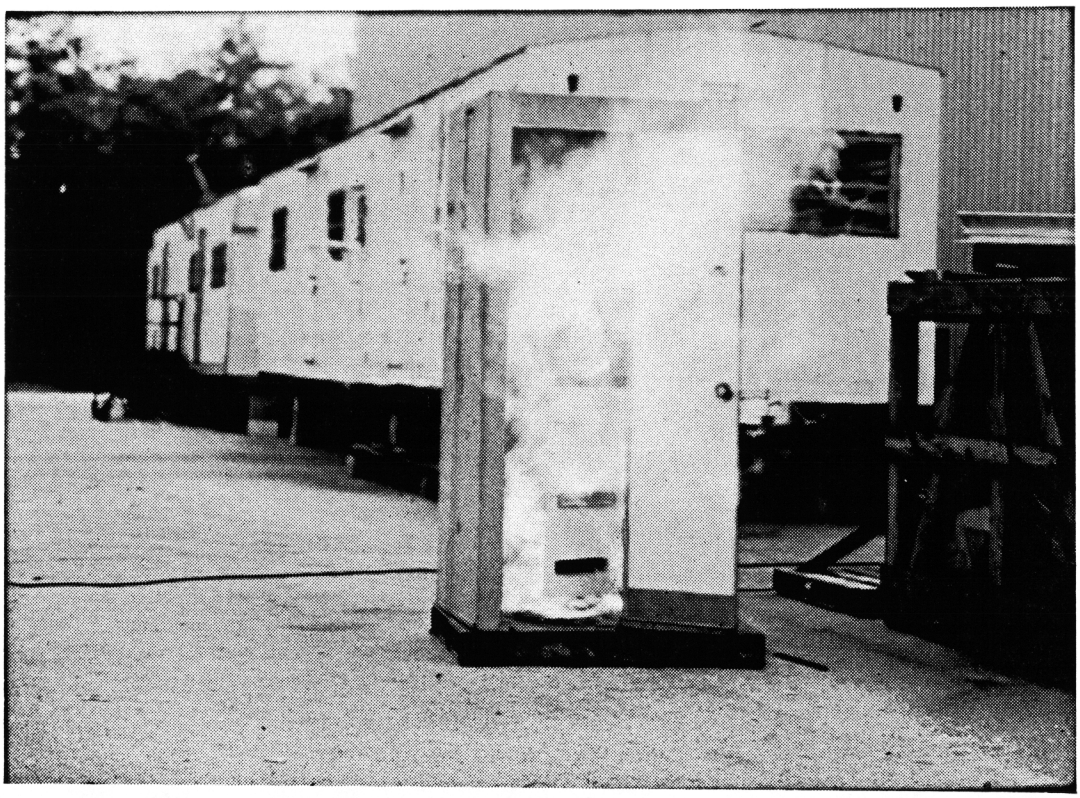


FIGURE 2. BUTANE IGNITED INSIDE LAVATORY (3 of 3 Sheets)

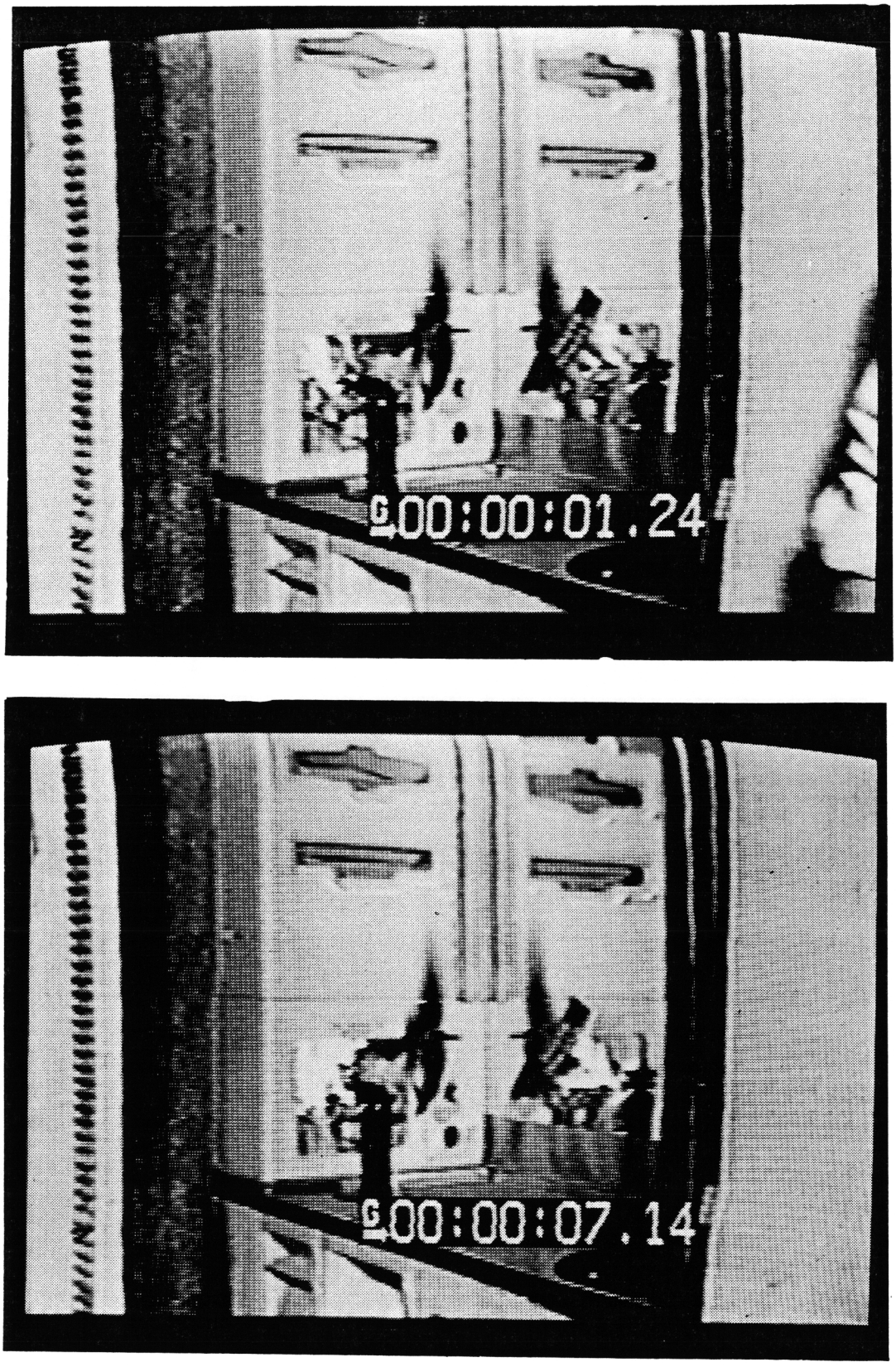
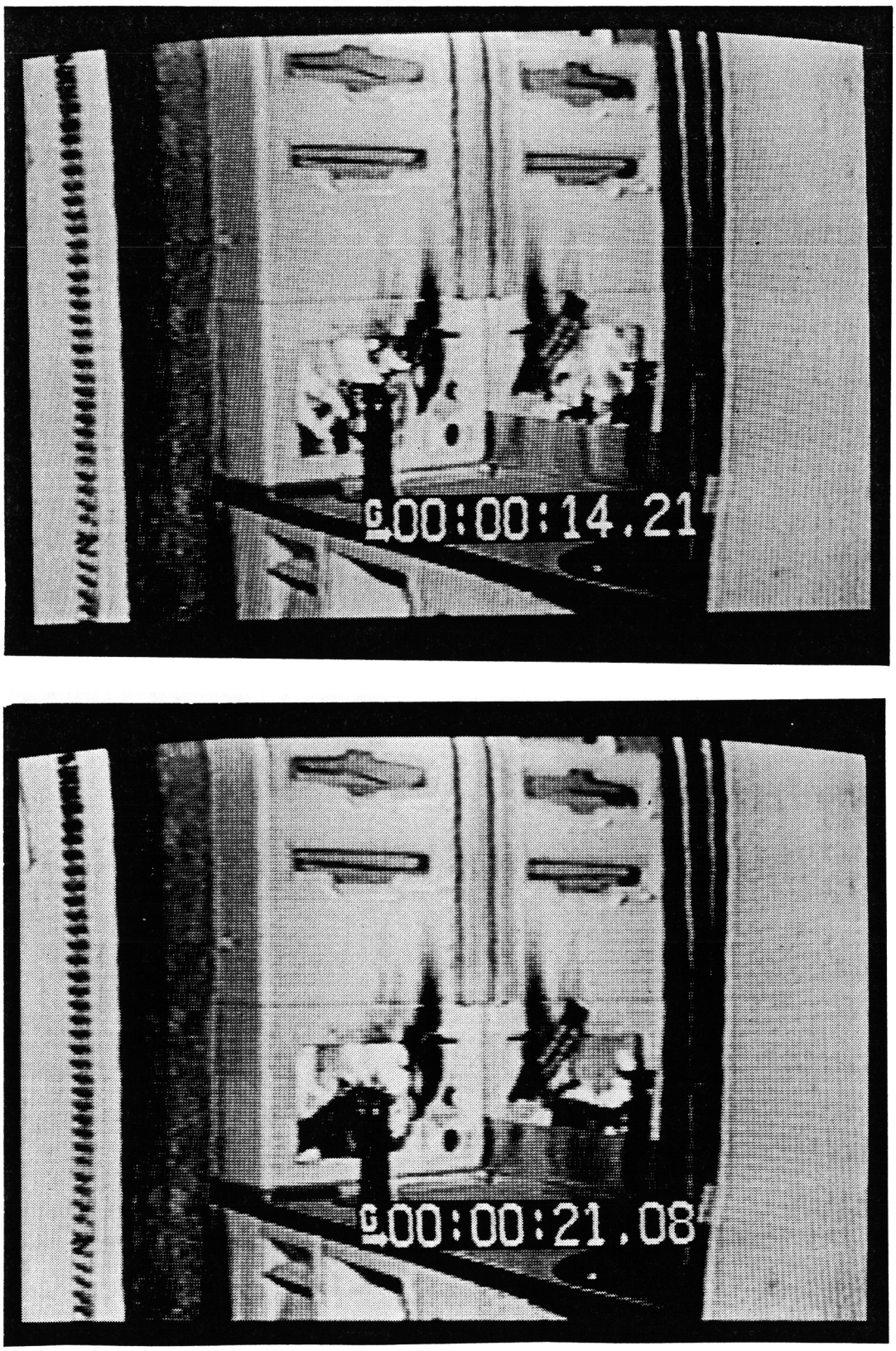


FIGURE 3. BUTANE TORCH AGAINST TRASH CHUTE (1 of 7 Sheets)



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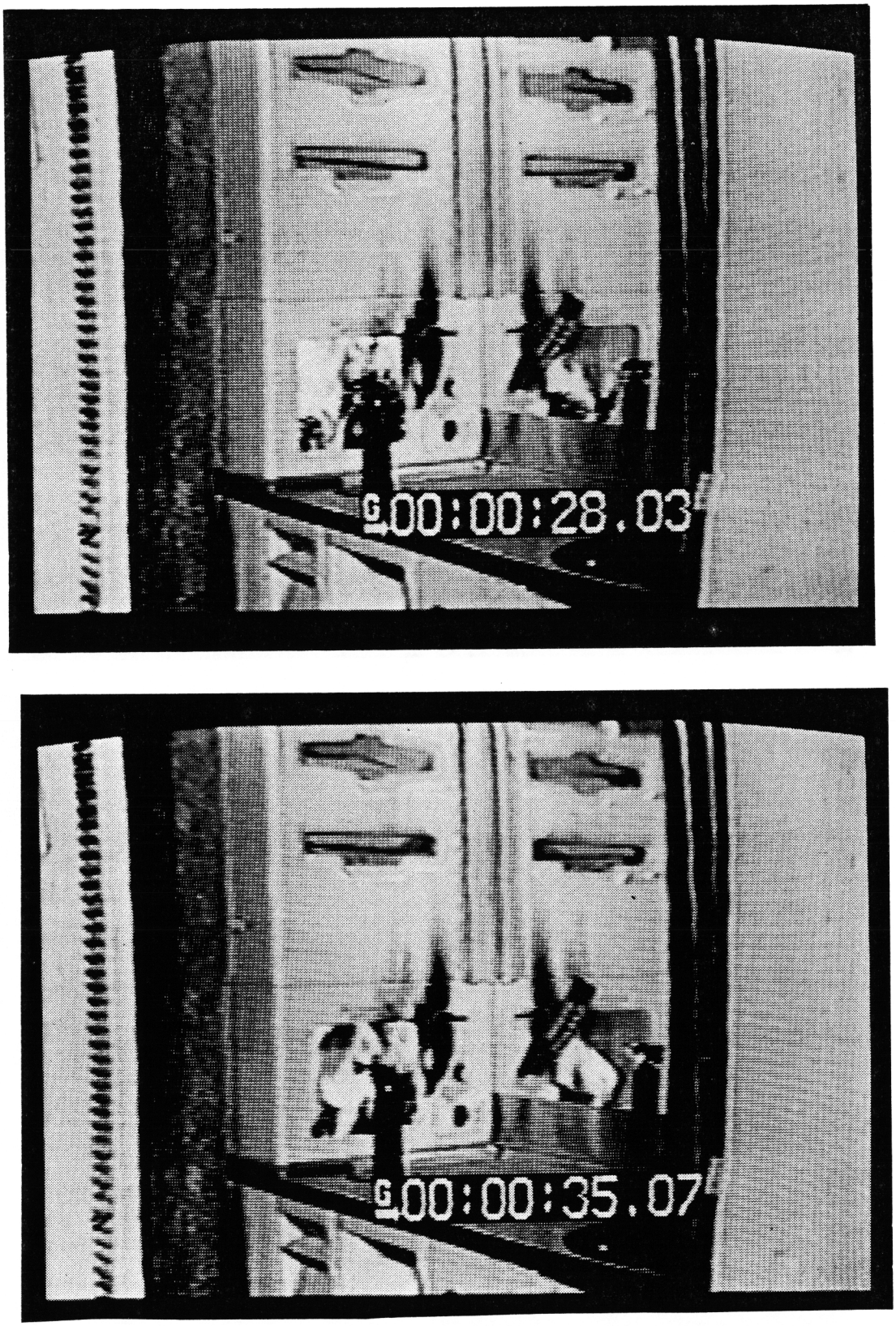

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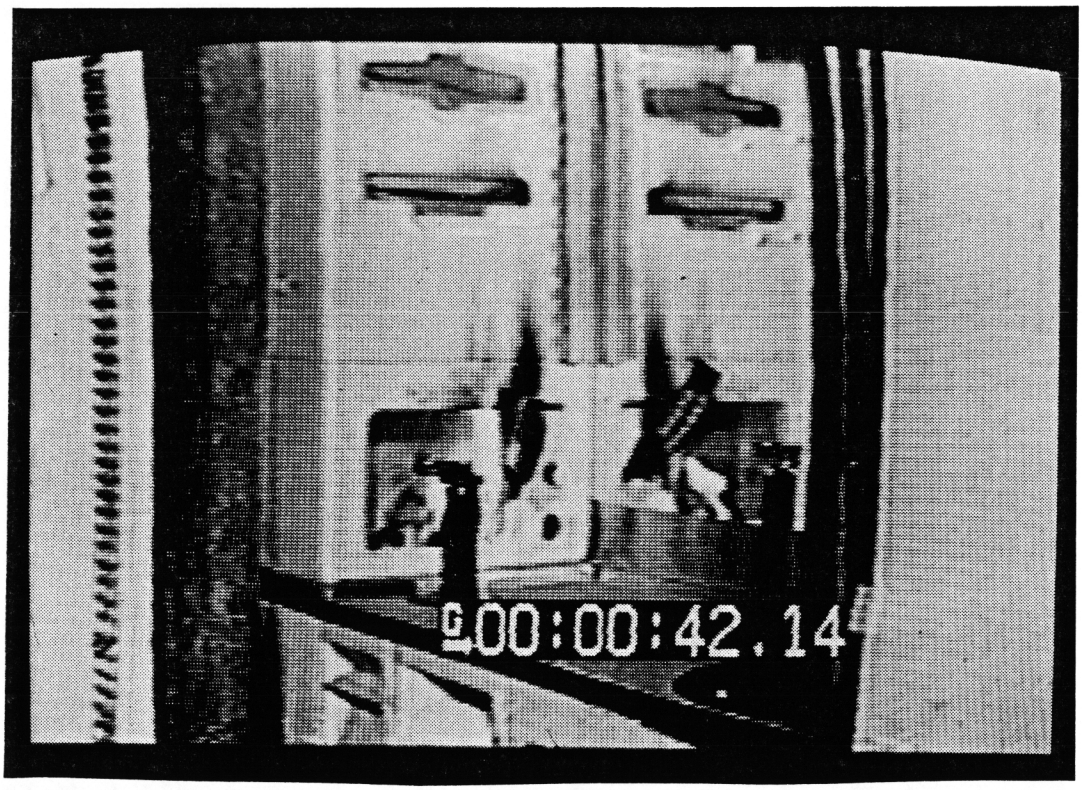
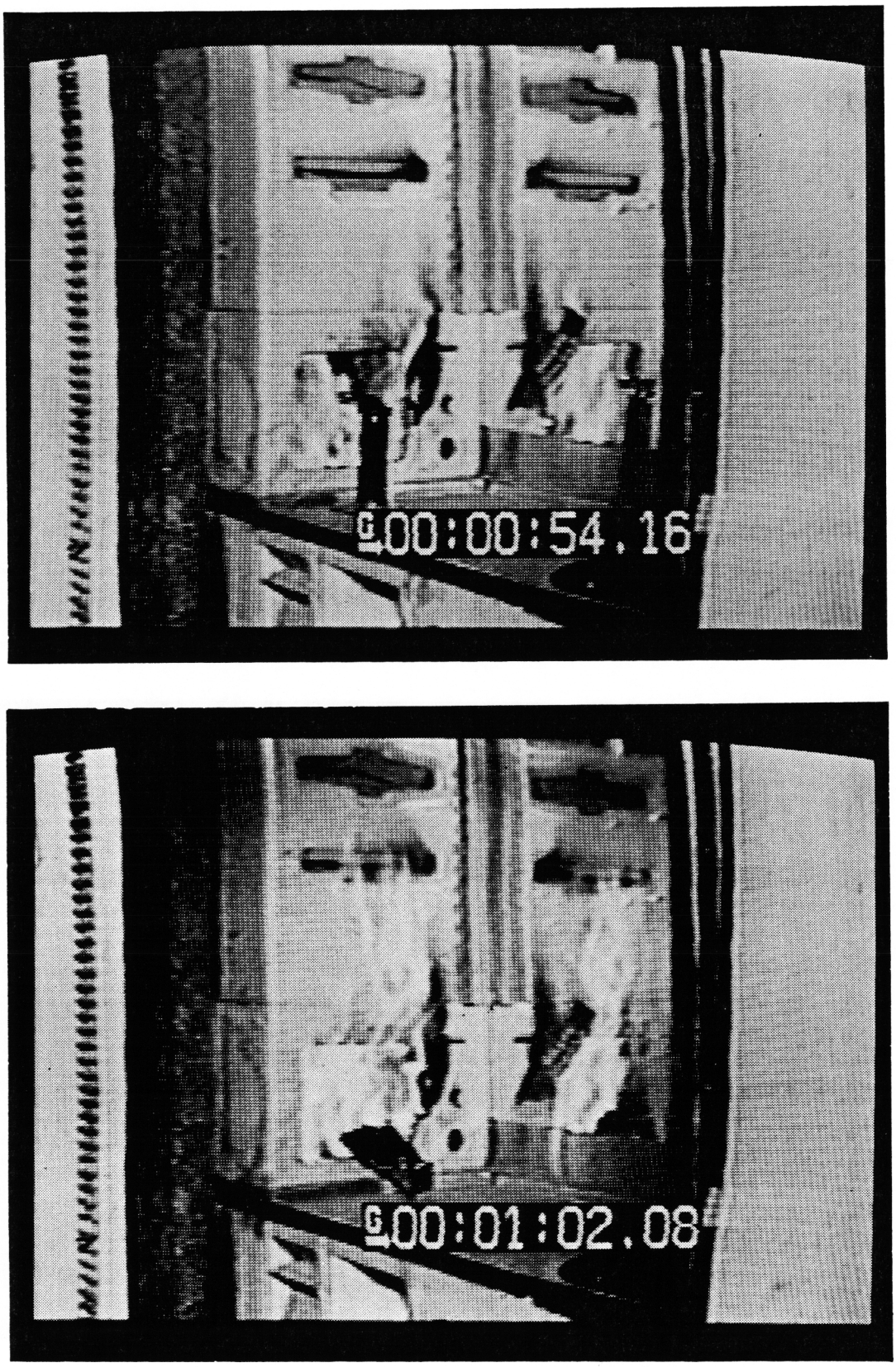


FIGURE 3. BUTANE TORCH AGAINST TRASH CHUTE (4 of 7 Sheets)



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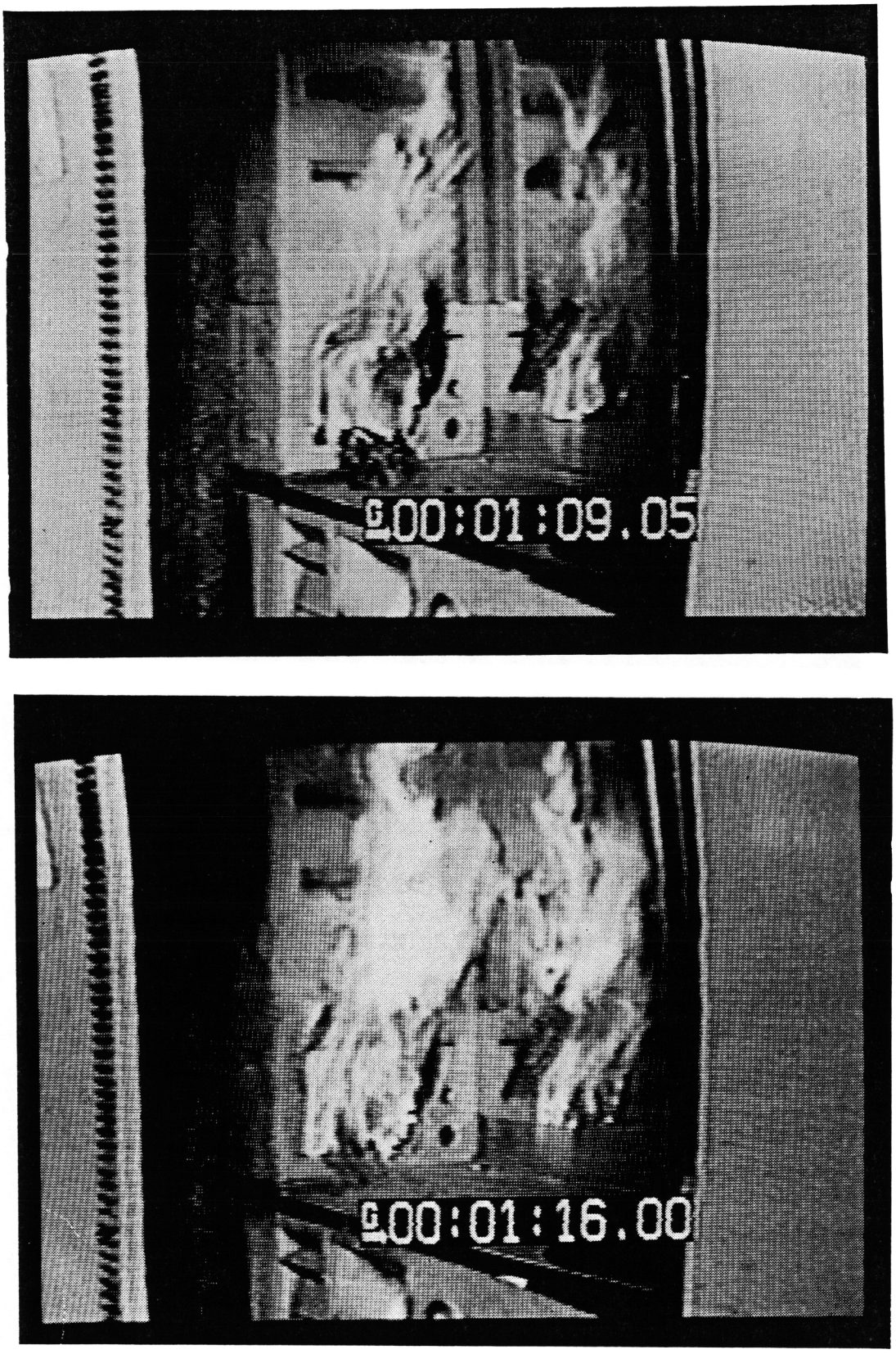

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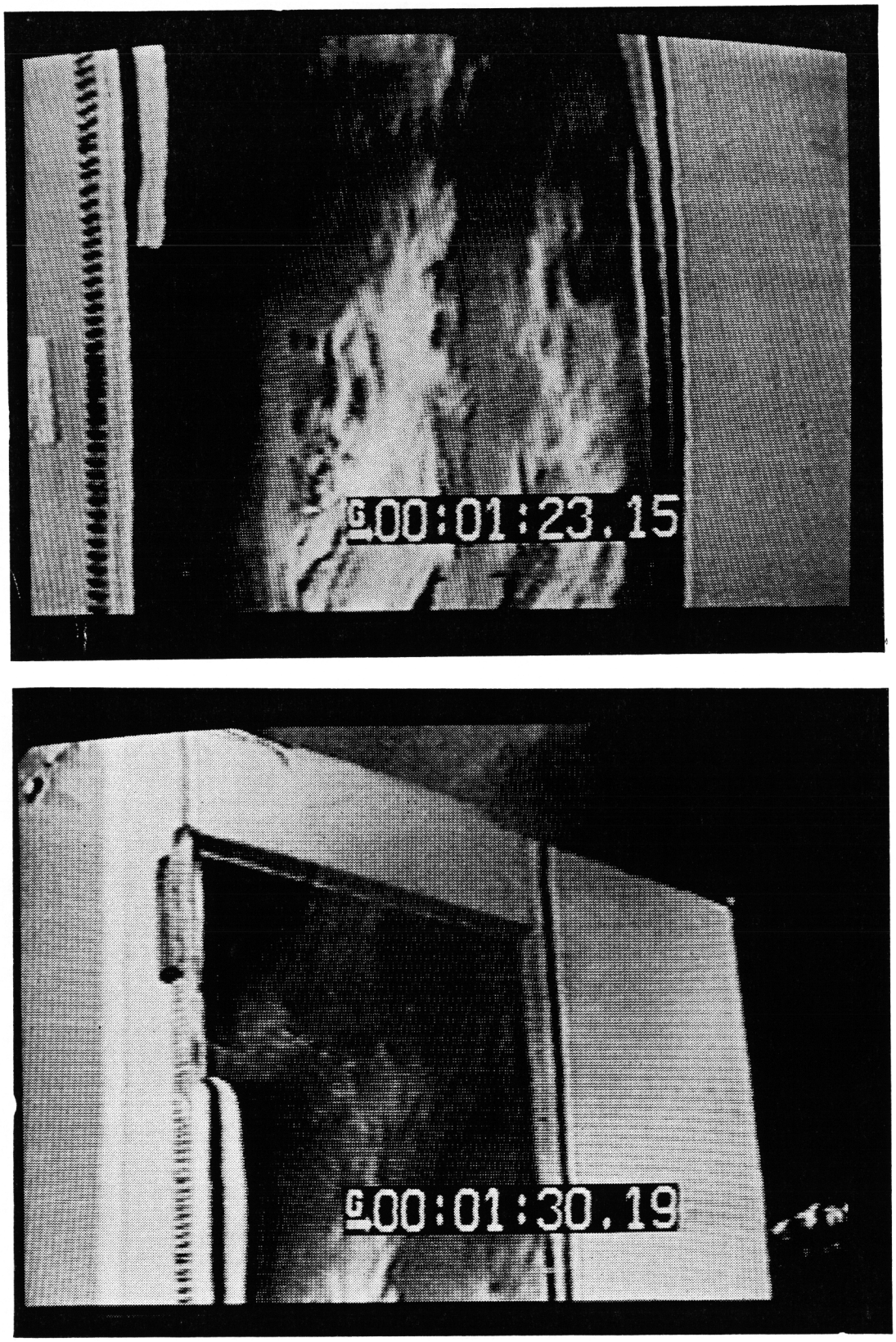

FIGURE 3. BUTANE TORCH AGAINST TRASH CHUTE (7 of 7 Sheets)

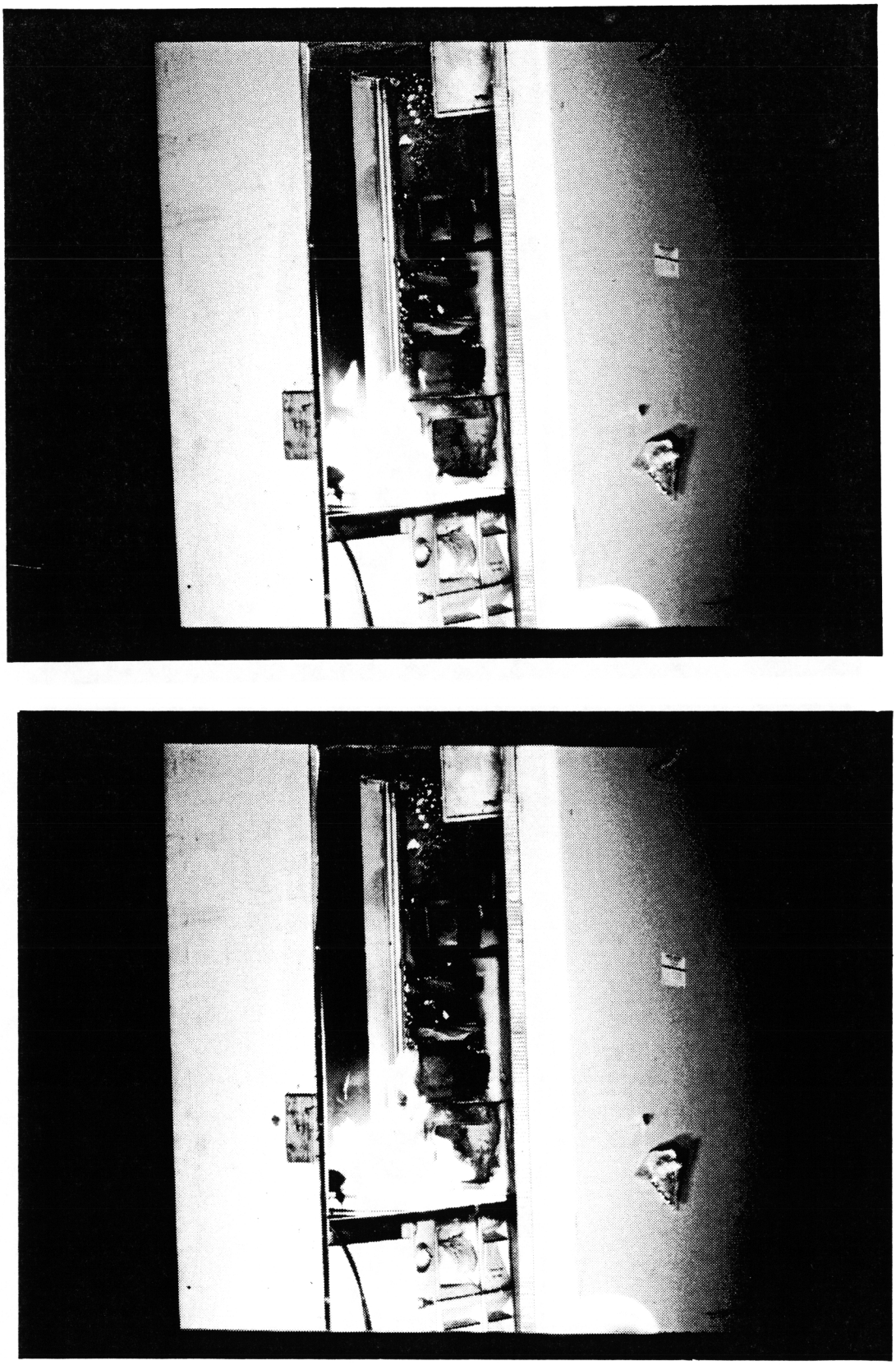

FIGURE 4. ETHER IGNITED ON LAVATORY COUNTER TOP (1 of 3 Sheets)

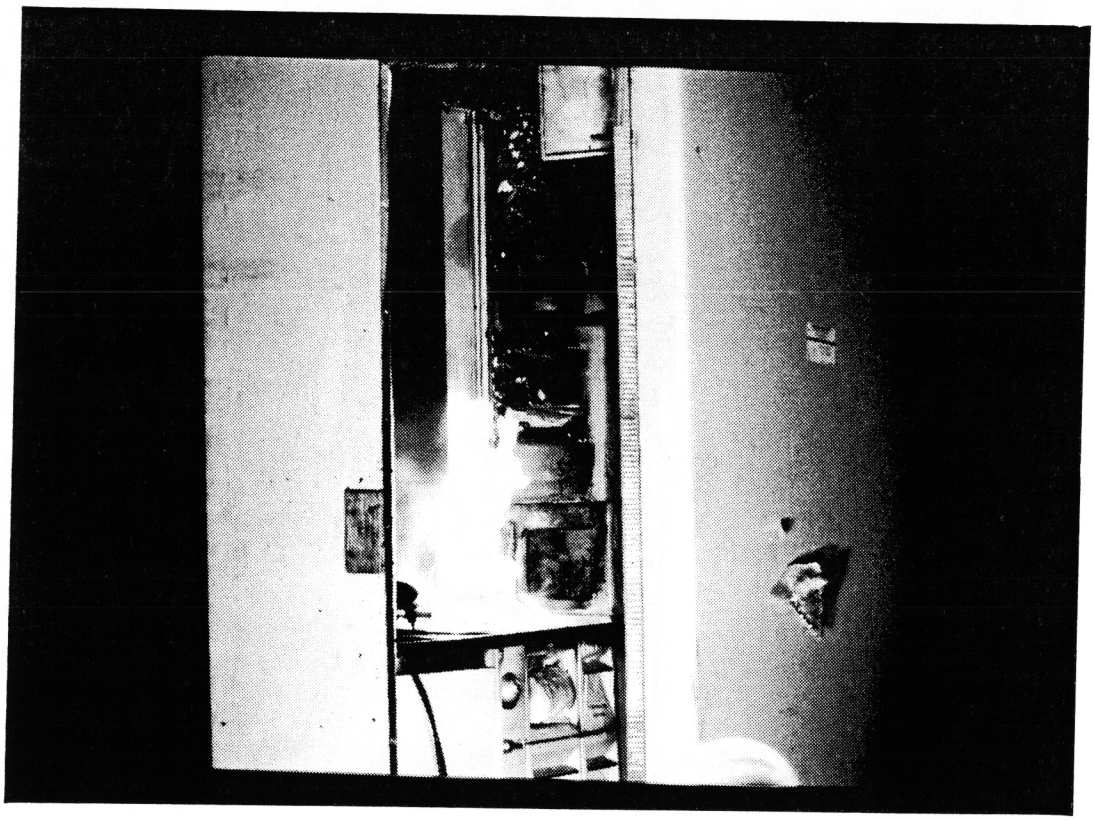

FIGURE 4. ETHER IGNITED ON LAVATORY COUNTER TOP (2 of 3 Sheets)

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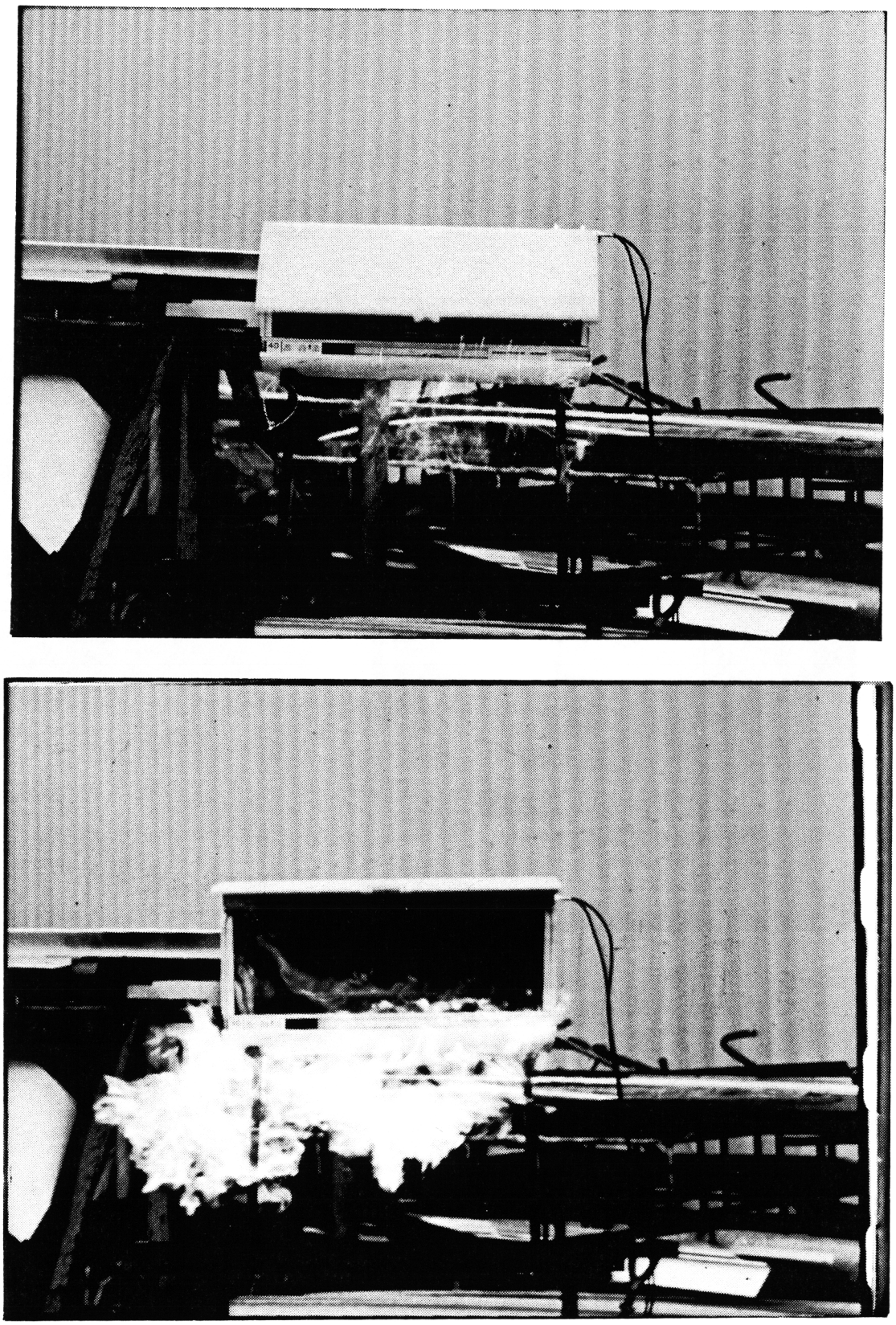


FIGURE 5. BUTANE IGNITED INSIDE STOWAGE BIN (1 of 4 Sheets)

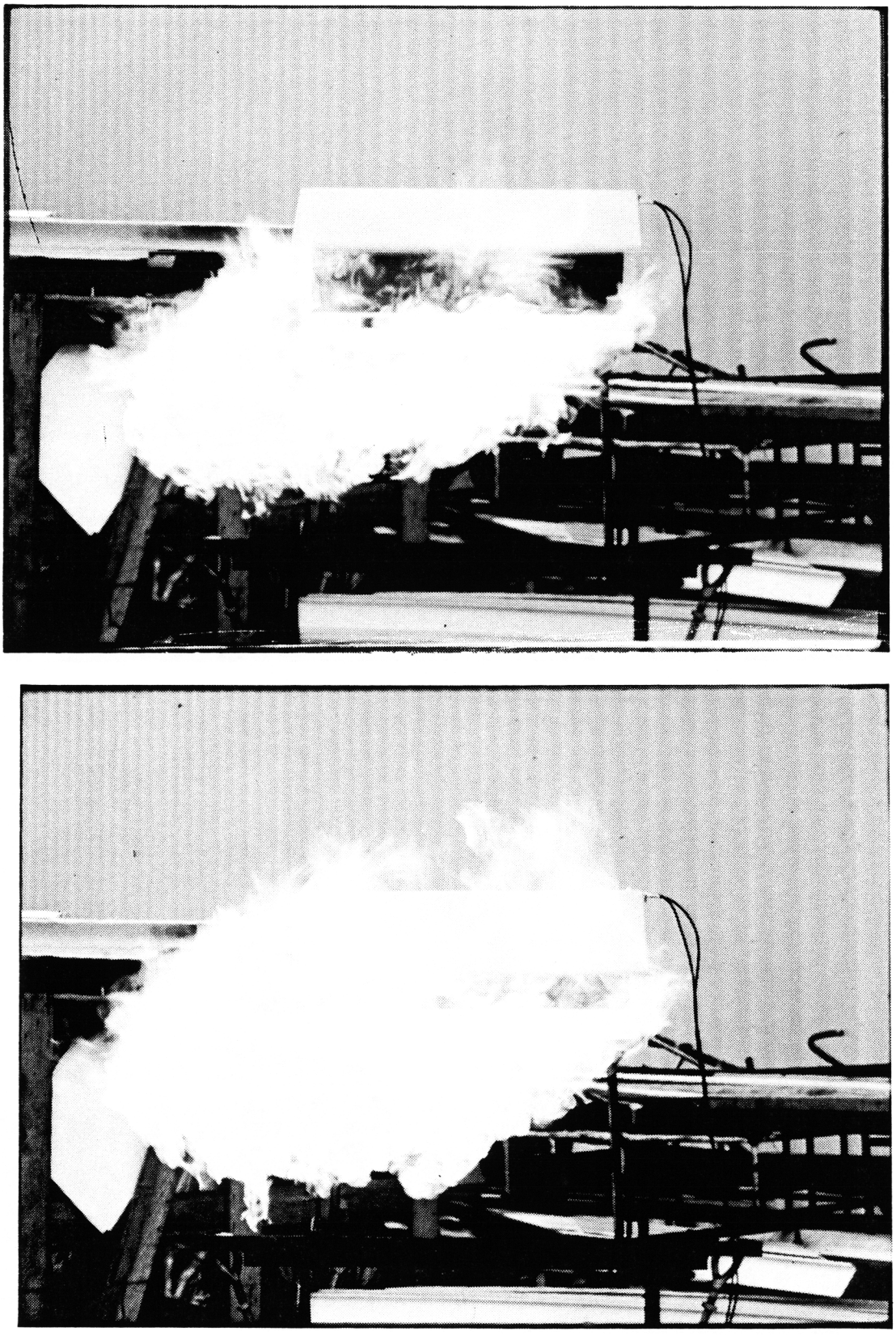
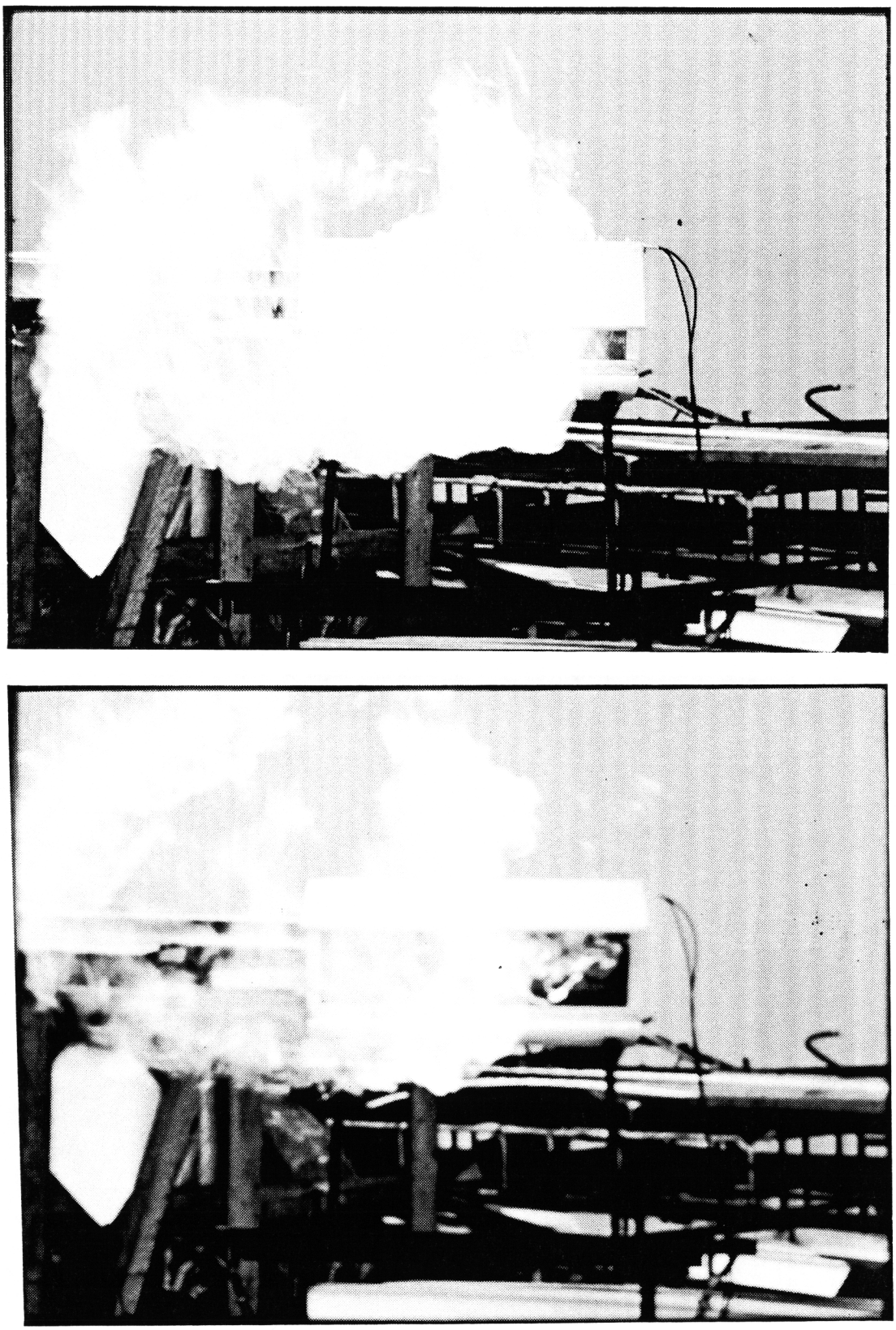


FIGURE 5. BUTANE IGNITED INSIDE STOWAGE BIN (2 of 4 Sheets)



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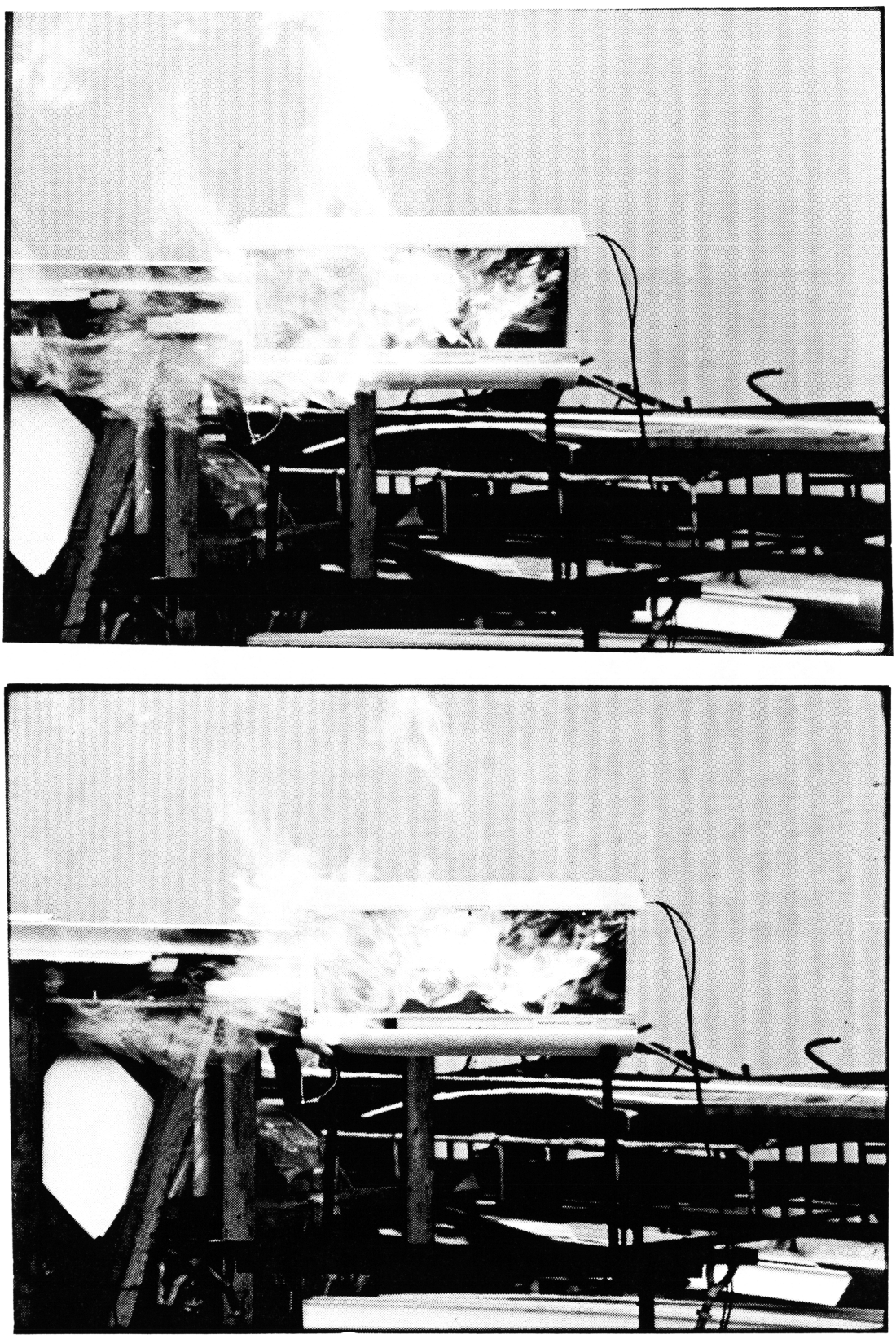

FIGURE 5. BUTANE IGNITED INSIDE STOWAGE BIN (4 of 4 Sheets)

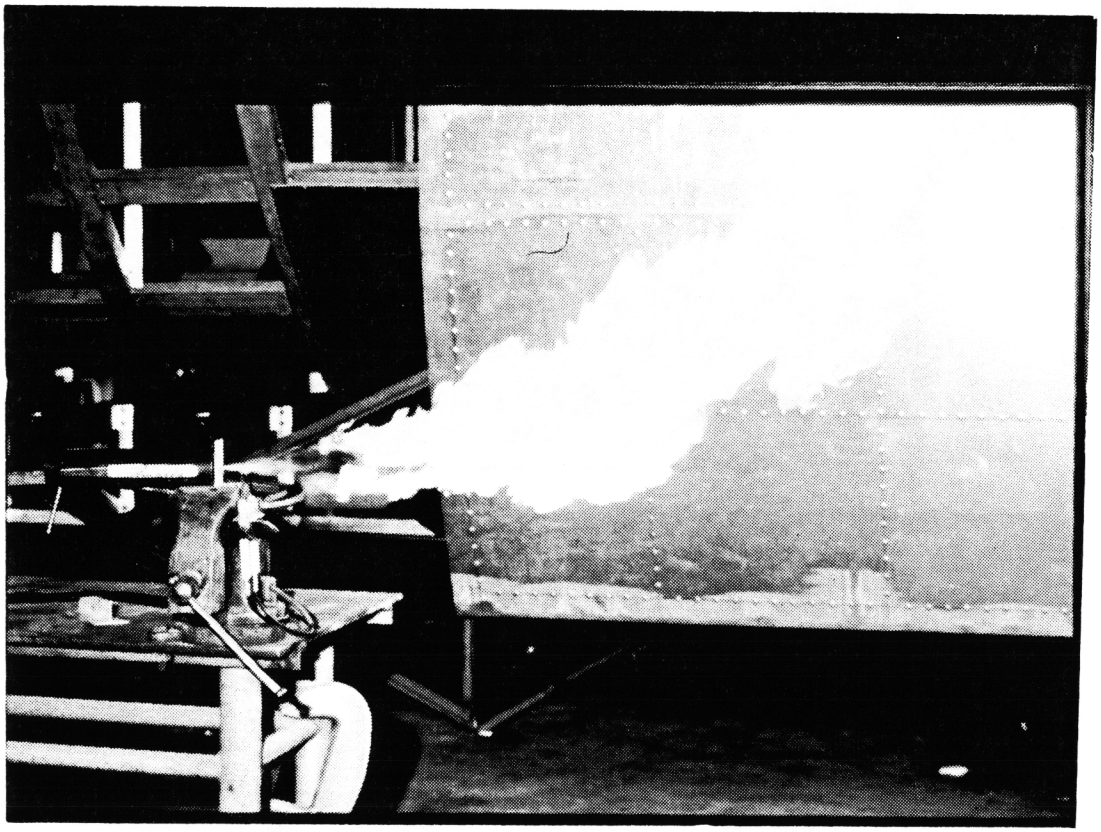

FIGURE 6. BUTANE SPRAYED ACROSS IGNITION SOURCE