MODEL FIRE TESTS ON POLYPHOSPHAZENE RUBBER AND POLYVINYL CHLORIDE (PVC)/NITRILE RUBBER FOAMS *

WILLIAM M. WIDENOR
Department of the Navy
David W. Taylor Naval Ship R&D Center
Annapolis Laboratory
Annapolis MD 21402

* Presented at the FIREMEN PROGRAM REVIEW, NASA-Ames Research Center, Moffett Field, California, 94035, April 13-14, 1978

ABSTRACT

A video tape record of model room fire tests was shown, comparing polyphosphazene (P-N) rubber and polyvinyl chloride (PVC)/nitrile rubber closed-cell foams as interior finish thermal insulation under conditions directly translatable to an actual fire situation.

Flashover did not occur with the P-N foam and only moderate amounts of low density smoke were formed, whereas with the PVC/nitrile foam, flashover occurred quickly and large volumes of high density smoke were emitted.

The P-N foam was produced in a pilot plant under carefully controlled conditions. The PVC/nitrile foam was a commercial product, which met the requirements of military specification MIL-P-15280H.

A major phase of the overall program involves fire tests on P-N open-cell foam cushioning.

INTRODUCTION

Laboratory fire tests for measuring ease of ignition, flame spread, smoke density, and rate of heat release, provide a means of screening many materials. However, tests of this type, even when employed collectively, are inadequate for assessing the potential fire risk of closed-cell foams as interior finish thermal insulation, or of open-cell foam cushioning for furnishings. The David W. Taylor Naval Ship Research and Development Center, and the National Bureau of Standards, Center for Fire Research, are engaged in a cooperative program for evaluating the fire risks of interior finish and furnishing materials.

APPROACH

Full scale room fire testing, under controlled conditions, is regarded as a reliable method for evaluating the fire risks of interior finish and furnishing materials. Full scale testing is not always feasible from the standpoints of time and cost. Nevertheless, numerous full scale room fire tests have been conducted at the NBS Center for Fire Research (CFR). More importantly, however, model room fire testing has been developed at CFR to the point where good correlation has been achieved between full scale and model room fire testing of interior finish materials, and to some extent, of furnishing materials.

DESCRIPTION OF MODEL ROOM AND MATERIALS

The tests described in this paper were conducted in a 1/4-scale model of a room 10 ft (3.05m) X 10ft (3.05m) X 8 ft (2.44m) high, having an open doorway 80 in (203.2cm) high X 30 in (76.2 cm) wide. The volume of the model chamber is 1/64th that of the room. For the test on the experimental polyphosphazene material, the walls and ceiling of the model chamber were lined with 1/2-in. (1.27 cm) thick closed-cell polyphosphazene foam insulation, produced in a pilot plant under carefully controlled conditions. The physical properties of this material, identified as APC, Sample No. 2, are given in Table 1. In a comparative test, the walls and ceiling of the chamber were lined with 1/2 in (1.27 cm) thick closed-cell PVC/nitrile rubber foam, meeting the requirements of military specification MIL-P-15280H, Plastic Material, Unicellular (Sheets and Tubes).

INSTRUMENTATION AND TEST CONDITIONS

Thermocouple trees were located inside the chamber and at the doorway. A photoelectric cell was used to measure smoke density continuously as it was emitted through the doorway. The ignition source was a methane diffusion burner, located at the right rear corner of the chamber. The heat output of the burner was 320 Btu/min (337.5 KJ/min), representing a small fraction of that needed to cause flashover

Table 1

Phosphazene Closed-Cell Foam, Pilot Plant Production
Physical Property Data Sheet

	APC #2	
Density, lbs/ft^3 (kg/m^3)	5.79	(92.7)
Tensile Strength, psi (MPa)	33.4	(0.23)
Elongation, %	40.0	
Compression Resistance, psi (MPa)	2.58	(0.018)
Water Absorption lbs/ft^2 (kg/m^2) of skinless area	0.0225	(0.11)
Dimensional Change @ 180°F (82°C), %	-3.5	
Water Vapor Permeability, perm-in. (kg/Pa·s·m)	<0.3	(<0.44×10^{-12})
Thermal Conductivity, k75 Btu · in./h · ft^2 · °F (W/m · K)	0.352	(0.051)
Compression Set, Method B, %	28.0	
NBS Optical Smoke Density		
D_m Flaming	55.0	
D_m Smoldering	63.0	

(full fire involvement) of the space. Carbon monoxide was measured continuously by infra-red equipment. Colorimetric indicator tubes were used to monitor HCN and HCl. Visual records of the tests were obtained by means of video tape and 16 mm motion picture film.

TEST RESULTS

In the test with the PVC/nitrile rubber foam, flashover occurred at 51 seconds, and dense black smoke poured from the doorway (Figure 1). At 58 seconds, the PVC/nitrile rubber foam was fully involved (Figure 2). No flashover occurred with the polyphosphazene foam, although the test was continued for 15 minutes. Figure 3 demonstrates the absence of flashover, with clock still running at 14 minutes, 50 seconds. A very limited amount of white smoke was produced by the polyphosphazene foam. A summary of the test results is given in Table 2.

Table 2

Quarter-Scale Model Room Fire Tests on Closed-Cell Foam Interior Finish Thermal Insulation

Material Under Test	Burner Output Btu/min (KJ/min)	Time to Flashover (sec,)	Max. Doorway Temp. T_1 (^oC)[1]	Time to T_1 (sec.)	Max. Interior Temp. T_2 (^oC)[2]	Time to T_2 (sec.)	Combustion Products, Peak Concentration[3]		
							CO (%)	HCl (ppm)	HCN (ppm)
PVC/nitrile rubber foam (MIL-P-15280H)	320 (337.5)	51	532	51	603	51	3.8	Approx. 1000	>600
Polyphosphazene (P-N) rubber foam, APC #2	320 (337.5)	>900	231	141	304	114	<0.1	<200[4]	$\leq$ 20

Notes: (1) One inch (2.54 cm) down from top of doorway opening
(2) One inch (2.54 cm) down from center of ceiling.
(3) Occurs at or immediately after flashover for PVC/nitrile. Applies throughout the test period for P-N foam.
(4) The P-N foam as produced is chlorine-free. Colorimetric detector tubes are subject to cross-sensitivity and the presence of combustion products other than those being evaluated may lead to erroneous indications.

DISCUSSION

It is noteworthy that the maximum temperature reached in the interior of the test chamber was approximately twice as high for PVC/nitrile rubber foam as for polyphosphazene foam. A similar relationship exists for doorway temperatures. The most significant, and striking, features of the polyphosphazene foam test were the absence of flashover and the low smoke output. The white smoke formed in a layer near the top of the chamber, but dissipated after 2 minutes, with none appearing thereafter. In the case of the PVC/nitrile rubber foam, severe (deep) charring occurred in the vicinity of the ignition source. In the remaining areas considerable surface charring was observed. Charred material produced on the polyphosphazene foam was not more than 1/8 in (0.32 cm) thick in the vicinity of the burner, and 1/32 in (0.08 cm) to 1/16 in (0.16 cm) thick in adjacent areas. The wall to the left of the doorway (and farthest from the burner) exhibited no charred material. The PVC/nitrile rubber foam produced approximately 200 ppm of HCl just prior to flashover and 4 to 5 times this amount after flashover. Similarly, HCN concentration was 300 ppm just prior to flashover and $>$600 ppm after flashover. A maximum of 3.8% carbon monoxide was observed at flashover. The corresponding figures for polyphosphazene foam (no flashover) were $<$200 ppm of HCl, $\leq$ 20 ppm of HCN, and

$<$ 0.1% carbon monoxide. It should be pointed out that the polyphosphazene foam as produced, is chlorine-free. Colorimetric detector tubes are subject to cross-sensitivity and the presence of combustion products other than those being evaluated may lead to erroneous indications.

CONCLUSIONS

These tests emphasize the great potential that polyphosphazene foams have for military and commercial applications, by reason of their flame resistance, low smoke-producing and low toxicity characteristics. Recently, the price of phosphazene polymers used in foam manufacture was substantially reduced. The price reduction also applies to phosphazene polymers for insulated wire and cable. The development of thermal insulation, foam cushioning, wire covering, paint systems and other polyphosphazene end products is continuing. It is anticipated that they will eventually take their place in competitive markets.

ACKNOWLEDGMENT

This research represents one phase of a cooperative effort with the National Bureau of Standards (NBS), Center for Fire Research, and was conducted jointly with Mr. W. J. Parker, Chief of the Construction Materials Program, and Mr. B. T. Lee, Research Fire Protection Engineer. Major funding for all polyphosphazene research and development is provided by Naval Sea Systems Command (NAVSEA) Materials and Mechanics Division. Fire research on polyphosphazene foams is supported by funds from both NBS and NAVSEA.

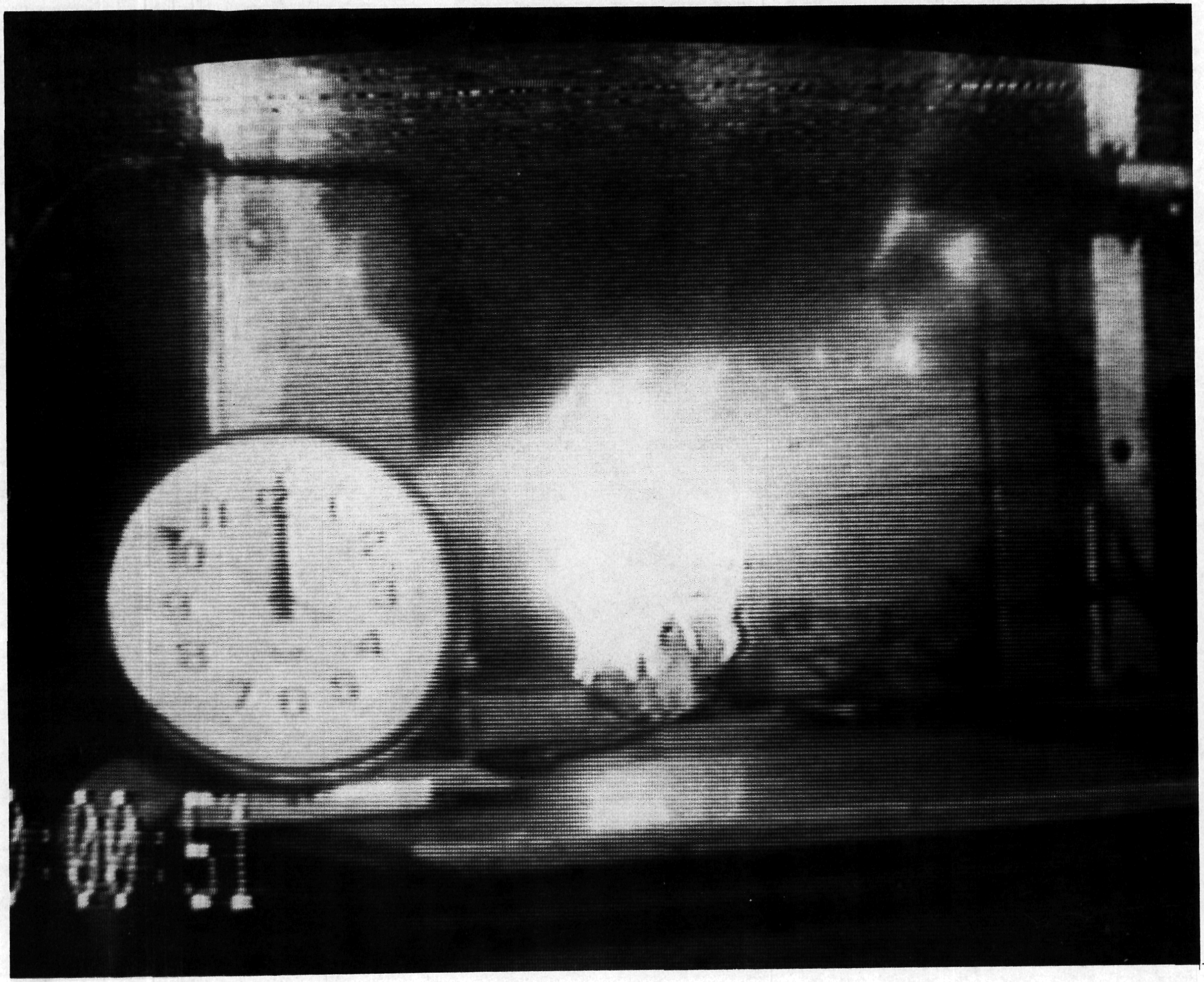

Fig. 1

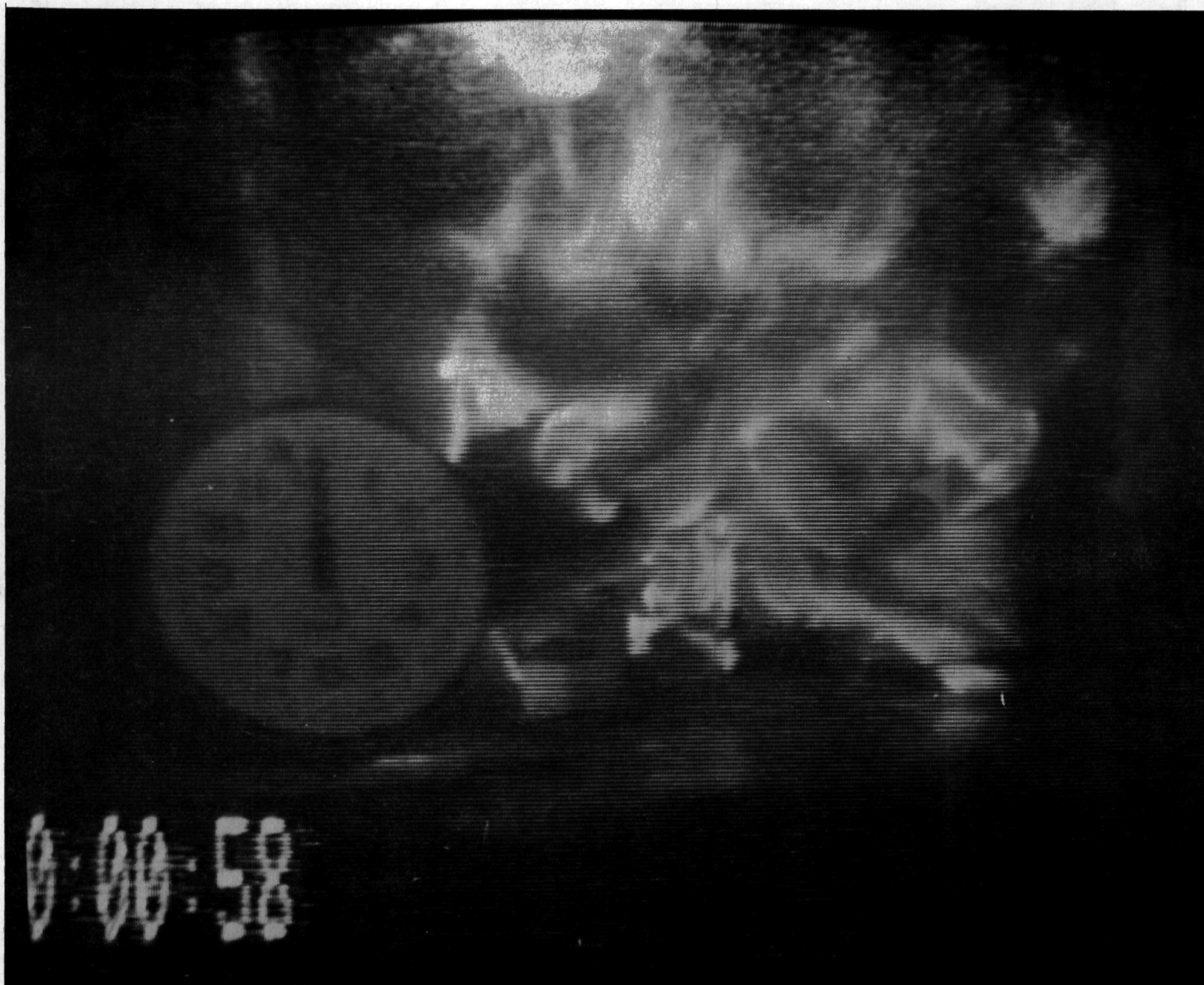

Fig. 2

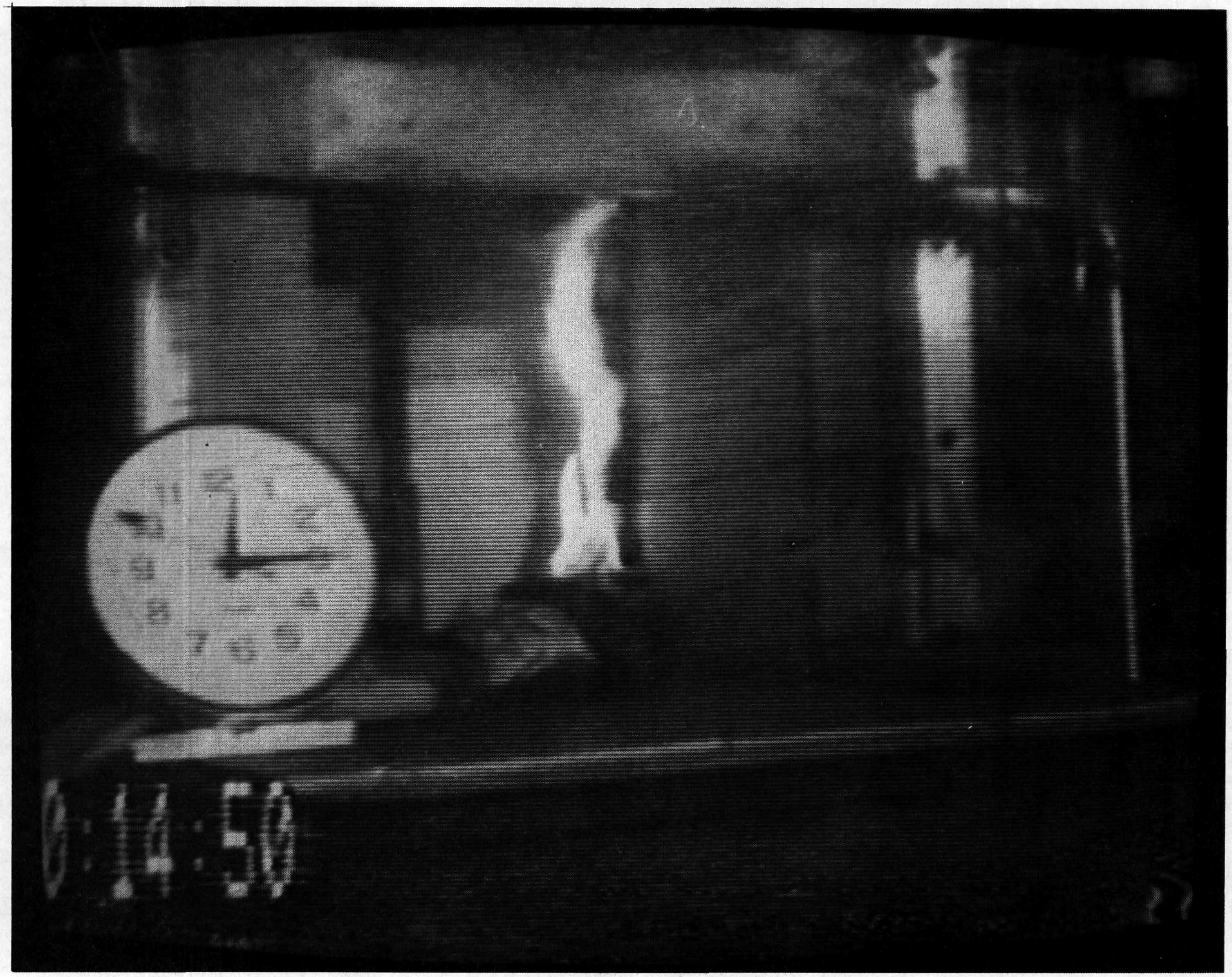

Fig. 3