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THE FIRE HAZARD OF WOODEN PACKING CASES IN POLYTHENE TENTS

by

R. H. Bigmore and G. C. Karas

Summary

This report deals with the fire hazard of storing tinned food in wooden packing cases inside polythene tents.

Experiments for assessing the hazard are described and recommendations are made for reducing it.

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1. Introduction

An atmosphere of low humidity is required to prevent the corrosion of food tins in storage. The absence of sufficient storage buildings where the humidity of the whole building can be controlled easily has necessitated an alternative method and it has been suggested by the Ministry of Works that stacks of cases could be enclosed in polythene tents in which the humidity could be controlled by means of small pumps circulating air through a drying medium.

Sheet polythene can be ignited from a small source and burns readily, therefore there is a risk that a continuing fire may be started involving wooden packing cases containing the tinned food. This hazard has been examined and recommendations are made for reducing it.

2. Proposals for storage

It is proposed to house the wooden cases in storage buildings of height 12 ft. x 6 in. to the eaves and having a concrete floor of area 215 ft. x 120 ft., the walls are of brick with three large doors in one side. A three span pitched roof of asbestos cement sheeting on steel trusses has a ventilator running the whole length of the building in each span. The cases (approximately 2 ft. x 1 ft. x 9 in. and of $\frac{1}{2}$ in. thick wood) are to be arranged in stacks approximately 12 ft. high covering a floor area between 28 ft. x 34 ft. and 42 ft. x 34 ft: each stack is to be enclosed in a tent of sheet polythene 0·010 in. thick supported 6 in. from the boxes by a steel framework, the base of this tent is to be a polythene/aluminium/paper laminate to which the walls of the polythene tent are to be sealed; the whole is to rest on wooden dunnage.

It is anticipated that a temperature of 70°F and a relative humidity of 45 per cent may be achieved in the tents and under these conditions the moisture content of the boxes would be between 8 and 11 per cent.

3. Consideration of the fire hazard

Polythene sheeting of the proposed thickness is readily ignited by a small flame, such as a lighted match, and in free air will burn with a vertical flame spread of 14 cm sec^{-1} (as measured on the semi-circular frame test [1]), this is equivalent to newsprint. Burning polythene melts and allows flaming drops to fall. These may start a fire involving the wooden cases by falling into the crevices and onto the ledges which are inevitable when the cases are stacked; or by falling onto the combustible base.

4. Experimental procedure and results

The various tests carried out to assess the fire hazard and to study means of reducing it are listed in Table 1.

Table 1

Experiments carried out

Test	Purpose	Details of test
A	Assessment of hazard	Ignition at vertical surface of stack
B		Ignition in crevices in stack
C		Ignition of base of stack
D	Reduction of hazard	Use of asbestos paper to reduce hazard A
E		Use of whitewash and limewash to reduce hazards A and B
F		Use of insulating board to reduce hazard C

4.1. Ignition at vertical surface of stack. Test A

Four wooden cases, having a moisture content between 8 and 10 per cent were arranged on an incombustible base shown in Plate 1. The base was covered with polythene. The cases were stacked so as to form at one vertical face a ledge approximately $\frac{1}{2}$ in. wide between the bottom and top rows and also a vertical gap nominally $\frac{1}{2}$ in. wide between the two columns. A sheet of polythene 3 ft. 6 in. long and 2 ft. wide was draped across this face with its lower edge lying on the base and in contact with it about 6 in. away from the cases, the sheet was inclined towards the boxes but did not touch them. The polythene was ignited at the centre of the bottom edge and flames spread upwards involving the whole sheet: burning polythene dropped onto the horizontal ledge and ignited the wood in several places, two vertical edges of the upper layer boxes continued to burn in an up-draught of 2 m.p.h., Plate 2.

4.2. Ignition in crevices. Test B

Eight cases in tiers of four were stacked as shown in Plate 3. The four cases in the lower tier were placed close together and the four in the upper tier were arranged so that the two vertical gaps were approximately 1 in. wide. A 4 ft. x 3 ft. sheet of polythene was supported 6 in. above the boxes on metal bars, with one supporting bar situated directly above the longer gap. The moisture content of the boxes varied between 7 per cent and 11 per cent. One edge of the polythene was ignited and flames spread across the whole sheet, as the flames progressed burning polythene fell onto the tops of the boxes and down the vertical spaces: small pools of burning polythene formed in two places on the ledges at the bottom of the joints (A and B in Figure 1) and ignited the sides of the boxes. Flames spread rapidly up the walls of the gap (Plate 4) and the whole boxes were soon involved.

4.3. Burning on base laminate. Test C

A 12 in. square sheet of polythene/aluminium/paper laminate 0·010 in. thick was placed on a 3/16 in. thick horizontal panel of three-ply wood with the polythene face uppermost. A chromel/alumel thermocouple was fixed between the laminate and the plywood at the centre.

It had been previously observed that when a vertical sheet of 0·010 in. thick polythene was burning, flaming drips did not fall from all points at once along the flame front but that the greatest width of flame front producing a single stream of drips was about 1 in. In order therefore to simulate the hazard to the base laminate an amount of polythene sheet equivalent to a strip 12 ft. long 1 in. wide approximately (i.e. 156 sq. in.) was taken as the greatest amount of polythene that would, when burning, drip in a single stream onto one point.

A sheet of polythene 0·010 in. thick and of area 156 sq. in. was suspended above the centre of the laminate and ignited so that the burning drops fell immediately over the thermocouple. The polythene continued to drip for six minutes and the pool formed on the laminate, which spread to about 8 in. diameter, continued to flame for 15 minutes. The temperatures recorded by the thermocouple are shown in Figure 2.

The surface of the plywood was heated to 285°C during the first two minutes when approximately one-third of the total polythene had dripped and this temperature was not increased due to the polythene burning during the next 4 minutes. However when the surface of the plywood had been maintained at 225°C for 4 minutes an exothermic reaction started and the temperature increased rapidly to 400°C. The top laminates and much of the core of the plywood under the pool was charred. Smoke issued from around the edges of the laminate. The aluminium foil layer was not perforated.

5. Reduction of the hazard

5.1. Protection of vertical face by asbestos paper. Test D

Twenty-four wooden cases were stacked (2 boxes wide x 12 boxes high) to form a column 4 ft. wide and 12 ft. high. The average moisture content of the boxes was 11 per cent. The face of the column was covered with asbestos paper 0·020 in. thick and a sheet of 0·010 in. thick polythene 12 ft. long x 4 ft. wide was hung 6 in. in front of the asbestos paper with its bottom edge resting on another sheet of polythene 4 ft. wide which extended underneath the column. The polythene was ignited at the centre of the bottom edge and as flames spread up the sheet, flaming polythene dripped onto the asbestos paper and burnt readily with the asbestos paper acting as a wick (Plate 5). The flaming persisted for about 15 minutes. Patches of the boxes immediately behind the flaming areas were charred.

5.2. Protection afforded by whitewash and limewash. Test E

The vertical crevices which would be formed in the stack were simulated as shown in Figure 3. Two samples (9 in. x 4 in. x 7/16 in.) cut from packing cases, were mounted parallel ¾ in. apart with their longer edges vertical, ¼ in. above a wooden base which was formed from two other samples (also 4 in. wide) butted together with the joint below the middle of the vertical gap. The ¼ in. space between the base and the vertical walls was closed by placing pieces of wood on the base and touching the outside faces of the vertical samples. The average moisture content of the wood for each test in this group was 7 per cent.

5.2.1. Test E (i)

The above arrangement was used for untreated wood and a 0.010 in. thick sample of polythene 6 in. long and 2 in. wide was suspended centrally $\frac{1}{2}$ in. above the vertical gap. The lower edge of the polythene was ignited (Plate 6) and burning polythene dripped into the gap for 1 minute forming a flaming pool at the bottom (Plate 7); the lower edges of the walls of the gap were ignited and a continuous fire was established in 3 minutes.

5.2.2. Test E (ii)

The protection against ignition given by one and two coats oil-free, non-washable, proprietary whitewash (2) and limewash (3) was measured by treating all exposed surfaces and edges in the arrangement described above and igniting polythene above the gap; four tests were carried out. In each test a number of 6 in. x 2 in. sheets of polythene were used consecutively. To maintain a continuously burning pool of polythene at the bottom of the gap each sheet was replaced when it had burned out and the new one was ignited as soon as the pool began to die out.

Table 2 records the application of fire retardant treatments, the number of sheets of polythene ignited, the time either to the establishment of a continuous fire in the wood or for which the pool continued burning (both times measured from first ignition) and gives general observations.

Table 2

Comparison of effects of treatments to surface of wood

Fire retardant	(1) Rate of application (after thinning) oz/sq.ft.	(2) Number of 6 in. x 2 in. sheets burned	(3) Burning time of pool or time for continued burning to be established in wood min.	(4) Remarks
Untreated	-	1	3	-
Distemper 1 coat	1·75	6	22 (continued burning)	The fire built up and involved the whole of the exposed faces at 24 min.
Distemper 2 coats	First coat 1·75 Second coat 1·75	10	15 (no continued burning)	-
Limewash 1 coat	1·25	2	$4\frac{1}{2}$ (continued burning)	Wood charred by first sheet. Whole of exposed faces involved in $9\frac{1}{2}$ min.
Limewash 2 coats	First coat 1·25 Second coat 1·0	5	$5\frac{1}{2}$ (continued burning)	Whole of exposed faces involved after $6\frac{1}{2}$ min.

From columns (2) and (3), Table 2, it will be seen that the average time elapsing between the ignition of successive sheets varied in each experiment. The longer periods were due to the pools continuing to flame because the wood assisted the burning slightly.

5.3. <u>Incombustible board on dunnage. Test F</u>

5.3.1. <u>Test F</u> (i)

A 12 in. square sheet of $\frac{1}{8}$ in. thick asbestos cement was supported on the faces of two lengths of 6 in. x 1 in. plain edged boarding resting edge to edge and a thermocouple was fixed at the centre between the asbestos cement sheet and the boards. A 12 in. square sheet of polythene/aluminium/paper laminate 0·010 in. thick was placed on top of the asbestos cement sheet with the polythene face uppermost.

A sheet of polythene 0·010 in. thick and 156 sq. in. in area was suspended above the centre of the laminate and ignited so that the burning drops fell immediately above a point over the thermocouples. The polythene continued to drip for six minutes and the pool formed on the laminate spread to about 5 in. diameter and continued to flame for 17 minutes. The temperatures recorded by the thermocouples are shown in Figure 2; the maximum value was 180°C. A hairline crack 5 in. long was formed in the asbestos cement sheet below the pool, the wood was not discoloured.

5.3.2. <u>Test F</u> (ii)

The same experiment was carried out using a $\frac{3}{8}$ in. sheet of plasterboard instead of the asbestos cement. A $5\frac{1}{2}$ in. diameter pool of polythene burned for $15\frac{3}{4}$ minutes. The temperature of the thermocouple reached 95°C 8 minutes after ignition of the polythene sheet and remained constantly at this temperature until 26 minutes after ignition when the temperature commenced to drop.

The under side paper of the paper/aluminium/polythene laminate charred completely whilst the top paper of the plasterboard was much discoloured by charring, considerable condensation was observed at the underside of the laminate. No effect was noticed on the bottom of the plasterboard sheet; nor was the wood discoloured.

<u>Discussion of results</u>

The experiments described in section 4 show that a continuing fire may develop if a polythene tent is ignited.

From Table 2 it is seen that two coats of limewash or one coat of the proprietary whitewash will considerably increase the resistance of the wooden boxes to ignition. The stacks could therefore be protected by painting or spraying all the boxes before stacking or alternatively treating the external walls after stacking and covering the top of the stack with incombustible or near-incombustible sheets such as plasterboard or asbestos cement. If the latter method should be adopted it will be necessary to ensure that all edges are protected by painting or spraying into the vertical gaps to a depth of about 1 in. Whitewash is preferable to limewash because it is less susceptible to damage by abrasion.

Asbestos paper is unsatisfactory for protecting the sides of the stack because it assists continued burning by acting as a wick to polythene dripping onto it, and also, as it is friable, it would be difficult to protect large areas without tearing the paper.

If the wood in the base is maintained at a temperature of 180°C for a sufficiently long period; an exothermic reaction may occur. Test F (ii) shows that the thermal resistance of the incombustible has a considerable effect on the final temperature and therefore either a $\frac{3}{8}$ in. sheet of plasterboard or $\frac{1}{4}$ in. sheet of asbestos cement would be adequate protection.

Conclusions

The fire hazard of packing cases stored on wooden dunnage under a polythene tent has been examined and the following recommendations are made for reducing it.

1. The top of the stack should be completely covered by incombustible sheets such as asbestos cement or plasterboard to prevent burning polythene dripping into crevices.

2. The vertical faces of the stack should be treated after stacking with one good coat of oil-free, non-washable, distemper; care being taken to protect all exposed edges.

3. If the stack is mounted on wooden dunnage a sheet of $\frac{1}{4}$ in. thick asbestos cement or $\frac{3}{8}$ in. plasterboard should be interposed between the polythene/aluminium/paper laminate and the wood in all positions where polythene may drip onto the laminate.

References

1. F.R. 107, Flammability of fabrics. Lawson, Webster and Gregsten.
2. British Standard 1053 : 1950. Water paints and distempers for interior use.
3. Building Research Station Digest No. 17. April, 1950. Colour-washes (including paints) on external walls.

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PLATE 1. ARRANGEMENT OF TEST "A" JUST AFTER IGNITION OF POLYTHENE.

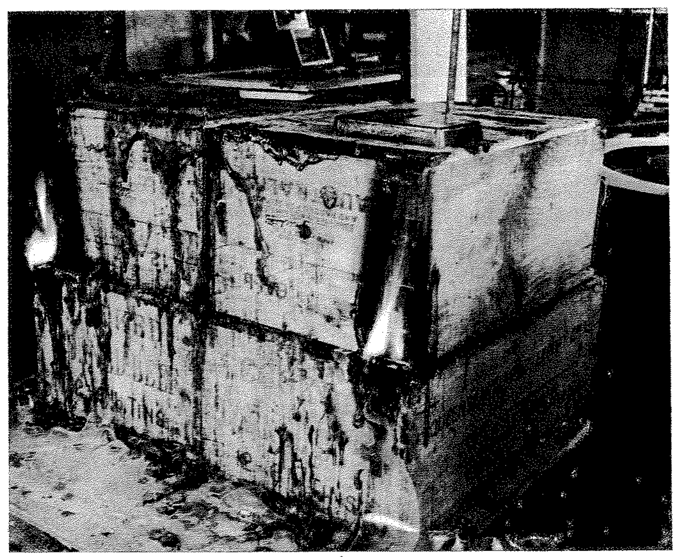

PLATE 2. DEVELOPMENT OF FIRE ON BOXES IN TEST "A" AFTER 12 MIN.

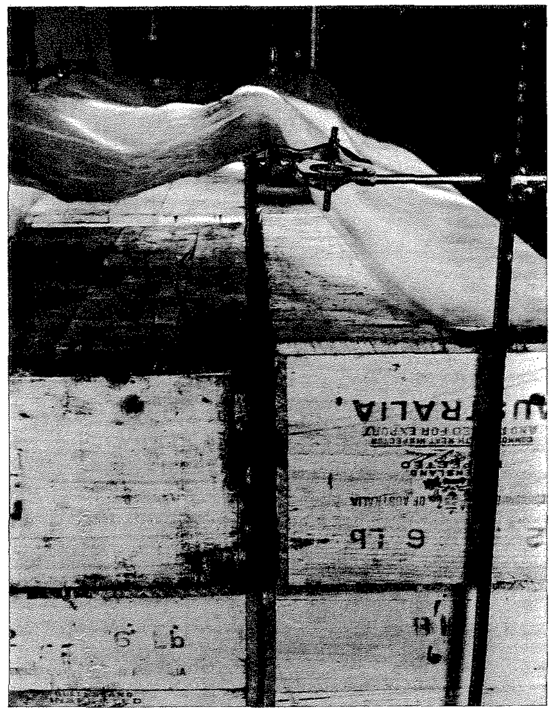

PLATE 3. ARRANGEMENT OF TEST "B" BEFORE IGNITION.

PLATE 4. DEVELOPMENT OF FIRE IN CREVICE DURING TEST "B".

PLATE 5. POLYTHENE BURNING ON ASBESTOS PAPER DURING TEST "D".

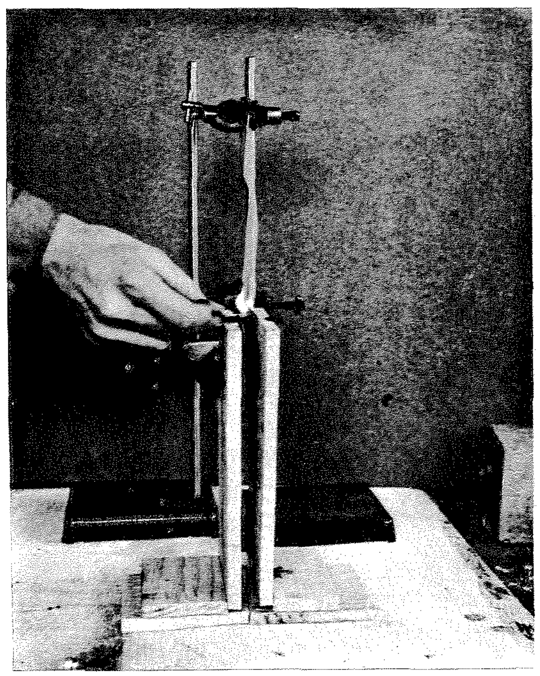

PLATE 6. IGNITION OF POLYTHENE IN TEST "E(i)."

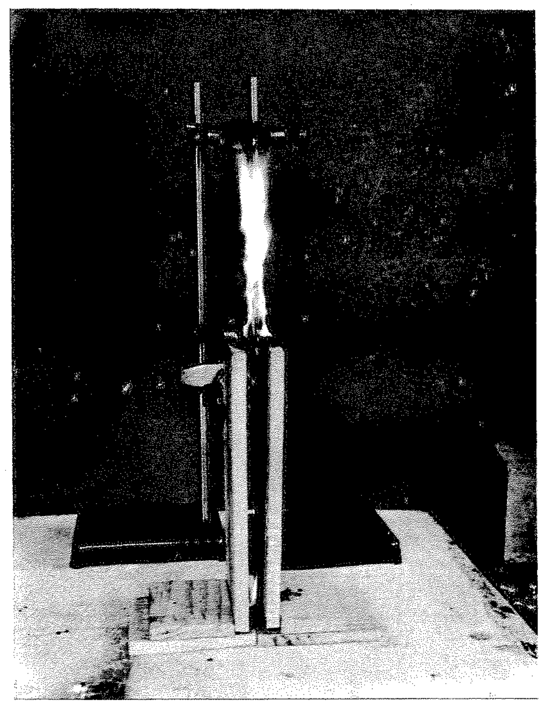

PLATE 7. IGNITION OF WOOD AT BOTTOM OF CREVICE IN TEST "E (i)".

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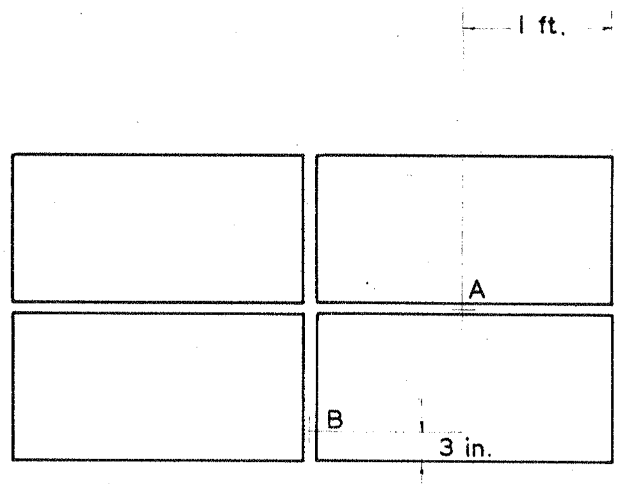

FIG. 1. PLAN VIEW OF BOXES IN TEST B.

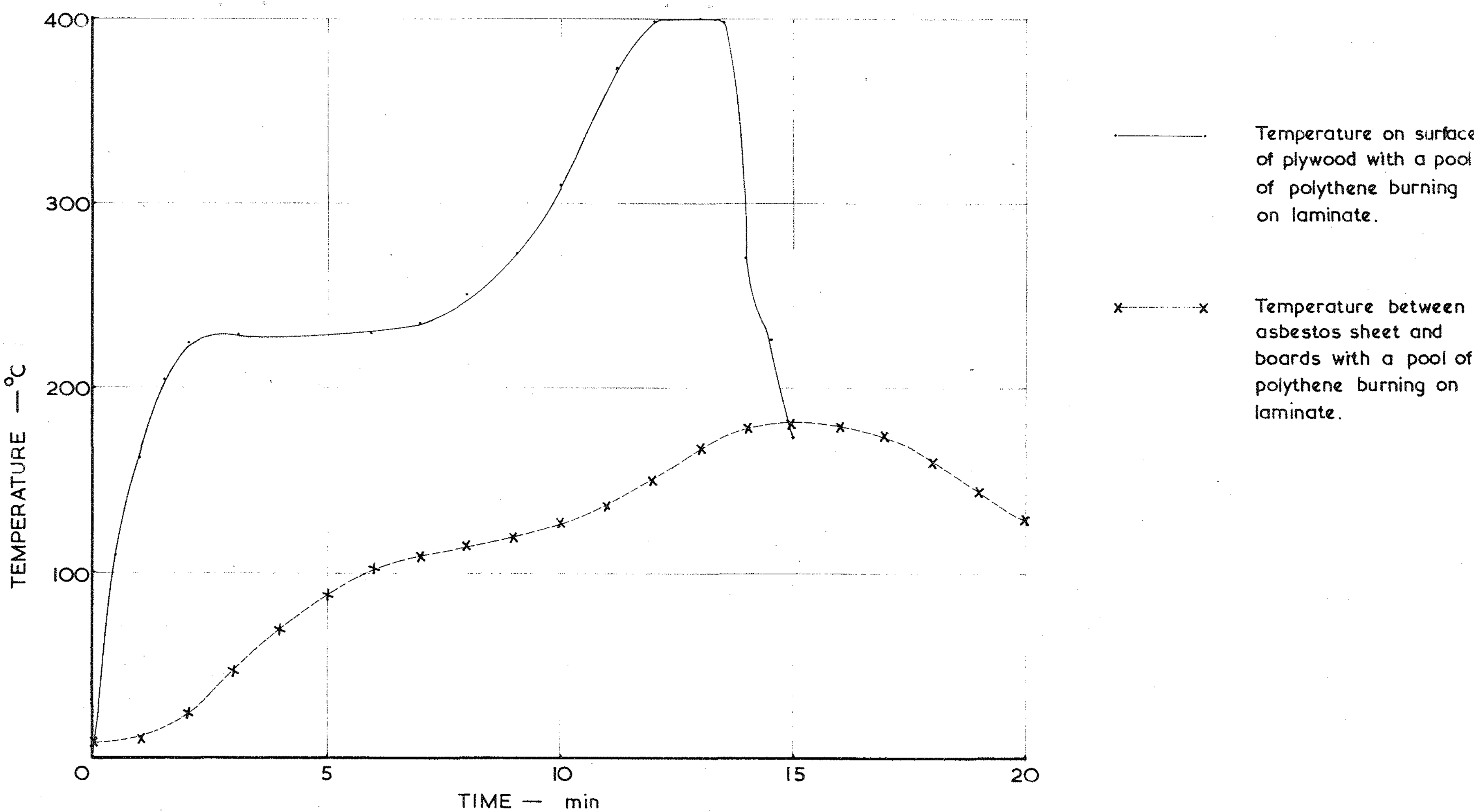

FIG. 2. TEMPERATURES ON DUNNAGE TESTS C AND F(i).

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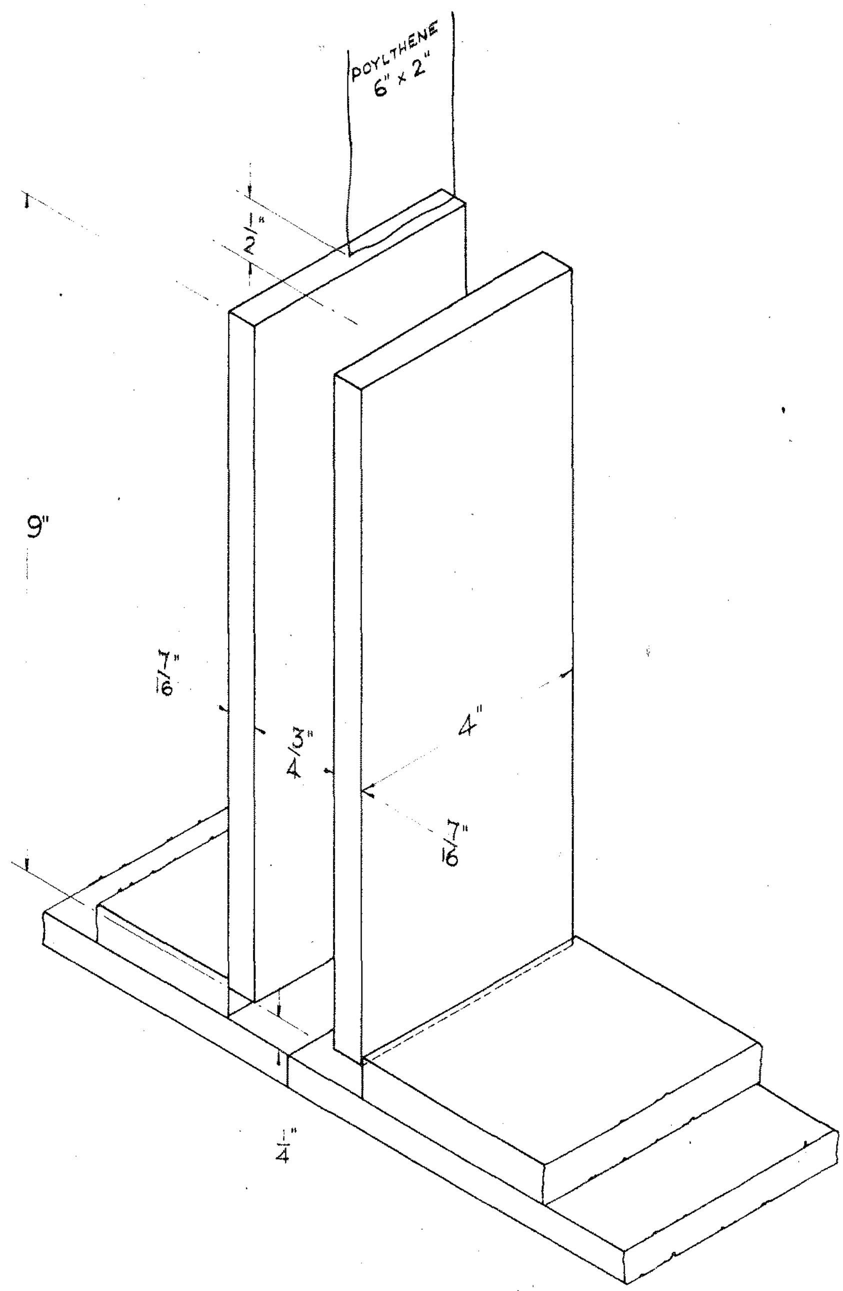

FIG. 3. ARRANGEMENT SIMULATING CREVICES.