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THE APPLICATION OF HIGH EXPANSION FOAM TO WOOD CRIB FIRES

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SUMMARY

Experiments have shown that when applied at an adequate rate, high expansion foam can readily extinguish flaming combustion in wood crib fires. The complete extinction of smouldering combustion, however, did not always occur and it was often necessary to top up with fresh foam in order to minimise smouldering beneath the foam.

KEY WORDS: Foam, high expansion, fuel solid, fire, wood, crib, extinguishing.

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1. INTRODUCTION

A short series of exploratory experiments has been made in order to investigate the performance of high expansion air foam on wood crib fires. The factors which have been considered are the fire load, rate of application of the foam and the likelihood of reignition of the fire.

2. EXPERIMENTAL ARRANGEMENT

The experiments were made in an enclosure of plan area 42 m^2 (456 ft^2), Fig 1, with a high expansion foam generator installed at ground level in one side. Wood cribs were erected in the enclosure and were ignited. Foam was applied at different rates and the temperatures at the surface of the wood sticks at the top and in the centres of the cribs were recorded. The experimental programme is given in Table 1.

Table 1. Details of experimental fires

Experiment No.	Fire	Mean rate of application of foam	Approximate expansion	Overall fire load kg/m^2 (lb/ft^2)	Recommended rate (see Section 5) m/min (ft/min)
1	1 crib (8 min pre-burn)	0.3 m/min (1 ft/min)	850:1	1.05 (0.2)	0.063 (0.2)
2	"	0.1 m/min (0.33 ft/min)	260:1	1.05 (0.2)	0.063 (0.2)
3	"	0.24 m/min (0.8 ft/min)	600:1	1.05 (0.2)	0.063 (0.2)
4	4 cribs (7 min pre-burn)	0.24 m/min (0.8 ft/min)	700:1	4.2 (0.8)	0.25 (0.8)

2.1. Enclosure

The enclosure was made using movable asbestos screens and was 6 m (20 ft) x 7.3 m (24 ft) in area. Foam could be contained in the enclosure to a depth of 2.7 m (9 ft).

2.2. Foam generation

A standard Walter Kidde P 500 high expansion foam generator, designed to produce 140 m^3 (5000 ft^3), per minute of foam of an expansion of 1000:1 was used. The rate of fill was varied by adjusting the fan speed and the water pressure on the foam generator. This also altered the expansion ratio of the foam as seen in Table 1.

2.3. Expansion measurement

Foam expansion was measured by filling a plastic container of known volume with foam, and noting the weight of the foam. As far as was possible, these measurements were made at the same place in the enclosure on each occasion.

2.4. Wood cribs

The cribs used were the same as those being developed for a standard fire test for fire extinguishers. The specification of the crib was as follows:-

Type of wood	:	white pine, 4 cm^2 cross section
Spacing	:	6 cm between sticks
Crib height	:	56 cm, i.e. 14 layers of 4 cm each layer
Crib width	:	50 cm
Crib length	:	100 cm
Weight of crib	:	46 kg $\pm$ 4 kg
Moisture content	:	12-14 per cent
Pre-burn time	:	2 min with 'Avgas' plus 6 min free burning

The cribs were supported at a height of 25 cm above the floor, and a tray equal in area to the crib was placed under the crib with sufficient 'Avgas'* in it to burn for 2 min.

*Aviation Gasoline, 100/130 octane.

2.5. Temperature measurements

The temperature at the top centre and the dead centre of the cribs was measured by chromel-alumel thermocouples strapped to the surface of the wood stick at the appropriate position. The leads from each couple were protected by asbestos and a 13 mm (0.5 in) diameter steel sheath. The output from each couple was monitored throughout each experiment.

3. EXPERIMENTAL PROCEDURE

In experiments 1, 2 and 3 a single crib was built in the centre of the enclosure (Fig 1). The settings on the foam generator of fan speed and water pressure were determined in a preliminary "cold" test. The 'Avgas' under the crib was ignited and after 8 min total pre-burn time foam generation was commenced, foam samples for expansion measurement were taken and the enclosure sealed. The progress of the fire and foam were observed and foam generation was stopped either when the enclosure was filled (experiments 1 and 3) or when the crib fire had burnt itself out (experiment 2).

In experiment 4 an attempt was made to see if a higher rate of foam application was necessary to control 4 crib fires in the enclosure. The 4 cribs were positioned as shown in Fig 2 and the procedure for the previous tests was followed except that the pre-burn time of the cribs, which were ignited simultaneously, was 7 min.

4. RESULTS

4.1. Experiment 1

Rate of foam application 0.3 m/min (1 ft/min)
Expansion 850:1

Table of Events

Time (minutes)	Event
0.00	'Avgas' lit in tray under crib
8.00	Foam application commenced
9.00	Foam expansion samples taken, foam reached bottom layer of crib
10.00	Foam reaches centre of crib
11.05	Foam level with top of crib, flames still breaking through
11.30	Flames out
17.00	Enclosure filled to depth of 2.6 m (8.5 ft)
50.00	Foam level fallen to 2.1 m (7 ft) Foam cleared away to expose crib. Foam had not entered crib
56.00	Crib re-ignited

There appeared to be no significant foam breakdown caused by radiation from the crib. Temperature-time curves for thermocouples at the top centre and dead centre of the crib are given in Fig 2.

4.2. Experiment 2 Rate of foam application 0.1 m/min (4 in/min)
Expansion 260:1

Table of events

Time (minutes)	Event
0.00	'Avgas' lit in tray beneath crib
8.00	Foam application commenced
9.00	Foam expansion samples taken
9.30	Foam surrounds crib at distance of 0.5 m (1 ft 8 in)
11.00	Foam reaches height of 0.7 m (2 ft 4 in) all round perimeter of enclosure, but still breaking down near crib
13.00	Situation as at 11 min, foam breakdown equalling foam production
16.00	Crib collapsed
17.00	Foam reaches edges of crib
18.00	Foam covers remainder of crib. Foam off.

At this rate of foam production, the breakdown caused by radiation prevented the foam from reaching the crib.

4.3. Experiment 3

This was a repeat of Experiment 1 and although the mean rate of foam application was lower than that for Experiment 1, the initial rate was similar and the time/event table was almost identical to that in Section 4.1.

In experiment 3 the foam level was maintained for one hour by topping up with fresh foam at the same rate at 30 min after ignition and 50 min after ignition. Temperature time curves are shown in Fig 3.

There was no time available at the end of this experiment to see whether the crib would have re-ignited on removal of the foam.

4.4. <u>Experiment 4</u> Four cribs, mean rate of application 0.24 m/min (0.8 ft/min)
Expansion 700:1

Table of events

Time (minutes)	Event
0.00	'Avgas' lit in trays under cribs
7.00	Foam application commenced
8.00	Foam surrounding base of all cribs
9.00	Foam expansion samples taken
11.00	Cribs 2 and 3 covered, no visible flaming
13.00	Cribs 1 and 4 covered, all flaming extinguished
19.00	Foam off, enclosure full of foam
31.00	Generator on
32.00	Generator off
46.00	Generator on
49.00	Generator off. All cribs apparently extinguished
68.00	Increase in temperatures in Crib 1
71.00	Generator on
73.00	Generator off
75.00	Crib 1 temperatures decreasing
84.00	Foam cleared away to expose cribs
85.00	Crib No. 1 re-ignited

A temperature time curve for Crib No. 1 is shown in Fig 4.

5. DISCUSSION

Although Experiments 1 and 3 were similar in many respects, in Experiment 1 recorded temperatures were lower than in Experiment 3. Fig 2 gives no indication of extensive smouldering within the crib at a total time of 50 minutes but when the foam was removed re-ignition occurred within 6 minutes. It is likely that there was a small area of smouldering remote from the thermocouple positions.

In Experiment 3, the temperature at the centre of the crib rose from 350°C to 400°C (above ambient) during the first topping-up process but then continued to fall. This rise could have been the result of the introduction of some fresh air due to movement of foam around the crib.

Just prior to the topping-up at 50 minutes, both the centre and top temperatures began to increase rapidly (see Fig 3) and continued to do so for the first two minutes of topping-up. It is possible that if topping-up had not been carried out, smouldering would have intensified. Re-ignition would almost certainly have taken place on removal of the foam.

In Experiment 4, the presence of four cribs rather than one did not appear to have any additional effect. The centre and top temperatures for cribs 2, 3 and 4 were similar to those shown in Fig 2 for the crib in Experiment 1; cribs 2 and 3 cooled rather more quickly than crib 4. The centre temperature of crib 4 increased from 250°C to 330°C during the first topping-up, probably for the same reason as stated above for Experiment 3.

Prior to the topping-up at 71 minutes, both the centre and top temperatures of crib 1 began to increase rapidly (see Fig 4) and continued to do so during the topping-up, after which they again decreased. On removal of the foam, cribs 2 and 3 were found to be completely extinguished but cribs 1 and 4 re-ignited.

In a previous publication[1] a minimum application rate of 0.06 m/min for each 1 kg/m^2 fire load (1 ft/min for each 1 lb/ft^2 fire load) was recommended for solid fuel fires at ground level. The recommended rate for each experiment is shown in Table 1 based on a fire load calculated for the whole area of the enclosure. The rates used in Experiments 1 and 3 were respectively 5 and 4 times the minimum recommended rate whilst that used in Experiment 4 was equal to the recommended rate. In all three experiments flaming combustion was consistently extinguished whilst smouldering combustion was not always completely extinguished. Smouldering was only controlled in some cribs and in two cases only by topping-up with fresh foam. Where smouldering was only controlled, re-ignition occurred on removal of the foam.

In Experiment 2, expansion was low and although the rate of application was above the minimum recommended rate for the particular fire load, foam did not even reach the crib. Foam was continually destroyed by radiation from the burning crib at the same rate as it was being applied. In order to flow along the ground, a "head" of foam has to be established, the magnitude of which determines the rate of advance. It is clear that in Experiment 2, the application rate was too low to build up a sufficient head of foam to enable the foam to advance at a rate high enough to overcome destruction by radiation.

6. CONCLUSIONS

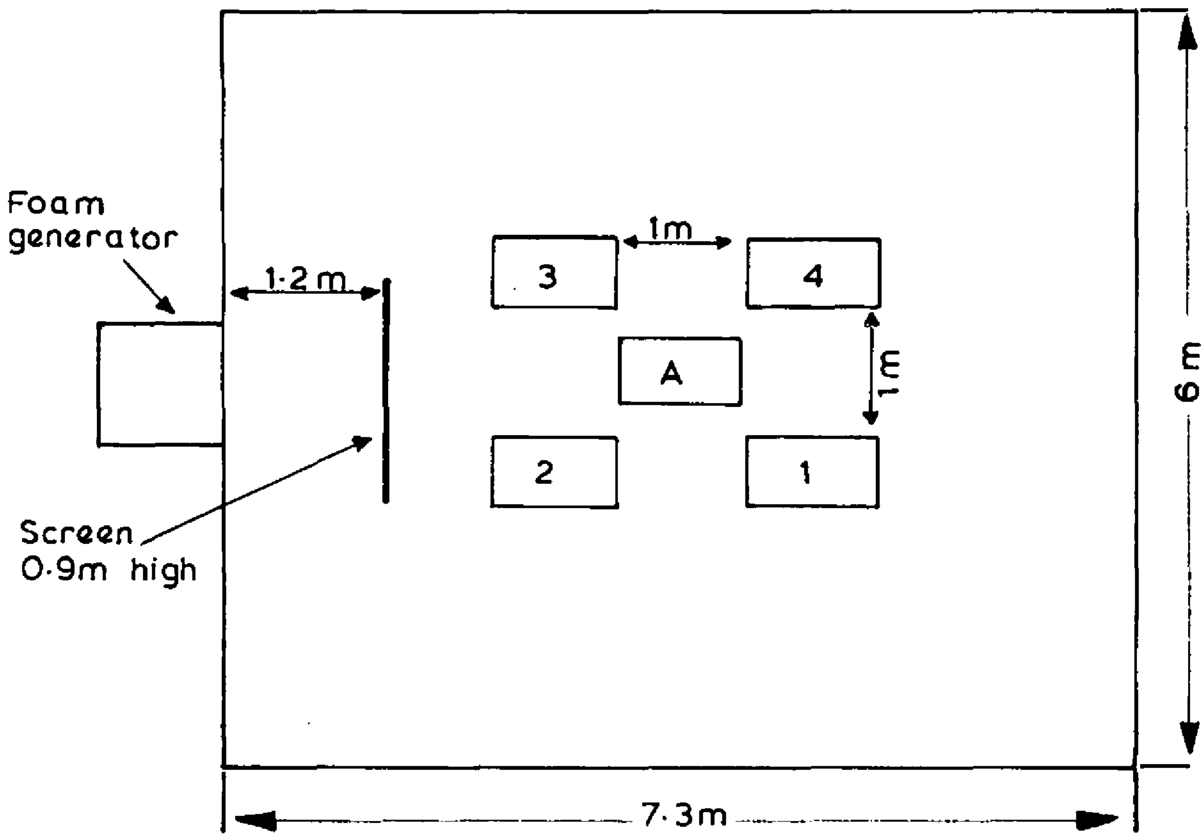
The general pattern which emerges from this limited series of experiments is that, when applied at an adequate rate, high expansion foam can readily extinguish flaming combustion in solid fuels. However, the complete extinction of smouldering does not always occur especially when the fire is deep seated. When it is not completely extinguished, smouldering may continue even though the fire may be completely submerged in foam. Maintenance of an adequate depth of foam above the fire helps to limit the smouldering.

These general conclusions have been confirmed by a series of experiments on a much larger scale involving the application of high expansion foam to a fire developing in high-stacked solid combustibles[2].

7. REFERENCES

1. THORNE, P. F., TUCKER, D. M. and RASBASH, D. J. Notes on the use of high expansion foam in fire fighting. F.R. Note No. 766, May 1969.

2. YOUNG, R. A., BRIDGE, N. W. and NASH, P. Fire tests with high expansion foam on high piled stock. F.R. Note 857 (1971).



A — Single crib in experiments 1, 2 and 3.

1, 2, 3, 4 cribs in experiment 4.

for crib dimensions see section 2.4.

FIG 1. ARRANGEMENT OF CRIBS IN ENCLOSURE

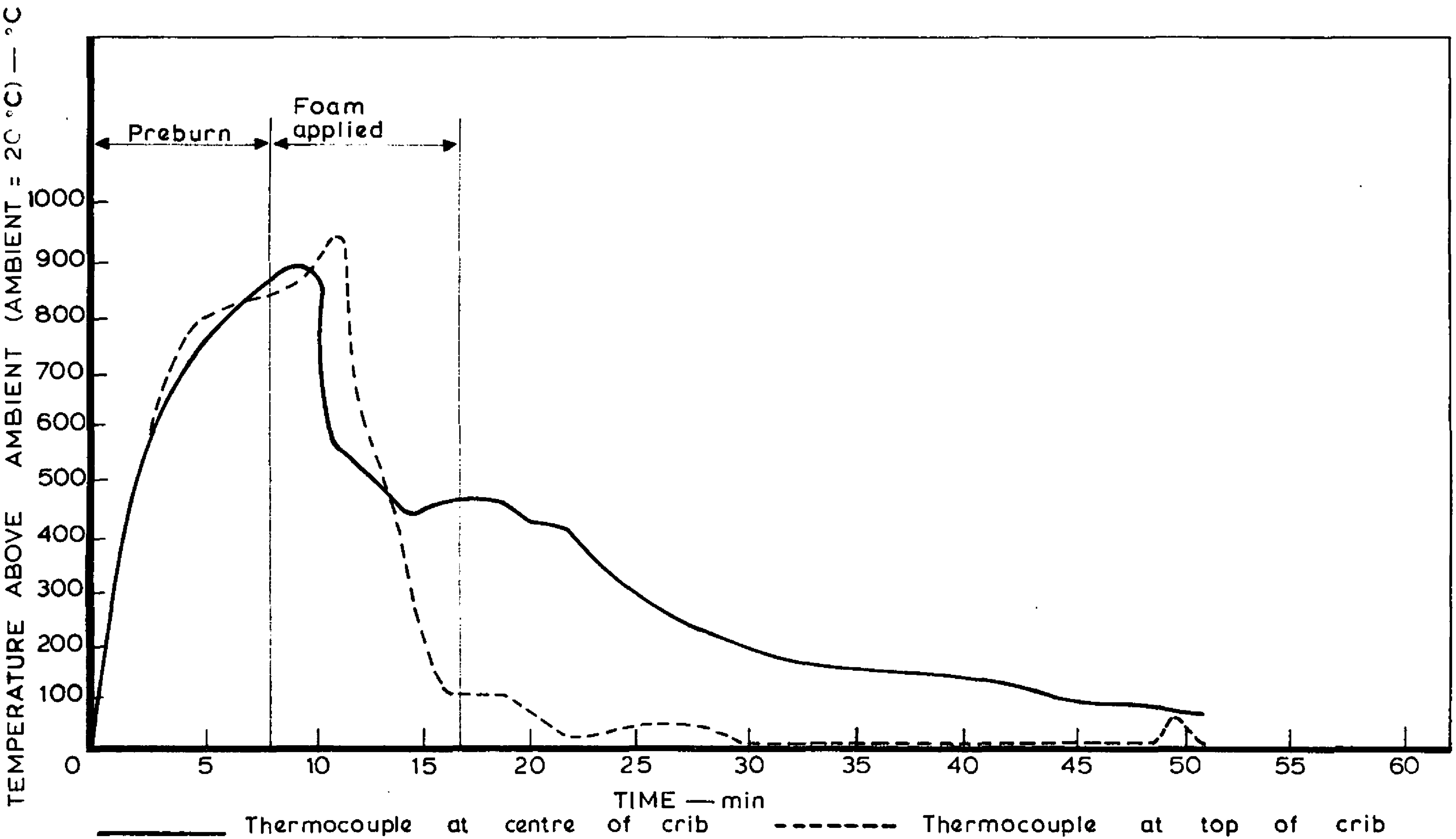


FIG 2 EXPERIMENT 1 TEMPERATURE — TIME GRAPH

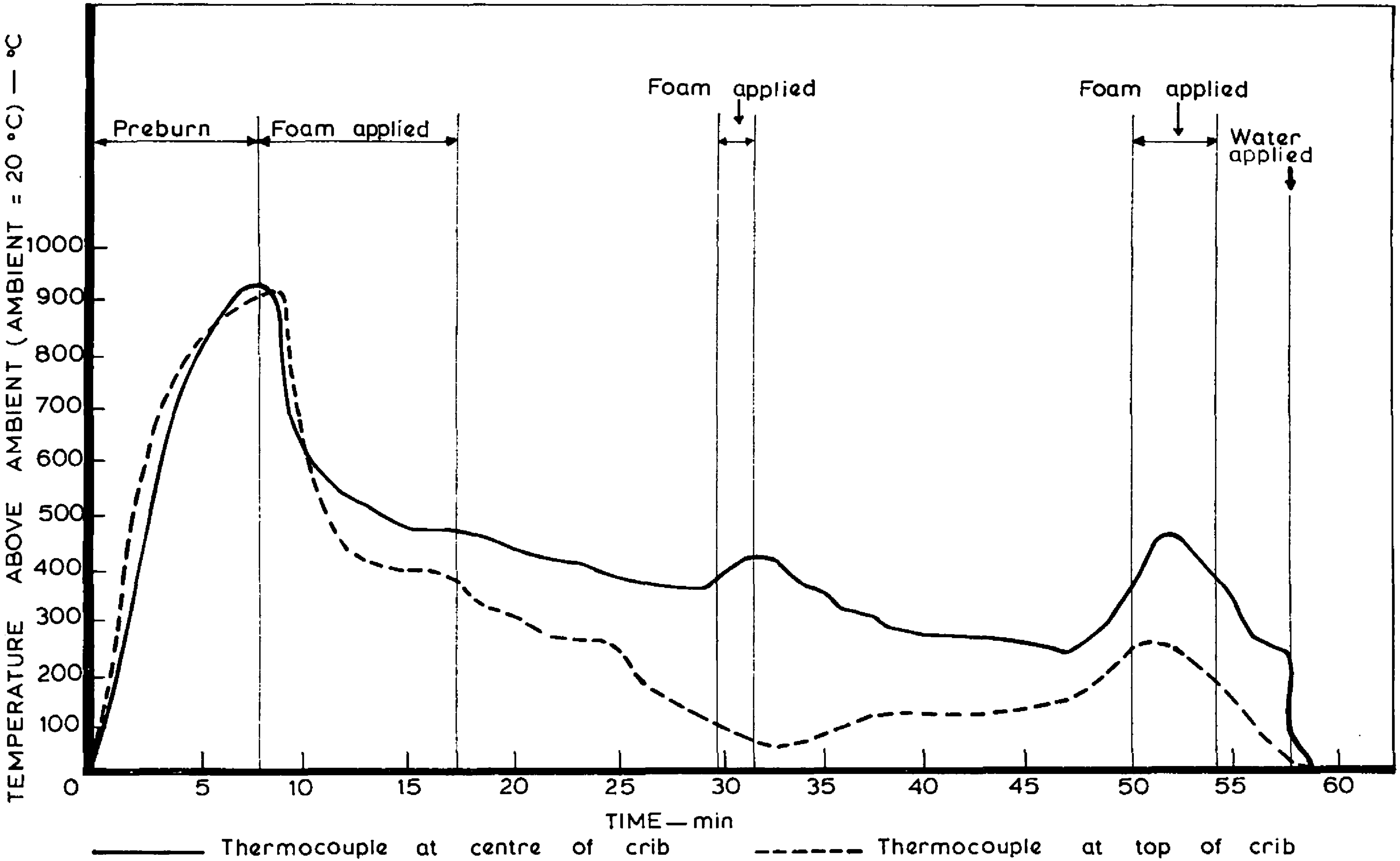


FIG 3 EXPERIMENT 3 TEMPERATURE — TIME CURVE

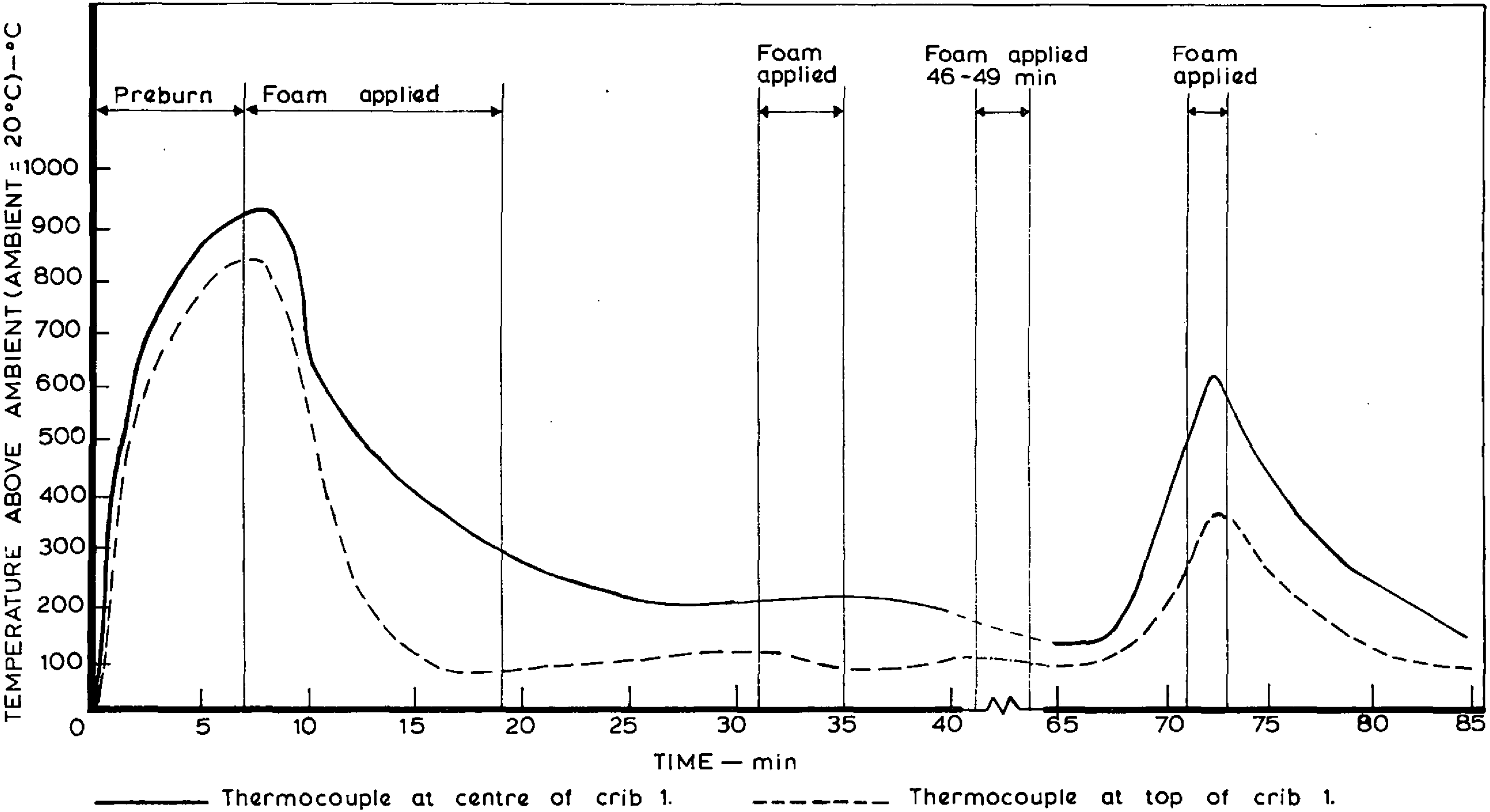


FIG 4 EXPERIMENT 4 TEMPERATURE TIME GRAPH