F. R. Note No. 479

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

WATER SOLUBLE FIRE RETARDANT TREATMENTS FOR THATCHED ROOFS

by

G. H. J. Elkins, E. H. Coleman and Miss J. M. Savill

Summary

Two water soluble fire retardant treatments for thatch have been examined. Both treatments conferred a degree of protection when first applied, but after one year of exposure to normal atmospheric conditions, this protection was substantially reduced.

The treatments appear to accelerate the physical break up of the thatch materials.

Some other methods of reducing the fire hazard of thatched roofs are discussed.

November, 1961

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Introduction

For some years the Rural Industries Bureau of Great Britain has recommended two alternative fire retardant treatments for thatched roofs. The Bureau, however, had no records of either the efficiency or permanence of the treatments and they therefore requested the Joint Fire Research Organization to examine these aspects.

Experimental

Thatching materials

The three types of material in common use for thatching in Great Britain were used. (1) Norfolk Reed, (2) Combed Wheat Reeds in which all the wheat straws have the same orientation and the seed heads and hulls have been removed and (3) Random Straw, which has not been combed or dressed and has a random orientation of the ends.

Retardant treatments

The two treatments used were solution of (a) a proprietary material referred to as Treatment 1, and (b) a mixture of salts traditionally used and often recommended by thatchers and hereafter referred to as Treatment 2.

TABLE 1

Fire Retardant Solutions for Treating Thatch

Name	Composition	Strength of solution lb/gal
Treatment 1	Understood to be based on monammonium phosphate + wetting agent	2.5 lb/gal
Treatment 2	Ammonium Carbonate 14lb Ammonium Sulphate 28lb Alum 14lb Boric Acid 7lb Borax 7lb	1.4 lb/gal

Treatment 2 is recommended for all three thatching materials mentioned above, but the proprietary material is not recommended for straw, which is said to be made brittle. The proprietary material dissolves readily to yield a clear solution, but with Treatment 2 the alum and ammonium carbonate react to form a gelatinous precipitate of aluminium hydroxide. It is claimed that this precipitate assists in the retention of salts. The hydroxide, however, settles and the mixture requires constant stirring in order to produce an evan deposit on thatch. In normal British thatching(1) straw thatching material is wetted before laying because it is then more pliable and less likely to break during laying. Norfolk reeds are usually laid dry. With both retardants the recommended treatment is as follows: The bundles of thatching material were soaked for half an hour in an aqueous solution of the retardant and drained on a horizontal grill. Norfolk reeds should be allowed to dry and the straw thatch is laid while still damp. Thus the laying techniques for the treated materials are similar to the normal methods using untreated materials, although extra labour is involved in preparing the solutions and ensuring complete immersion of the materials. However, it is doubtful if the Norfolk Reeds when treated would be completely dry when laid, as the time required to treat and completely dry under British weather conditions might be prohibitive.

Panels for exposure tests

Thatch panels, 8 ft long, 5 ft wide and approximately 10 inches thick, set at a roof pitch angle of 50°, were prepared from each material. They were laid on timber beams and framing as in a normal roof. The panels were prepared, under practical conditions, by master thatchers working under the supervision of a thatching adviser from the Rural Industries Bureau. Two sets of four panels were prepared; one set was exposed to the weather for one year on a flat roof with a southern aspect (Plate 1), and one set was kept in the dry as a control. The panels were

(a) Norfolk Reeds with Treatment 1.

(b) Norfolk Reeds with Treatment 2.

(c) Combed Wheat Reeds with Treatment 2.

(d) Random Straw with Treatment 2.

The top 1 ft of each panel was covered with a sheet P.V.C. coping to prevent moisture entering the ends of the reeds. Three glass funnels, 1 inch diameter with $\frac{1}{4}$ in bore stems, were bult into each panel during thatching at depths of 1 in, 3 in and 6 in respectively below the surface. Tubes ran from each funnel through the panels into collecting vessels. It was hoped that information about the depth and degree of moisture penetration, if any, might be obtained. The rainfall at the exposure site (Plate 1) was continuously recorded and the panels were examined periodically for deterioration and water penetration.

Samples for Laboratory Test

(a) Laboratory prepared samples: A standard procedure for preparing samples was adopted. Bundles of 40 straws of either Norfolk Reeds or of Combed Wheat Reed, were tapped lightly with butts downwards and then tied tightly with string at 6 in, 18 in, and 30 in from the butts. The bundles about 1.25 inches in diameter were then reduced to 36 inches in length by trimming the tops. It was not possible to select discreet straws with random straw and so bundles of similar diameter and length were prepared by taking bunches of straw which were tied and trimmed. The prepared samples were brought to constant weight at 60°F and 67 per cent relative humidity, and weighed. The weighed bundles for laboratory impregnation were immersed in the appropriate solution for half an hour, laid horizontally on a grill to drain and brought to constant weifht as before. They were then re-weighed and the amount of salts deposited was calculated. This amount is referred to as the "add-on". The "add-on" of samples prepared in the field is not known. Although Treatment 1 is not recommended for straw, the treatment was tried out on some of these laboratory samples. Both treatments produced a white deposit on the bundles; that from Treatment 2 was the easier to remove by rubbing.

(b) Weathered samples: After 6 months and 1 year respectively, bundles of material were withdrawn from the weathering and control panels. The Norfolk Reed and Combed Wheat Reed samples consisted of 40 straws, drawn at random from the panels and made up as described above. The Random Straw could not be extracted in this way, and was drawn out randomly in bunches and treated as described above. Three bundles of material were prepared from each panel at both time intervals.

Results of tests

Small scale burning tests

The efficacy of the treatments was assessed by burning the bundles under standardized conditions of air flow and ignition source. The bundles were suspended butts downward in a steel cabinet 7 ft 6 in high and 1 ft square with a glazed front for observation (Plate 2).

Air at 0.09 ft/sec was introduced through a distributor at the base and a 6 in luminous flame from a $\frac{5}{8}$ in diameter gas burner was arranged so that it could be swung to a position with the base of the flame 3 in below the bundle. The flame was applied either until the sample ignited, or for two minutes. The times of ignition, burning and afterglow were recorded. It had been intended to use the distance of flame travel as one of the criteria, but this was not possible because the burning behaviour was so erratic. With all the samples, whether prepared in the field or in the laboratory, the outer straws usually burned at a faster rate than the inner straws, but occasionally they burned more slowly. Often one side of a bundle burned faster than the other side. Initially the tests were made with all three string ties in position, but the ties restricted burning and in all the tests shown in Table 2, the 6 in tie was removed before igniting the bundle. In most tests where a flame travelled up the bundle, the flame went out at of before the 18 in tie. It thus seems that the constraint produced by the ties present in a thatched roof could be effective in initially restricting the spread of flames from the eaves up to the ridge.

The results of burning tests on all samples are given in Table 2.

The results obtained are too variable to allow any detailed quantitative conclusions to be drawn. However, it is obvious that the newly treated materials are more difficult to ignite and also that their rates of burning are retarded. The untreated specimens ignited within 1 second and the straw samples burned faster than the Norfolk Reeds. In general the samples impregnated in the field burned more easily than those treated in the laboratory. This may be due to less uniform treatment under practical conditions.

After six months' and one year's exposure, samples of all materials ignited and burned in the same way as untreated materials, whereas those taken after one year from the unexposed control panels had very similar ignition and burning characteristics to the freshly treated materials prepared in the field or in the laboratory.

Weathering

Initially all the panels, when subjected to rain, became thoroughly wet to a depth of 3 in - 6 in, and in all cases small areas of damp appeared on the undersides of the panels. Water percolated into some of the collecting funnels after 3 months (Table 3).

TABLE 3

Amounts of rain percolating through panel drains in 3 months in inches of rain

Material	Treatment	Depth of collecting funnel below surface of Panel		
		1 in	3 in	6 in
Norfolk Reeds	Treatment 1	2.5	2.4	8.0
Norfolk Reeds	Treatment 2	7.4	Nil	5.4
Combed Wheat Reeds	Treatment 2	Nil	3.9	Nil
Random Straw	Treatment 2	Nil	1.1	1.1

N.B. Total rainfall over this period:- 9.18 in.

The volume of water collected through any one tube has been assumed to originate from rain falling on the surface area immediately above the funnel. In Table 3 these volumes are expressed as inches of rain falling on the area within the rim of the collecting funnel. The results show that rain penetrated the panels to a considerable degree during the first three months exposure.

At this stage most of the soluble deposits in the surface layers of the panels appeared to have been leached out. Once this occurred, the panels began to perform more normally, and subsequently rain only penetrated the top inch of thatch. All the panels except the Random Straw panel eventually appeared dry throughout their depth. During this drying out period, considerable growths of mould were observed on the surface layers of the Combed Wheat Reed and Random Straw panels and to a smaller extent on the Norfolk Reed panels. The Random Straw panel had a very musty odour and appeared to be rotting except for the top layers. After one year's exposure the panels were allowed to surface dry and were then placed indoors.

The exposed and control panels were examined by representatives of the Rural Industries Bureau, and all were found to be mouldy although the degree varied between the panels. The weathered panels of Norfolk Reed had growths of green algae on their surfaces, the panel with Treatment 1 being the worse affected. The reeds had become friable, and when the panels were brushed, clouds of mould dust were formed. Their general appearance was said, by a Rural Industries Bureau representative, to be like that of thatch that had been exposed for at least ten years. Although the surface of the Random Straw panels had dried, the straw from 3 inches under the surface downwards was still very damp and appeared to be rotting. The Combed Wheat Reed panel had deteriorated and had considerable growths of mould in the body of the panel.

The unexposed panels of Norfolk Reed exhibited no algae growths, but mould patches were visible and the reeds had become friable. The Combed Wheat Reed also had mould growths and the Random Straw panel appeared to be rotting internally.

Humidity measurments showed that all the panels exposed and unexposed were damp below their surface layers, with the Norfolk Reed the least damp and Random Straw the most damp.

Leaching of soluble salts

One set of samples of thatch, withdrawn from the thatch panels as described previously, was used to measure the loss of retardant during exposure. The sample bundles taken at six months and one year periods were subdivided into four portions, three 3 inch sections, working from the exposed butts, and a composite sample of the residue (Fig. 1). At the end of the year's exposure, additional samples were taken from the thatch panels. A section of each panel was taken normal to the surface of the panel. The first, second and third inch of depth were collected separately, and a similar sized average sample was then taken from the remaining depth of the section (Fig. 2).

All the samples were chopped into small pieces and known amounts of each were extracted twice for two hours in a standard Soxhlet apparatus using water as the extracting medium.

The main constituent of the proprietary retardant is monammonium phosphate and so the extracts from the materials treated with this retardant were analysed for their phosphate, ($-PO_4$), content (2). With Treatment 2 the main constituents are boric acid/borax and so these extracts were analysed for their Boron (B), content (3).

The results of these analyses are given in Figs 3 - 10. In these figures the average concentration of retardant in the bulk of the panels, i.e. in the layers 3 inches and more below the surface is taken as 100 per cent.

In the panels of Norfolk Reed and Combed Wheat Reed (Figs 3-5), where the straws are parallel, the outer tips of the straws show very high initial concentrations. This is probably due to drainage of the solutions after the damp reeds have been built into the thatch. After six months exposure the concentration at the exposed tips had dropped to less than half the bulk concentration and after one year a further small decrease was evident. This loss of retardant will decrease with increasing time of exposure, as the exposed thatch was less readily penetrated by rain as the time it had been exposed increased. The Random Straw panel (Fig. 6) had a lower concentration of retardant at the exposed surface than in the bulk of the material. With this material drainage to the outer tips is probably prevented at the ties since the stalks are more readily crushed and also the surface concentration may have been lowered by handling. In addition, the leaves and seed heads would readily absorb the retardant. After six months' exposure the surface concentration had been reduced to about 60 per cent of the bulk concentration, and after one year a further reduction to 45 per cent had taken place.

Thus with all four types of panel (Figs 3 - 6) in the first 5 - 6 inches of reed length, corresponding to the first inch of depth of the reeds, the concentration of the retardant was substantially reduced after only one year's exposure. The core samples (Figs 7 - 10) confirm that this reduction in retardant concentration was confined to the surface layers of thatch.

The variations in the concentrations of retardants found in the surface layers of the unexposed panels emphasises the difficulty of obtaining a uniform "add-on" of retardant using a simple dip and drain technique. This difficulty is added to by the fact that reeds grown in different beds often have very different natural characteristics.

Fire tests

The panels were each divided into two parts, from ridge to eaves. One part of each panel was tested for ignition when exposed to radiant heat by a modification of the test procedure in British Standard for Roof Tests(3) which requires a panel of roof section, mounted at 45 degrees to the horizontal to be exposed to a radiant heat source while applying suction to the rear of the panel (Plate 3).

A test flame is applied to the surface of the specimen after 5 minutes' exposure to radiation, if surface ignition has not occurred by then. As the thatch samples could not conveniently have suction applied, this part of the test procedure was omitted. A typical panel is shown under test in Plate 4. The results obtained are given in Table 4.

TABLE 4

Ignition of thatch panels exposed to radiant heat

Material	Treatment	State	Time for surface ignition	Time to penetrate
Norfolk Reed	Treatment 1	Unexposed	*Test flame applied	46 min 30 sec
" "	"	Exposed	3 min 30 sec	37 min
Norfolk Reed	Treatment 2	Unexposed	*Test flame applied	16 min
" "	"	Exposed	1 min 35 sec	46 min
Combed Wheat Reed	Treatment 2	Unexposed	*Test flame applied	56 min 15 sec
" "	"	Exposed	53 sec	34 min 30 sec
Random Straw	Treatment 2	Unexposed	1 min 30 sec	Not after 60 min
" "	"	Exposed	15 sec	50 min 30 sec

*Test flame applied for 5 minutes

All the exposed panels ignited without the test flame being applied. The unexposed panels required the test flame or ignited more slowly. In general the unexposed panels exhibited a greater resistance to ignition, surface spread of flame and burning than the exposed panels.

Wind tunnel test. A second series of experiments was carried out on the remaining part of each panel in a wind tunnel to simulate the effect of wind on the growth of fire on thatch ignited by a typical hazard, such as a flame or burning brand. A plumber's blow lamp was used as the source of ignition.

The panels were mounted on a frame at 45 degrees in a wind tunnel with a wind of 10 ft/sec on the surface of the panels. The blow lamp was played on the centre line of the panels about 1 ft 6 in from the eaves for 30 seconds and then removed. The time taken for the panel to burn through to the underside was recorded. The results are given in Table 5. A typical test is shown in Plates 5, 6 and 7.

In all cases the panels were burned out completely in 35 minutes or less, as distinct from the behaviour in the modified British Standard test.

TABLE 5

Ignition of thatch panels in wind

Material	Treatment	State	Time to penetrate (min)
Norfolk Reed	Treatment 1	Unexposed	28.0
" "	"	Exposed	0.5
" "	Treatment 2	Unexposed	17.8
" "	"	Exposed	1.2
Combed Wheat Reed	Treatment 2	Unexposed	26.5
" " "	"	Exposed	6.2
Random Straw	Treatment 2	Unexposed	17.5
" "	"	Exposed	2.0

Burning took place under the surface and spread considerably before the surface layers became involved, this effect being more marked with the unexposed panels. Once the burning zone reached the eaves of the panels and flame and decomposition products began to blow under the back of the panels, the panels burned rapidly to destruction.

CONCLUSIONS

Effectiveness of treatments

When first applied, both treatments examined make ignition of thatch more difficult, retard the rate of burning and inhibit afterglow. The treatments, however, do not prevent the burning of thatch in a wind. After one year of continuous exposure both treatments have relatively little effect on the burning characteristics of the thatching material. The washed out surface of the treated thatch allows flame to spread rapidly over the surface, and thus increases the risk of deep seated fires being established.

Degradation due to treatments

Both treatments appear to encourage the growth of mould and, to a lesser extent, surface algae, and one year of exposure had an affect said to be comparable to that of ten years' exposure for untreated materials.

The initial water repellant character of the thatching material is seriously impaired by the treatments as the layers of deposited salts separate the reeds thus allowing water to seep through. This undoubtedly encourages the break up of the material.

Other methods of treatment

Two other methods have been advoated for reducing the fire risk of thatch. In one(5) the underside of the roof members is sealed with an incombustible lining such as asbestos wood and a concrete seal is made between the thatch and the top course of brickwork. This procedure is said to restrict air flow and greatly inhibit the growth of a fire started externally. In the second method a slurry of clay, mud or cement is applied to the surface of the thatch. This method protects the thatch from external ignition, but completely alters the appearance of the thatch.

Where it is required to preserve the appearance of the thatch, the first method would suggest itself. However, this method does not protect the beam structure of the roof as the panels are pinned underneath these members and the presence of the panels would make subsequent rethatching difficult.

Unless a method of fire proofing thatch is found that is cheap and simple to apply, it would seem that the next best precaution is to try and protect the roof structure from serious damage in the event of the thatch igniting. This might be accomplished by a scheme on the following lines. Treat all woodwork with a protective coat such as an intumescent paint. Lay $1\frac{1}{2}$ - 2 in mesh chicken wire over the woodwork and lay a mat of mineral wool on top of this. The thatch could then be laid in the normal manner on top of the mineral wool, the binding cords passing through the mineral wool and wire netting. An incombustible binding cord would help retard the spread of a fire. Access of air to the underside of the thatch could be reduced further by plastering or suitably painting the exposed mineral wool surface.

Some experimental work is required to test the feasibility and effectiveness of such a scheme.

Acknowledgments

The authors wish to thank Mr. G. W. V. Stark for his advice and help, and also Mr. T. Davies and Mrs. V. P. Cannon who assisted with the experimental work.

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COMBUSTION OF THATCHING MATERIALS IN SMALL SCALE BURNING TESTS

Material	Treatment	Untreated material			Material treated at J.F.R.O.				Material treated in the field				Unexposed panel 1 year			Exposed panel 6 months			Exposed panel 1 year		
		Times in seconds			Add-on Percentage by wt	Times in seconds				Times in seconds			Times in seconds			Times in seconds			Times in seconds		
		Ignition	Burning	After Glow		Ignition	Burning	After Glow		Ignition	Burning	After Glow	Ignition	Burning	After Glow	Ignition	Burning	After Glow	Ignition	Burning	After Glow
Norfolk Reed	Treatment 1	1	190(L)	0	10.5	13	78(S)	0	Add - on not determined on field work	13	175(L)	0	13	102(S)	0	2	118(L)	0	3	115(L)	0
	Treatment 1	N.D	217(L)	0	10.7	15	223(M)	0		15	182(L)	0	11	147(M)	0	2	157(L)	0	2	88(L)	0
	Treatment 2				3.8	5	173(M)	0		10	125(L)	0	5	185(S)	0	0	110(L)	0	3	135(L)	0
	Treatment 2				10.0	13	175(S)	0		13	122(L)	0	14	11(S)	0	0	130(L)	0	1	123(L)	0
Combed Wheat	Treatment 2	1	55(L)	0	8.4	7	75(L)	78		3	72(L)	292	1	73(L)	83	0	75(L)	82	3	100(L)	47
Reed	Treatment 2	1	35(L)	0	16.4	5	105(L)	250		6	104(L)	231	2	95(M)	31	0	159(L)	44	2	61(L)	63
	Treatment 1				17.7	7	153(L)	0													
	Treatment 1				18.6	6	124(M)	0													
Random Straw	Treatment 2	1	41(L)	669	12.9	Did not ignite				1	38(T)	8	3	33(S)	0	0	73(T)	0	0	60(L)	33
	Treatment 2	1	43(L)	123	33.6	20	35(T)	0		2	80(M)	5	5	55(T)	0	0	33(T)	0	1	43(L)	0
	Treatment 1				30.0	Did not ignite															
	Treatment 1				30.1	25	10(T)	0													

Code letter	Maximum length of flame developed
L	1 foot and upwards
M	6 inches - 1 foot
S	2 inches - 6 inches
T	Single straws or surface only

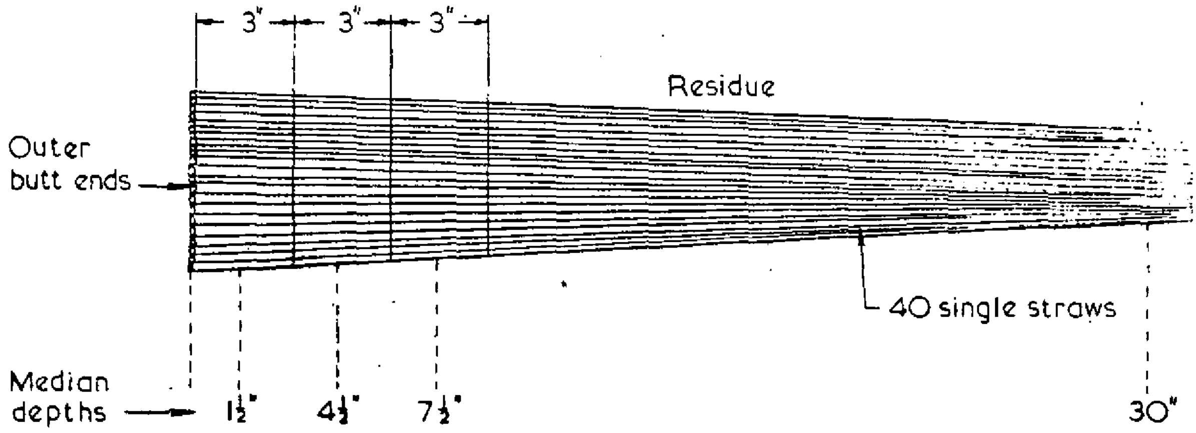

FIG. 1. METHOD OF SAMPLING FROM BUNDLES

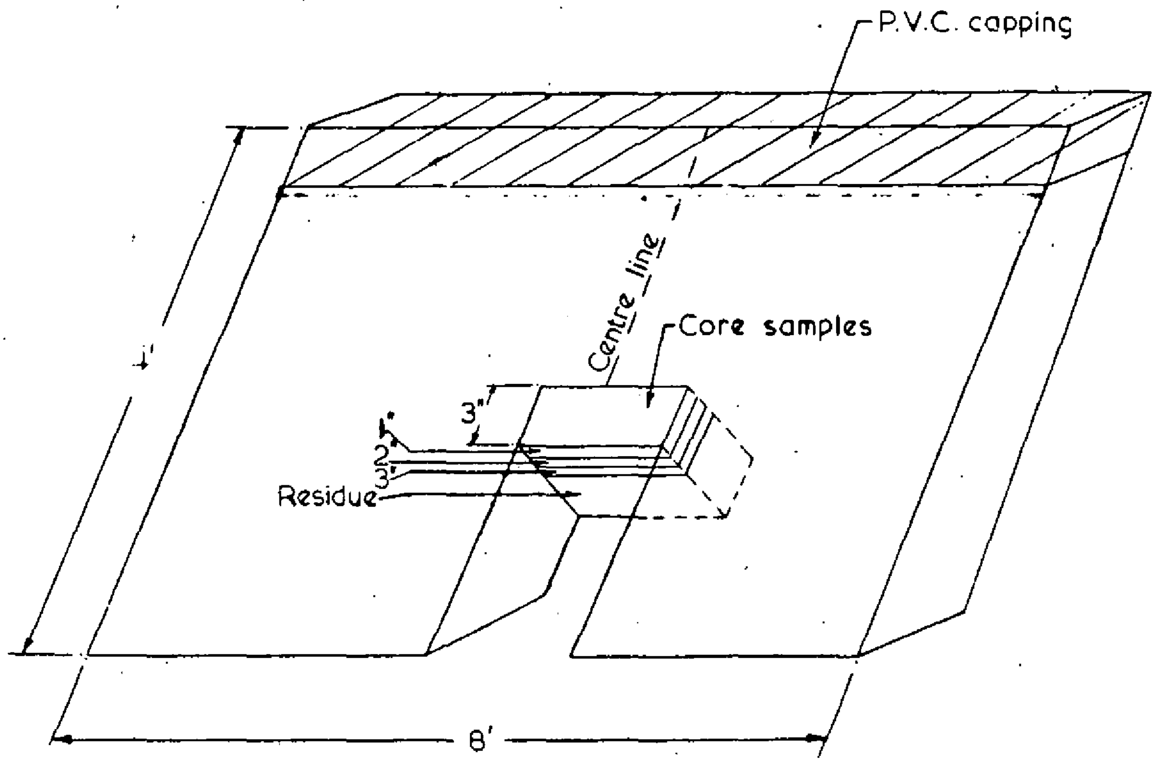

FIG. 2. METHOD OF SAMPLING FROM PANELS

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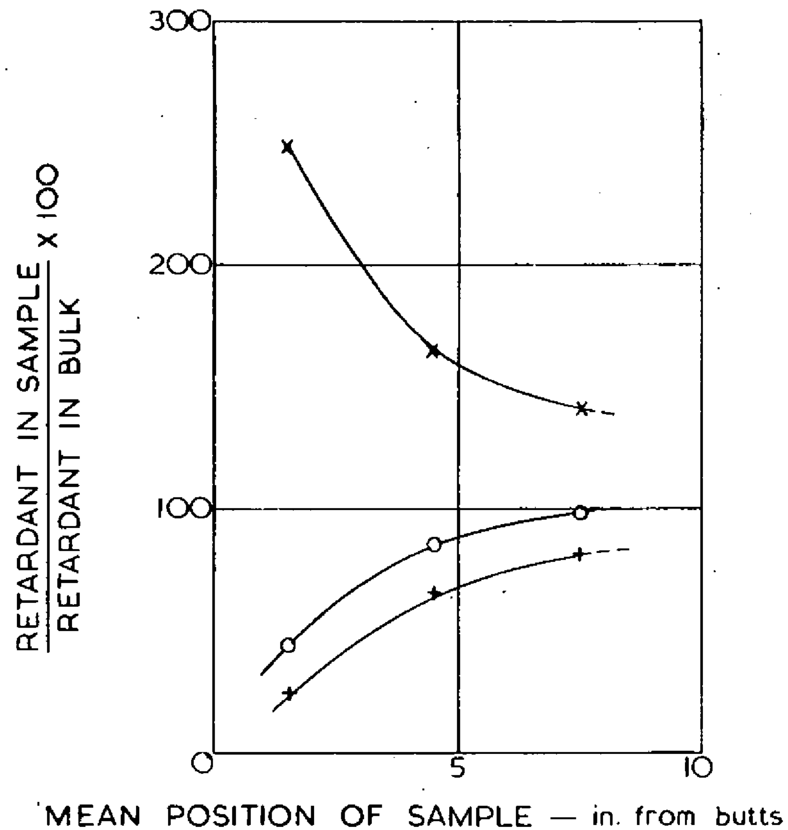
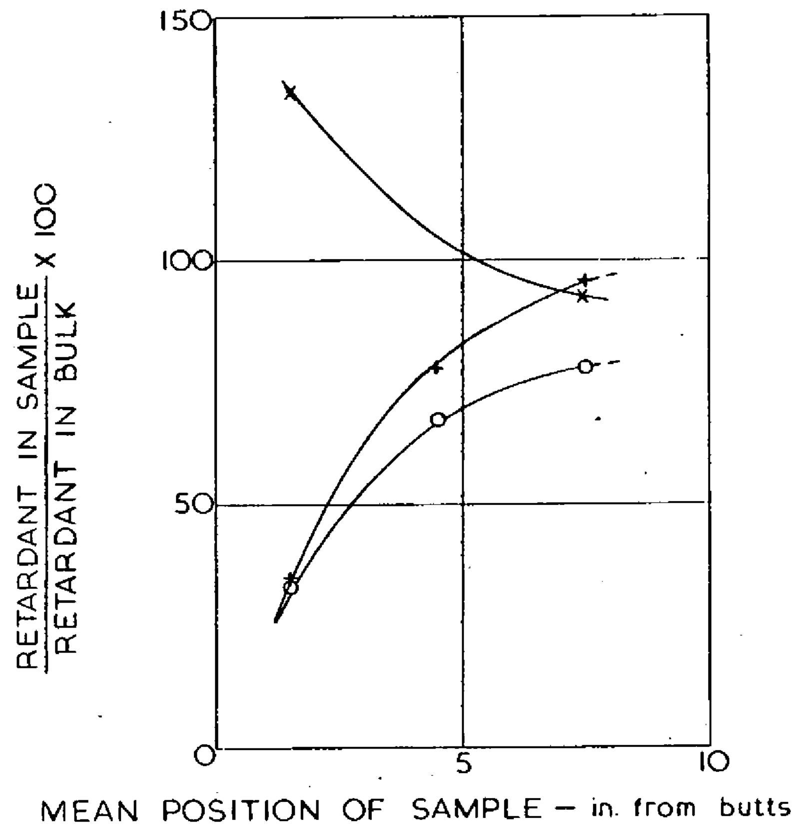


x Unexposed
o 6 months exposure
+ 1 year exposure

FIG.3. EFFECT OF WEATHERING ON THE CONCENTRATION OF RETARDENT IN NORFOLK REED.-TREATMENT 1



x Unexposed
o 6 months exposure
+ 1 year exposure

FIG.4. EFFECT OF WEATHERING ON THE CONCENTRATION OF RETARDENT IN NORFOLK REED -TREATMENT 2

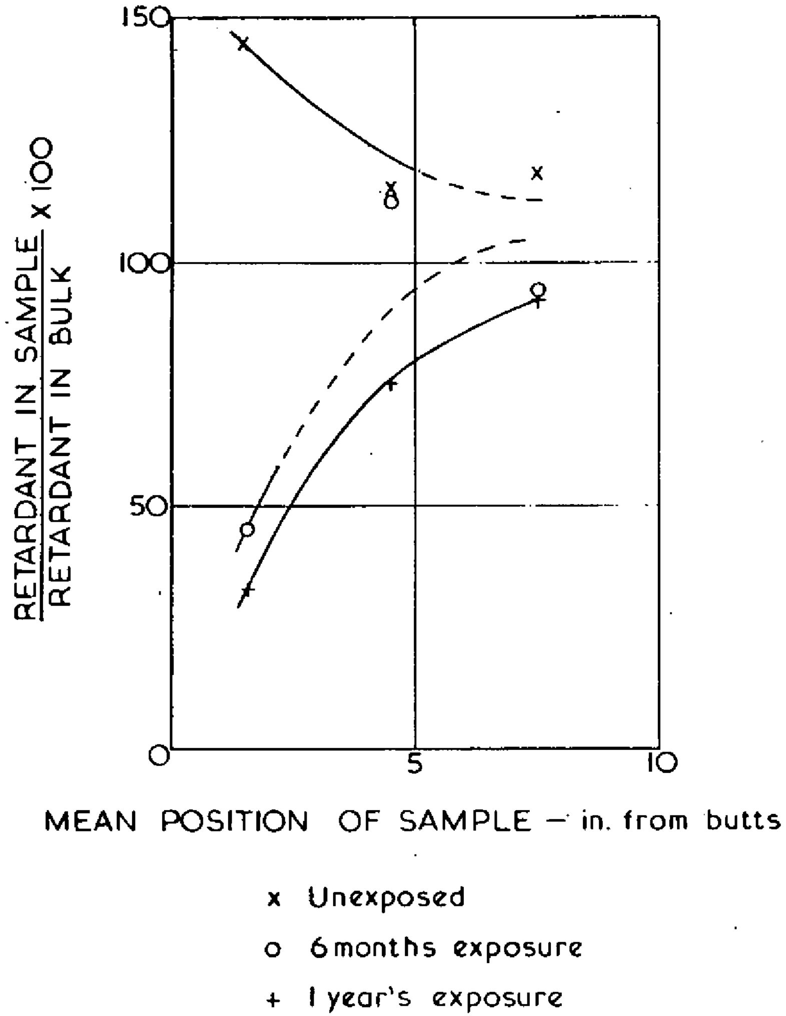


FIG. 5. EFFECT OF WEATHERING ON THE CONCENTRATION OF RETARDENT IN COMBED WHEAT REED. TREATMENT 2

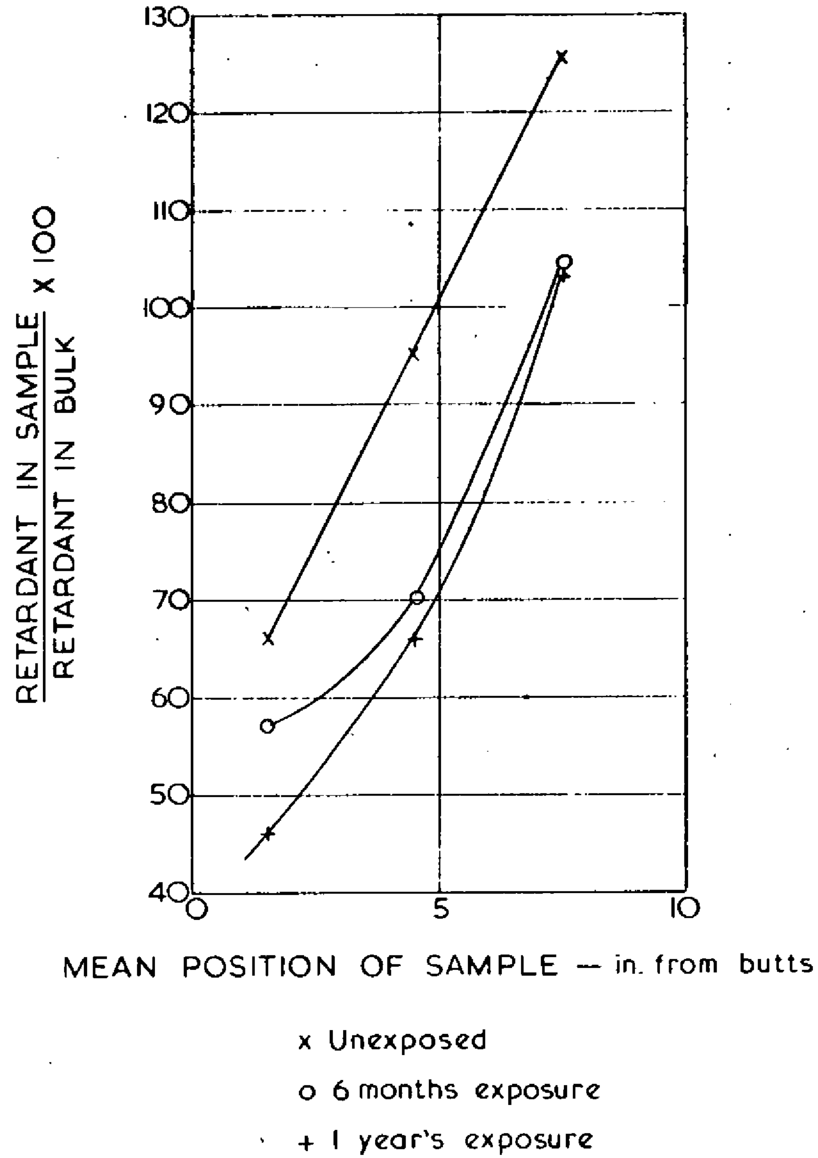
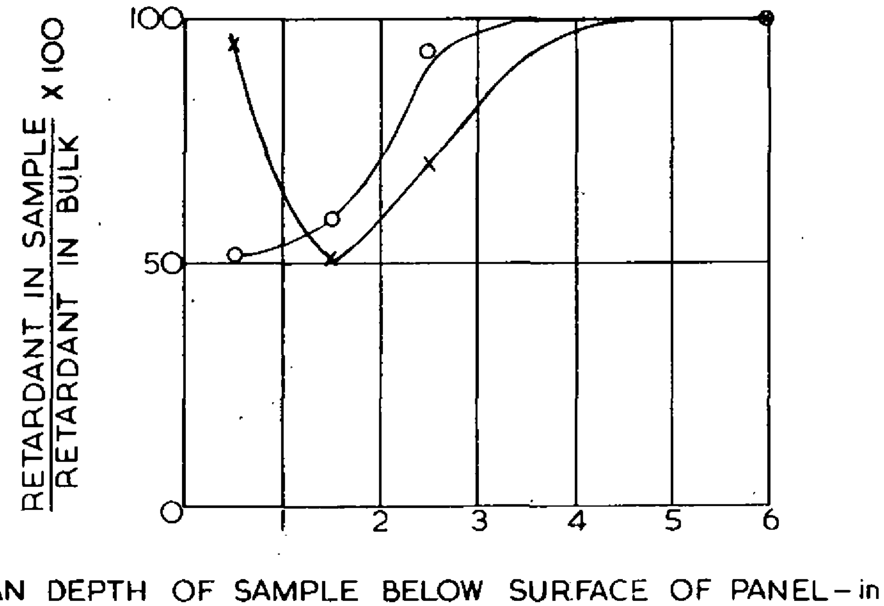


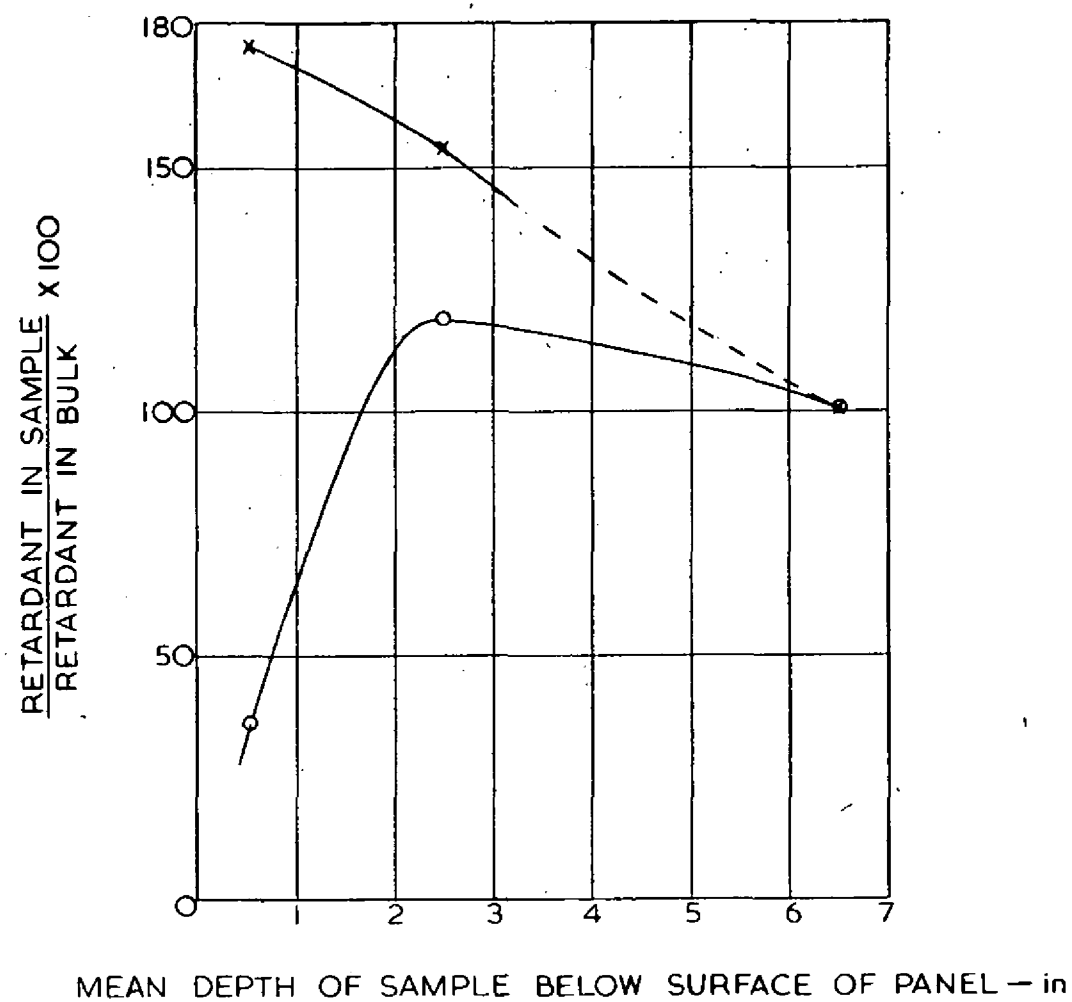
FIG. 6. EFFECT OF WEATHERING ON THE CONCENTRATION OF RETARDENT IN RANDOM STRAW.-TREATMENT 2



x Unexposed sample

o 1 year's exposure

FIG. 7 EFFECT OF WEATHERING ON THE CONCENTRATION OF RETARDANT IN NORFOLK REED.-TREATMENT 1



x Unexposed sample

o 1 year's exposure

FIG. 8. EFFECT OF WEATHERING ON THE CONCENTRATION OF RETARDENT IN NORFOLK REED – TREATMENT 2

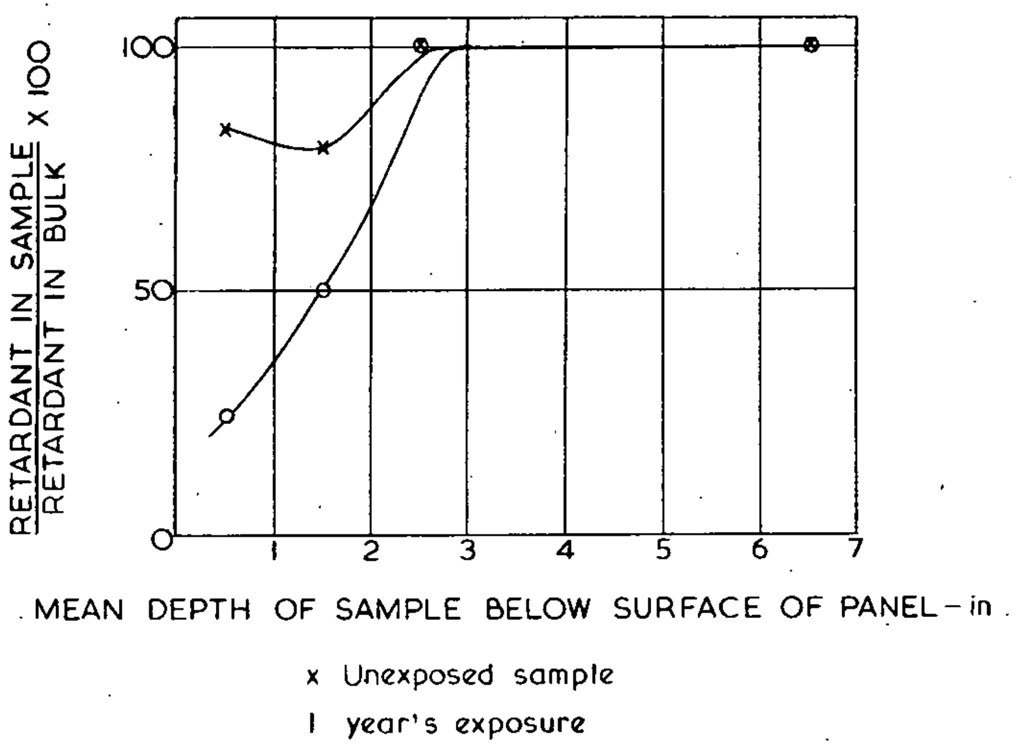


FIG. 9. EFFECT OF WEATHERING ON THE CONCENTRATION OF RETARDANT IN COMBED WHEAT REED. TREATMENT 2

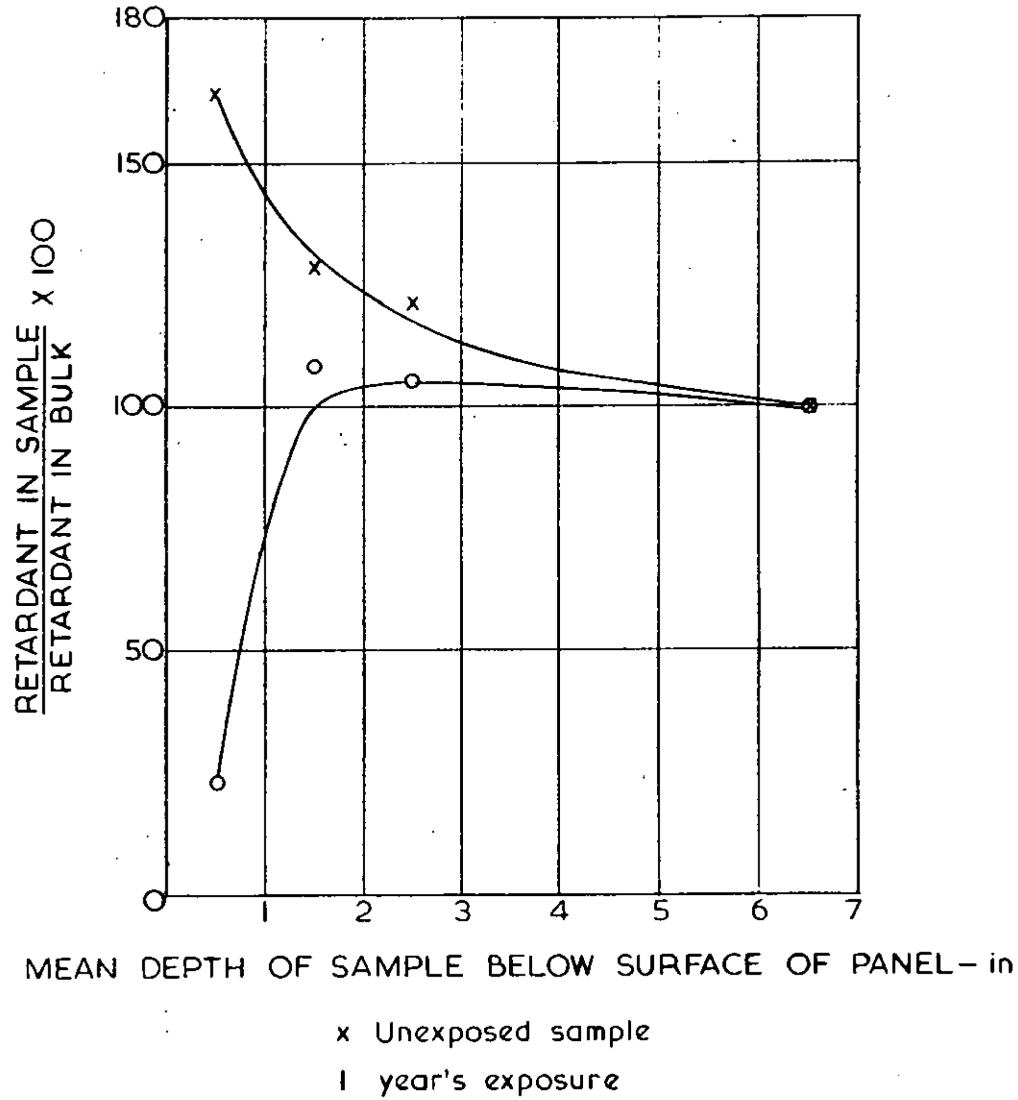


FIG. 10. EFFECT OF WEATHERING ON THE CONCENTRATION OF RETARDANT IN RANDOM STRAW TREATMENT 2

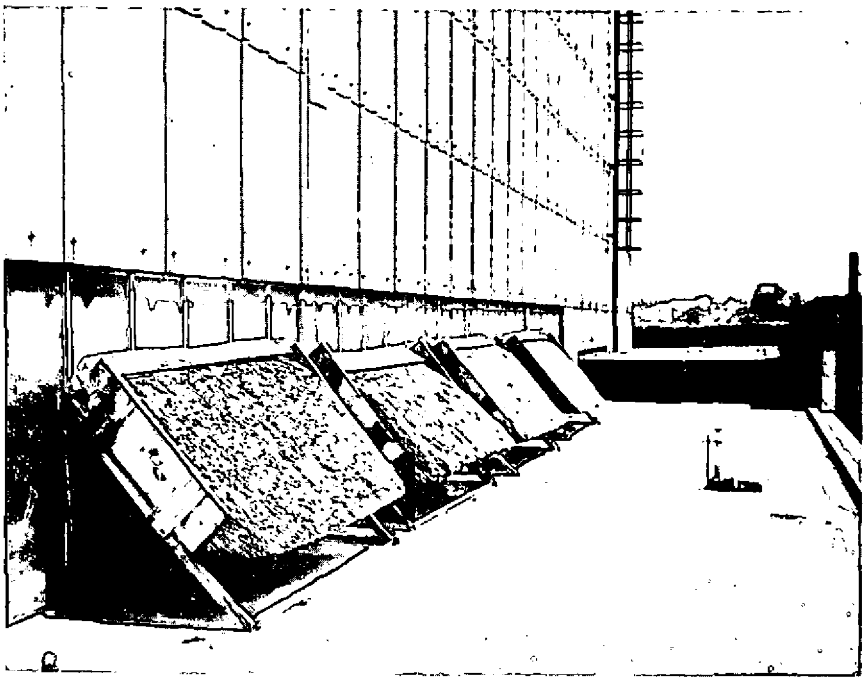


PLATE 1. EXPOSURE SITE FOR THATCH PANELS

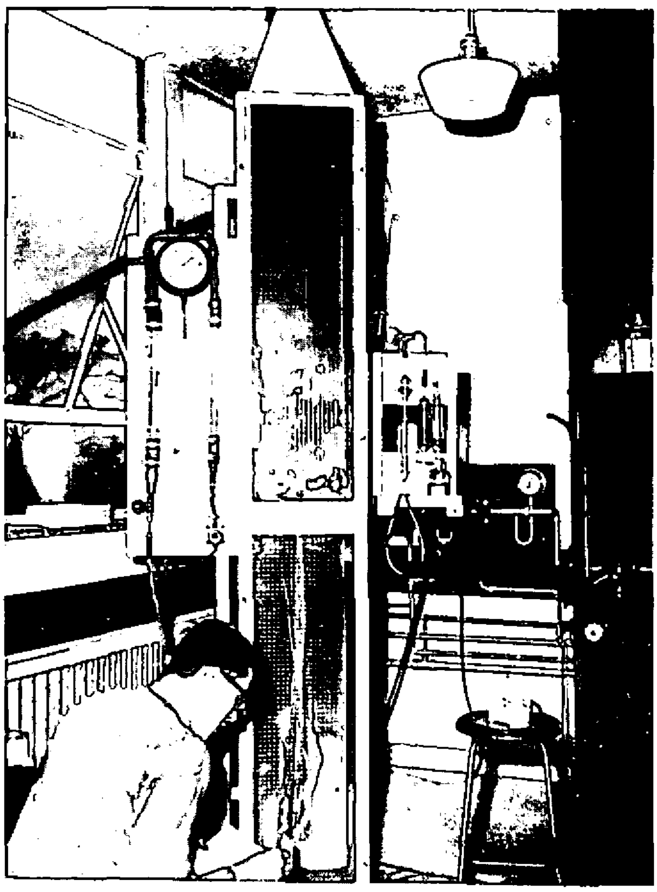


PLATE 2. SMALL SCALE BURNING TESTS

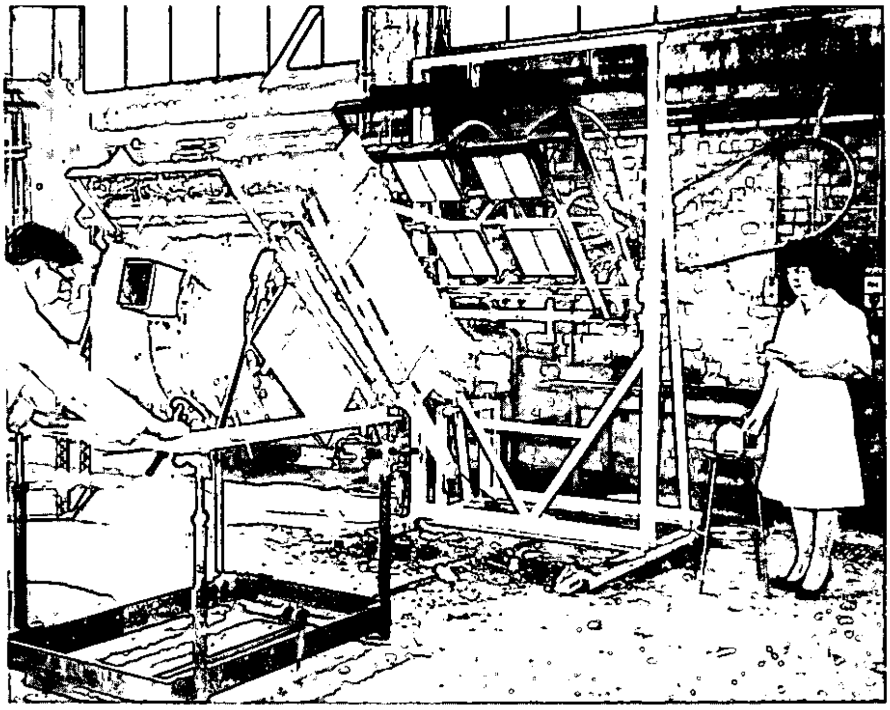


PLATE 3. B.S. ROOF TEST APPARATUS

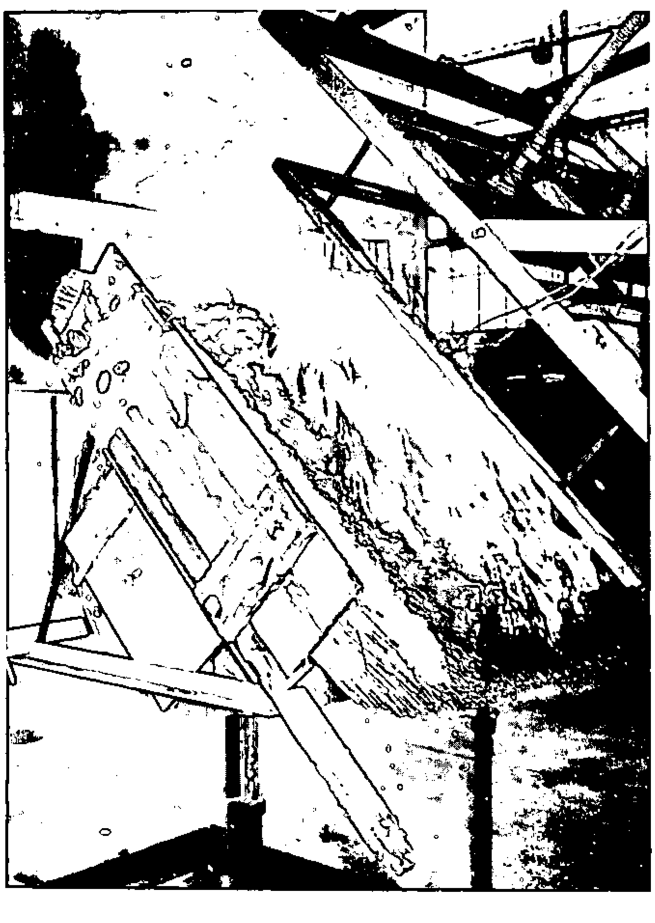


PLATE 4. EFFECT OF RADIANT HEAT ON A TYPICAL PANEL AFTER 3 MINUTES EXPOSURE

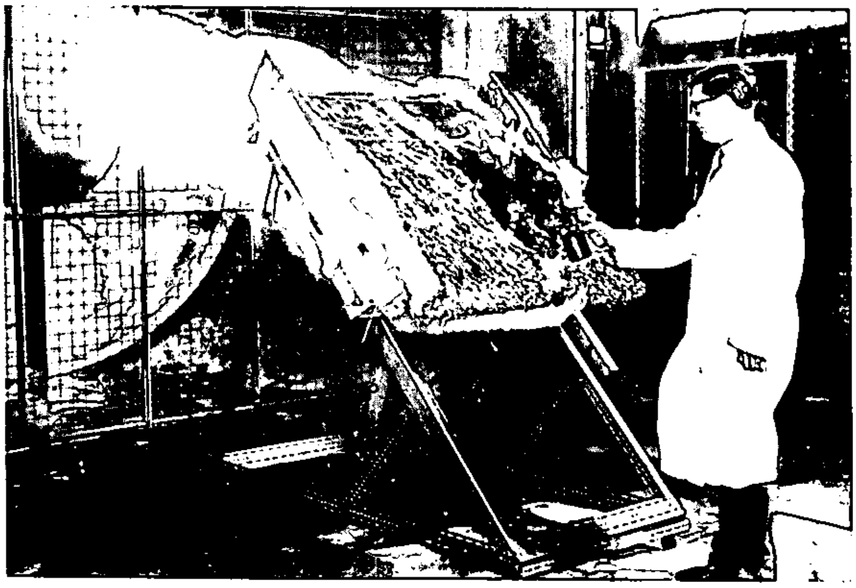


PLATE 5. 25 SECONDS

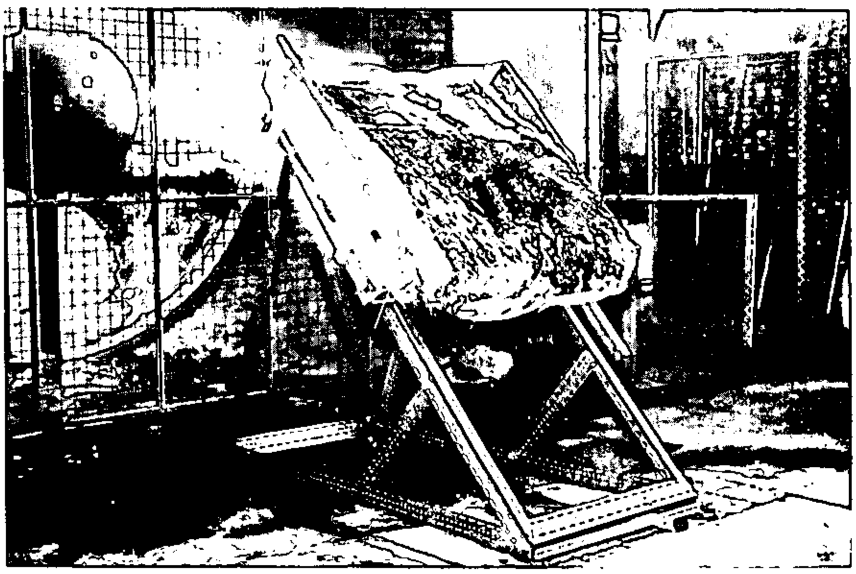


PLATE 6. 2 MINUTES

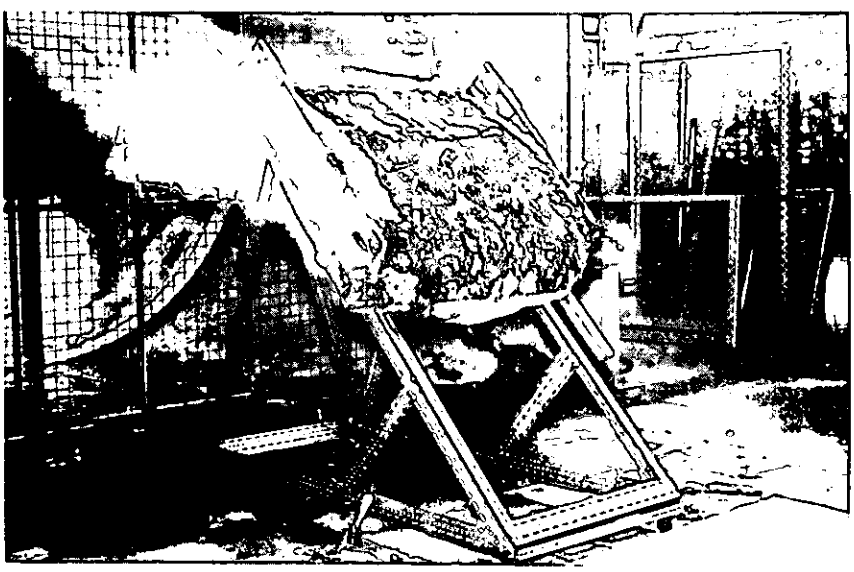


PLATE 7. 6 MINUTES 10 SECONDS

TYPICAL WIND TUNNEL TEST ON A THATCH PANEL