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JOINT FIRE RESEARCH ORGANIZATION

THE FIRE HAZARD OF COMBUSTIBLE EXTERNAL WALLS - I. HOLOPLAST

by

L. A. Ashton and D. Hird

Summary

At the request of the Ministry of Education an investigation has been made of the fire hazards in multi-storey schools having external walls faced with combustible material, such as "Holoplast". The primary consideration, namely whether the use of such materials would affect escape from a building involved in fire, was examined by comparative tests on models using noncombustible and combustible external walls. The exposure hazard with external walls of Holoplast was also investigated.

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Introduction

The Ministry of Education Building Bulletin No. 7, Fire and the Design of Schools, recommends that, for buildings of more than one storey, the external walls shall be of non-combustible materials. This provision conforms to the regulations for buildings generally in this country, which are given statutory force in the Model Byelaws of the Ministry of Housing and Local Government.

A request was received from the Ministry of Education for an investigation to be made into the hazard entailed in the use of one type of combustible external cladding for multi-storey schools. The requirements for a combustible external wall, apart from fire-resistance, are that, in the event of a fire on one of the lower stories of the building, flames issuing from a window would be spread neither vertically nor laterally over the surface of the wall to communicate the fire through windows to parts of the building which would not have been affected if the walls were non-combustible. Such by-passing of fire-resisting floors and walls might occur rapidly and endanger escape. The exposure hazard inherent with combustible external walls can, with knowledge of the properties of the materials used, be minimized by proper siting of the buildings.

It was considered that if the hazard of spread of flame with a given combustible cladding were not significantly greater than that with a non-combustible cladding and if the minimum permissible separation for such combustible buildings to eliminate the exposure hazard were determined, then the major objections to its use would be overcome. This note describes the comparative tests devised to assess the flame spread hazard of the cladding in question and includes an estimate of the exposure hazards which its use would introduce.

Description of the cladding

Holoplast is a paper-based phenol-formaldehyde laminate of cellular form (see Fig. 1). It is produced for walls and partitions in 8 ft. x 4 ft. panels of different thicknesses, in which the webs forming the boundaries of the cells are parallel to the longer edges. It offers advantages as an exterior cladding for multi-storey schools and has already been used for single-storey schools. When used for exterior walls the Holoplast panels are 1 11/16 in. thick and are filled with Pyrok, a cementitious material containing exfoliated vermiculite, and may have asbestos paper incorporated in the faces of the flanges for fire-retardant purposes. The cladding would thus be largely noncombustible but the arrangement of the materials would bring it into the category of "externally combustible". Two other fire characteristics of the cladding have been determined:-

(1) Fire-resistance. A partition of Pyrok-filled Holoplast satisfied the requirements for one hour fire resistance when tested in accordance with B.S. 476 (1).

(2) Surface spread of flame. In the standard test of B.S. 476 samples of the cladding incorporating asbestos in the faces were classified as surfaces of very low flame spread (2).

The results of the spread of flame tests were not considered to be valid for indicating the hazard of flame propagation on external surfaces since the conditions would be more severe when the cladding was exposed to flames issuing from a window. Full-scale tests to demonstrate the hazards would have been prohibitive in cost and with no standard test available it was necessary to devise ad hoc tests by means of models.

The model tests

A considerable amount of research has been done at the Fire Research Station using models (3) on the development of fire in a standard room having dimensions of 18 ft. x 12 ft. x 9 ft. high. Correlation has been obtained between the conditions in a full-size room and models of $^1/10$, $^1/5$ and $^1/2$ linear dimensions, in particular it has been possible to construct models such that the flame temperatures were of the same order for all scales.

It was proposed to carry out tests on $^1/10$ and $^1/5$ scale models in the first instance, comparing the behaviour of Holoplast exterior cladding with that of a noncombustible wall. The arrangement of the models for the first tests with the corresponding full-scale dimensions is shown in Fig. 2. The room was provided with an unglazed opening to represent a window 10 ft. x 5 ft. centrally placed in one of the longer walls. In the opposite wall was a door opening 6 ft. 6 in. x 2 ft. 9 in. The material representing the cladding under test was mounted on the window face of the room to represent a wall about 40 ft. high and without openings other than that in the room. The room was lined and furnished so that the fire load in each experiment was approximately 40,000 B.Th.U/ft^2, ensuring that the cladding was exposed to flames from the window for some 10 minutes.

A comparison of the effect of flame on combustible and noncombustible external walls was obtained from the models in three ways: (1) by making a photographic record from the time when flame began to issue from the window, (2) by measuring the affected area of the walls after the flame had died down (this was made practicable for the noncombustible wall by coating it with a temperature sensitive paint which exhibited a colour change on the area covered by flame), (3) by measuring radiation from the flames at the positions shown in Fig. 2.

A test of greater severity was added to the first series using $^1/5$ scale models with the same two types of cladding, in which two rooms with their external walls and windows were placed at right angles to one another, representing the re-entrant corner of a building. Fires were started in both rooms so that the conditions produced on the external walls were more hazardous than those with a single window.

Results of tests

(1) Single room

There was no lateral spread of flame on the Holoplast and the amount of flaming was of the same order as on the noncombustible claddings.

The Holoplast was heavily damaged in an area just above the window and the surface over this was blistered where the flames had been in contact. These observations are illustrated in the photographs, Plates 1 and 2, of the $^1/5$ scale models during and after test, and are confirmed by the diagrams of flame contact, Fig. 3 and by the radiation records in Fig. 4, which show that the contribution from the burning Holoplast was negligible. Similar results were obtained in the tests on the $^1/10$ scale models.

(2) Re-entrant corner

The photographs, Plate 3, showing the flames during the test and the subsequent destruction pattern on the Holoplast, give a clear indication that the greater intensity of exposure did not increase appreciably the hazard to the building from the flames.

The exposure hazard

A building having walls which are externally combustible may be in danger of ignition when exposed to radiation from a neighbouring burning building unless adequate separation of the two buildings has been allowed. The severity of the hazard depends on the ease with which the combustible wall can be ignited and on the size and siting of the buildings.

The intensities of radiation at different distances from burning buildings of various sizes have been calculated and are published elsewhere (4, 5). The minimum intensity of radiant heat required to ignite the type of Holoplast used in these experiments in conjunction with a small pilot flame on the surface to simulate the conditions present with burning brands, was determined by the method developed at the Fire Research Station (6). This minimum intensity was found to be 0·94 cal/cm^2/sec.

The minimum separation of a Holoplast-clad building from neighbouring buildings for the exposure hazard to be negligible is given in Fig. 5 in terms of the length and height of the exposing building and the percentage of window openings. These calculations assume the window openings to be evenly distributed over the facade of the building and all to be involved in fire at the same time.

Since a lower intensity of radiation is required to ignite timber than Holoplast, any timber in window frames or doors in the exposed building might be ignited at separations considered safe for the Holoplast cladding. This reservation, however, applies also to buildings with noncombustible walls.

Conclusions

The *ad hoc* tests described in this note indicate that external walls of Holoplast, which is classified as having a surface of very low flame spread, are unlikely to present a greater fire risk in multi-storey buildings than noncombustible walls, if due attention is paid to siting the buildings in relation to their neighbours to reduce the exposure hazard. Lateral spread of flame from a window over the surface of Holoplast did not occur in the model tests and similar behaviour in fires in actual buildings is to be expected. In the important aspects of the vertical flame spread and the radiation from the flames Holoplast compared favourably with noncombustible walls in the model tests and similar results should be obtained on full-scale.

Acknowledgements

Thanks are due to Mr. Pickard and Miss Law for their assistance with some of the experimental work.

References

(1) British Standard No. 476 : 1953. Fire Tests of Building Materials and Structures. British Standards Institution.

(2) Joint Fire Research Organization Confidential Report F.R.O.S.I. No. 416.

References (contd.)

(3) Hird, D. and Fischl, C. F. The Fire Hazard of Interior Linings. To be published as a National Building Study.

(4) Lawson, D. I. and Hird, D. Radiation from Burning Buildings. Fire Protection Association Technical Booklet No. 18. London, 1953.

(5) Bevan, R. C. and Webster, C. T. Department of Scientific and Industrial Research. National Building Study Technical Paper No. 5. H.M.S.O. London, 1950.

(6) Lawson, D. I. and Simms, D. L. The Ignition of Wood by Radiation. Brit. J. Appl. Phys. 1952-3 (9) 288-92, (12) 394-6.

PC.

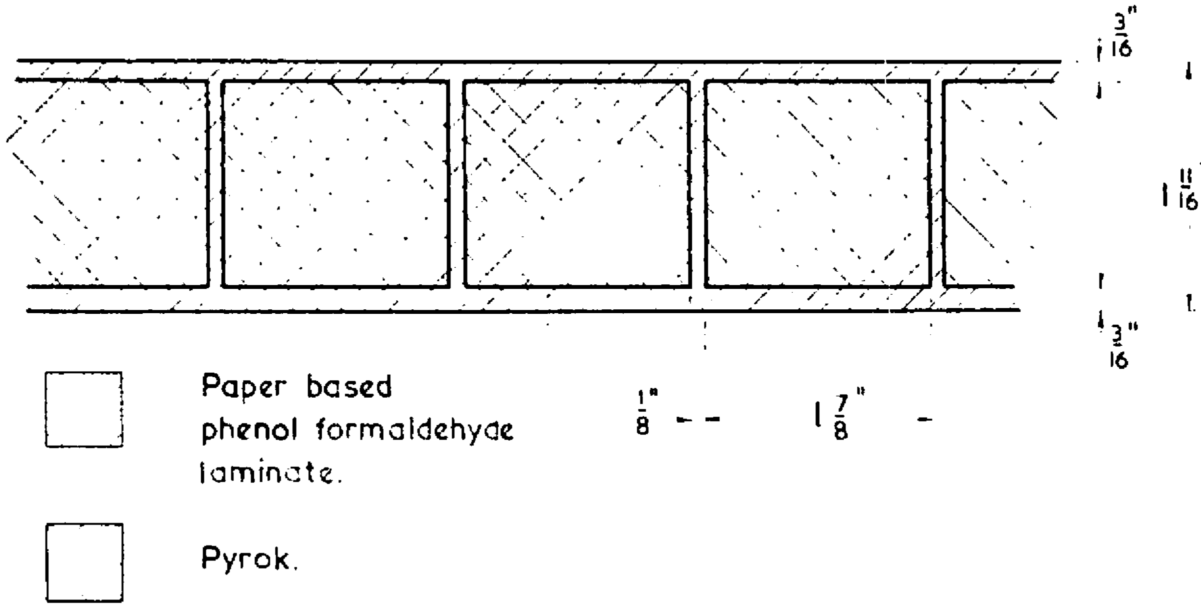
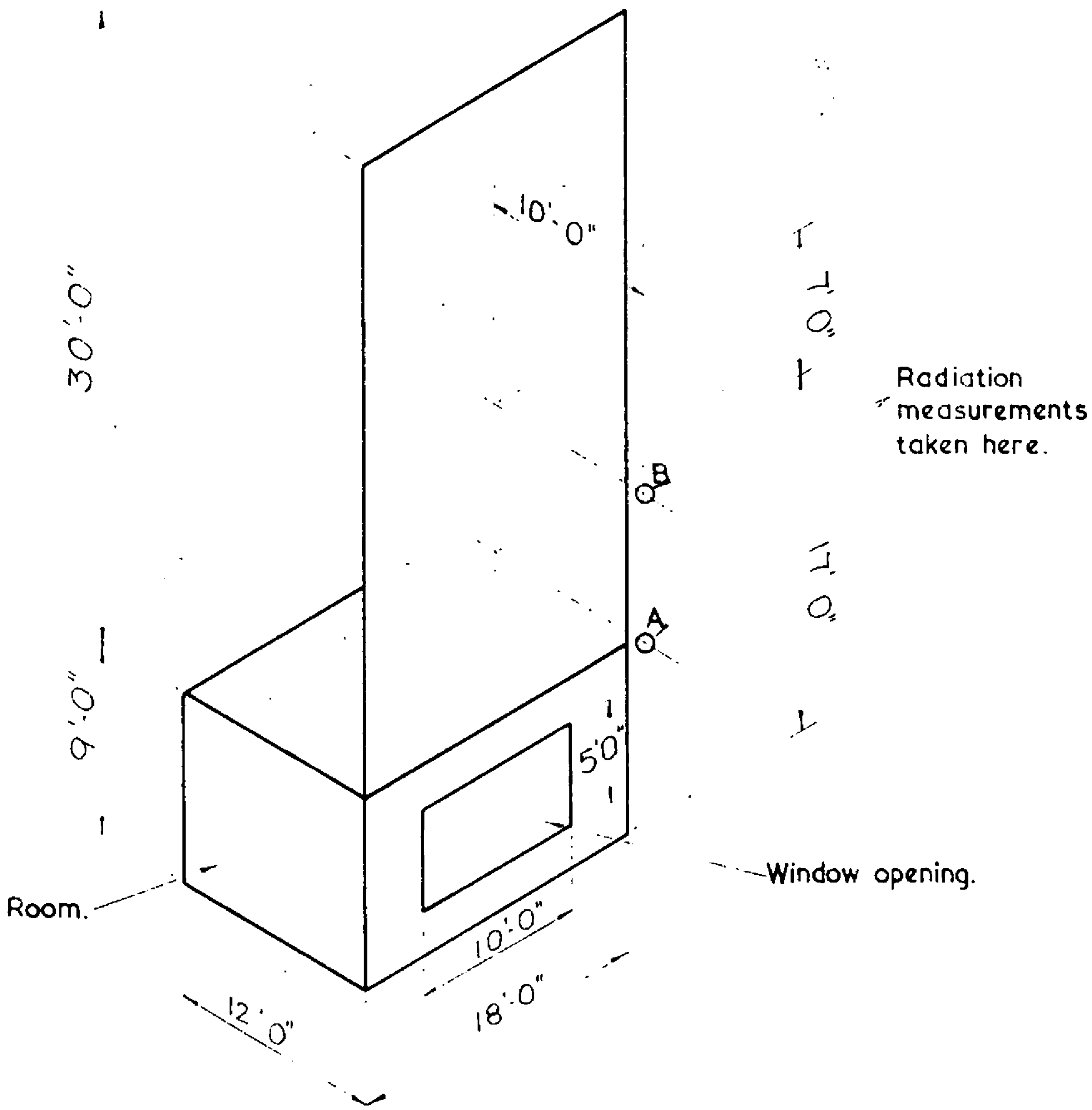


FIG. I. SECTION OF HOLOPLAST PANEL.



All the dimensions shown are full scale and the tests were carried out with these dimensions scaled to 1/5 and 1/10.

FIG. 2. SCHEMATIC DIAGRAM OF EXPERIMENTAL ARRANGEMENT.

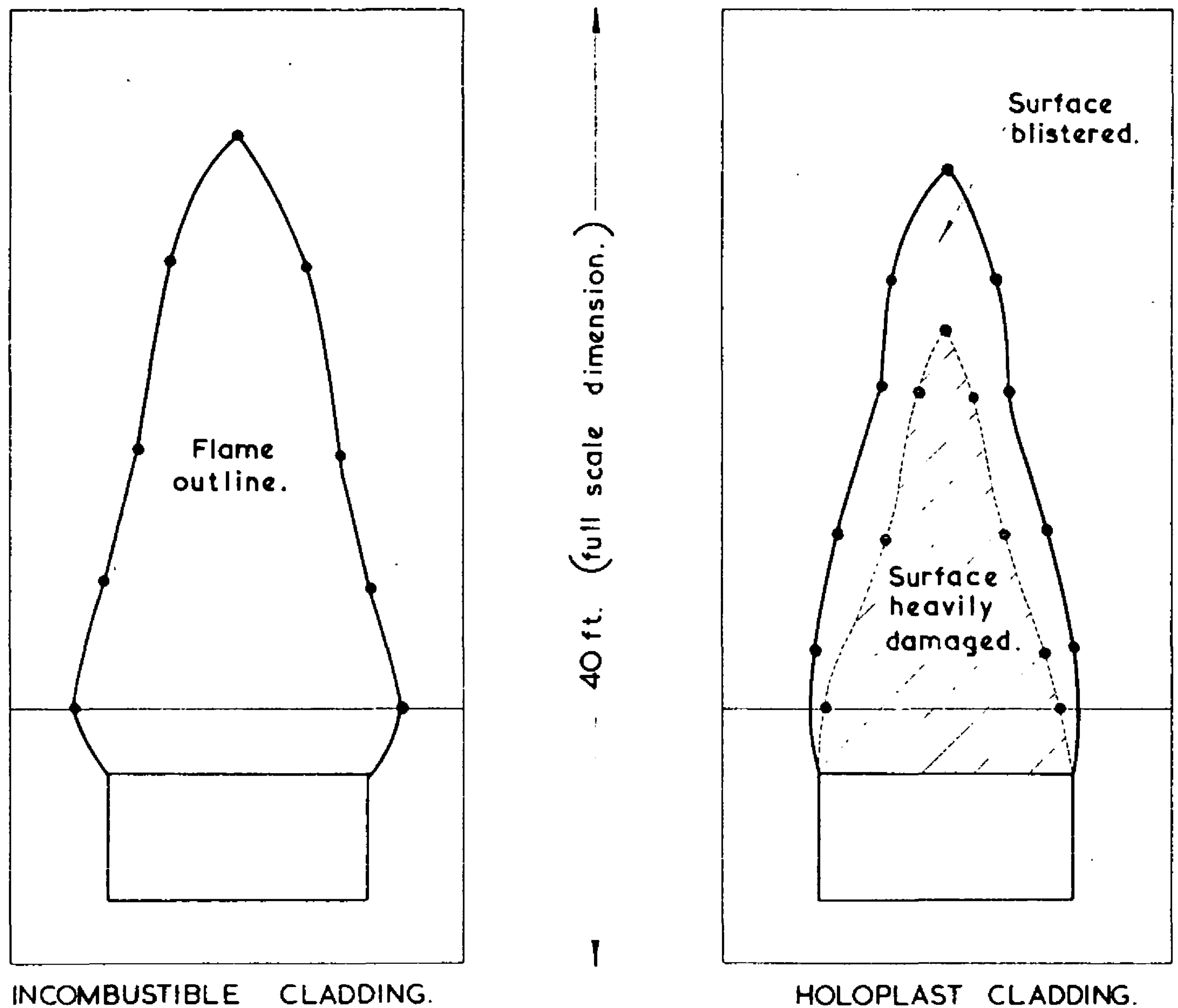


FIG. 3. SPREAD OF FLAME ON HOLOPLAST AND INCOMBUSTIBLE PANELS.

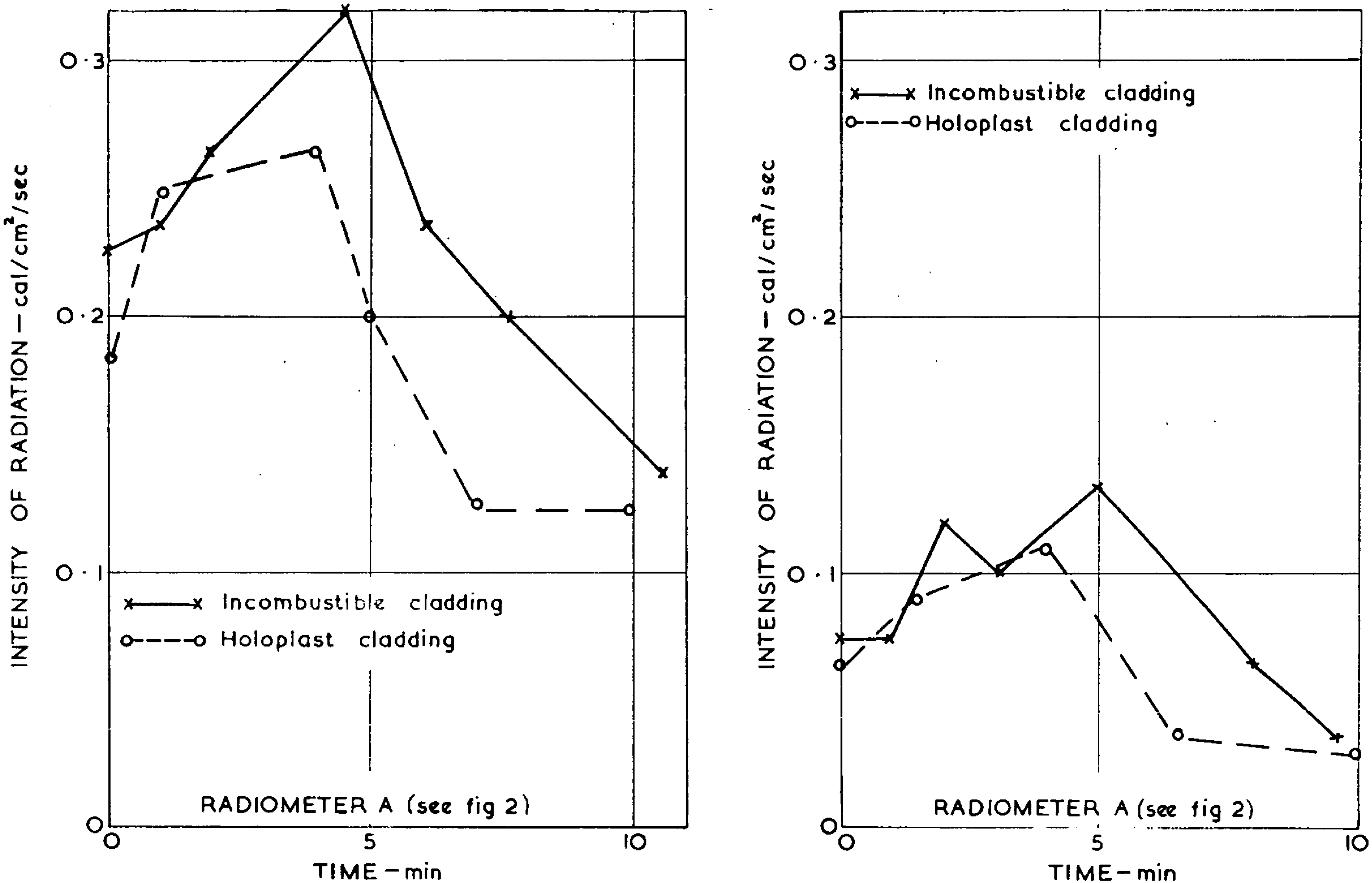


FIG. 4. RADIATION RECORDS OF TESTS WITH HOLOPLAST AND INCOMBUSTIBLE CLADDINGS

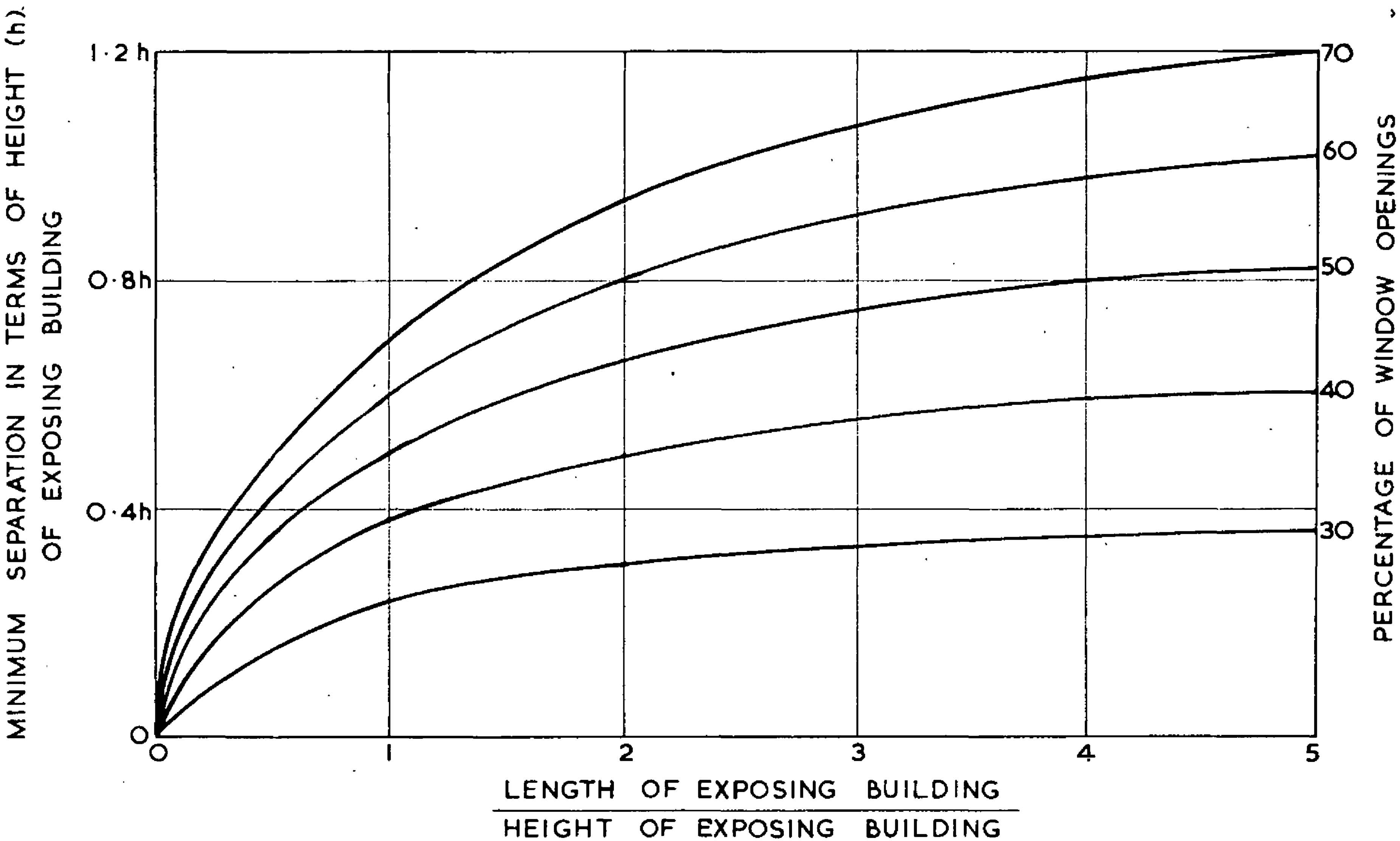
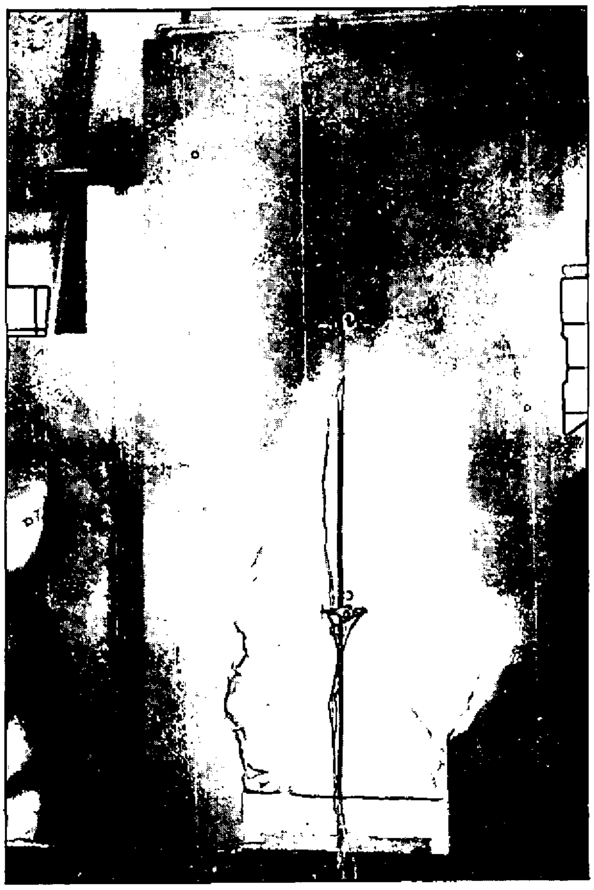
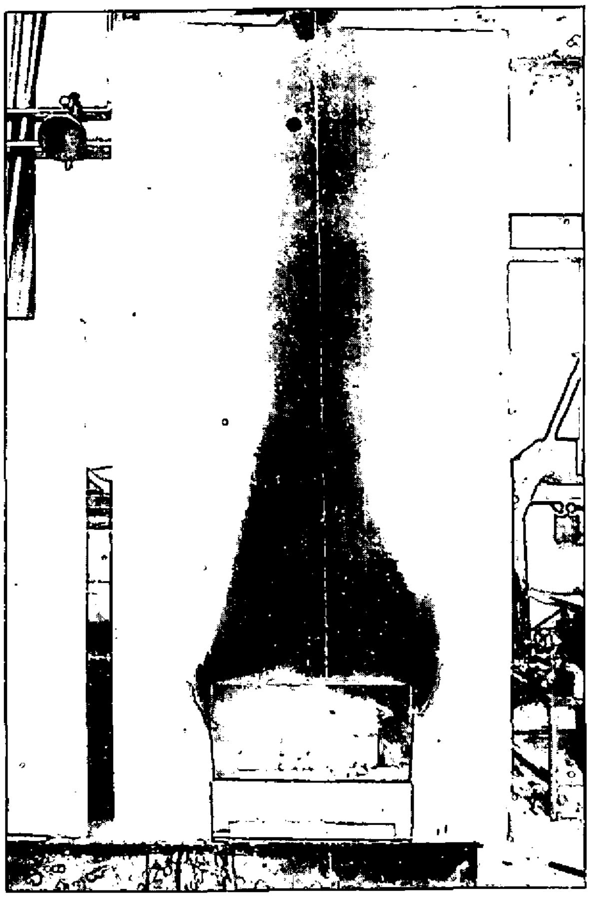


FIG. 5. VARIATION OF SEPARATION OF HOLOPLAST CLAD BUILDINGS WITH HEIGHT AND LENGTH OF BUILDING AND WINDOW OPENINGS

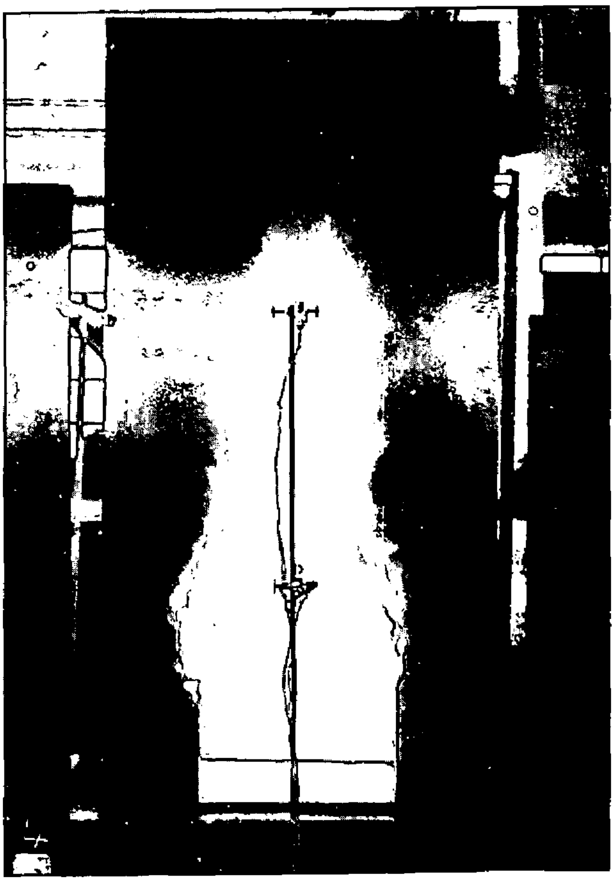


(a) During test

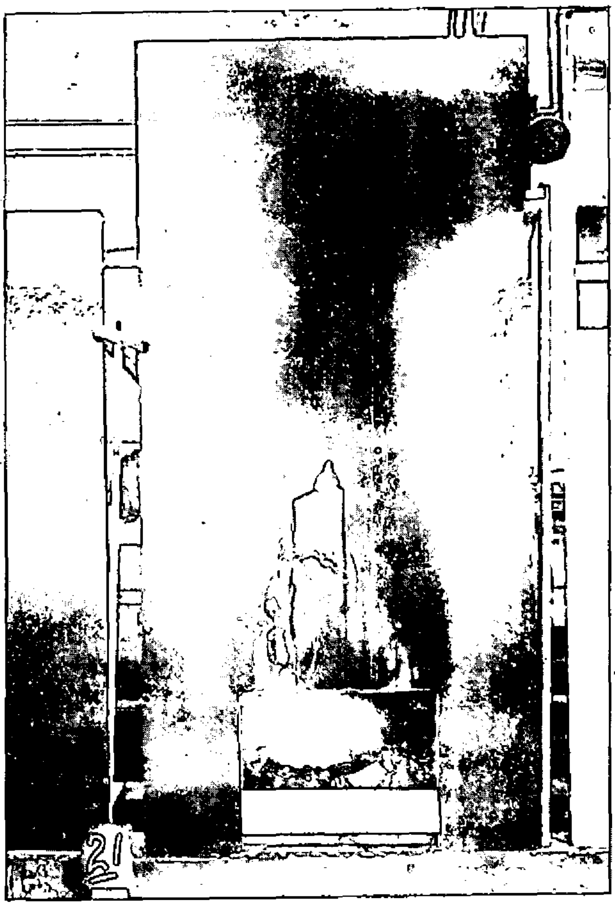


(b) After test

PLATE. I. INCOMBUSTIBLE PANEL

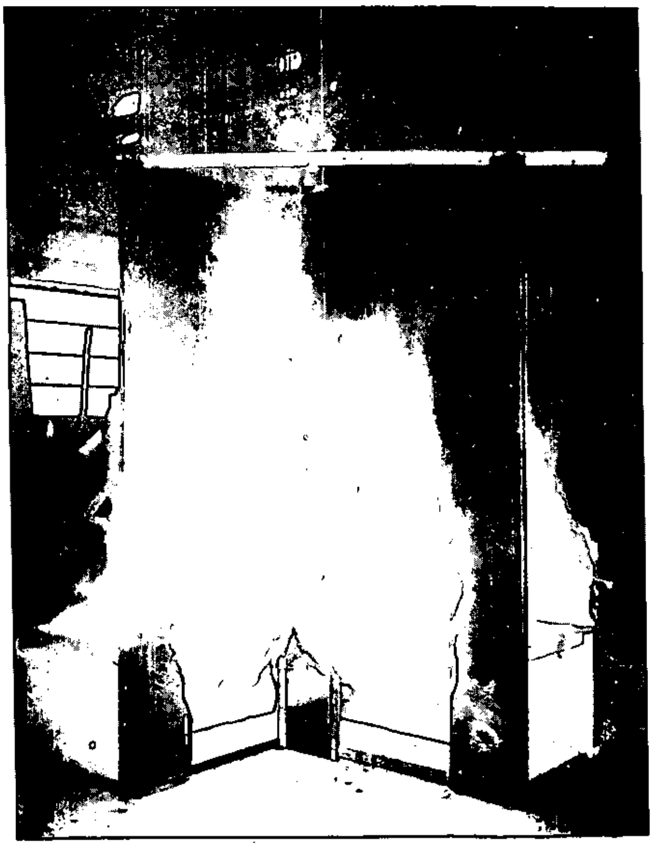


(a) During test

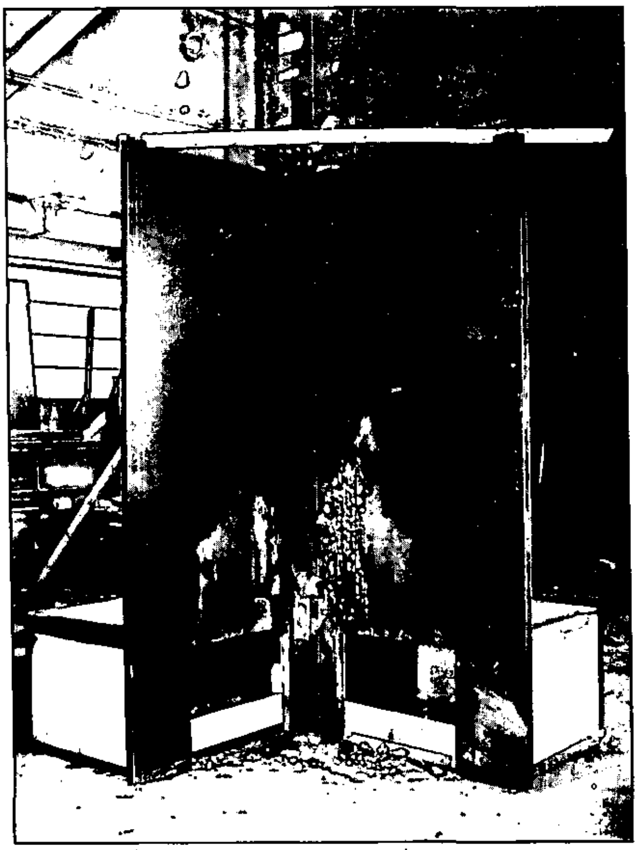


(b) After test

PLATE. 2. HOLOPLAST PANEL



(a) During test



(b) After test

PLATE.3. HOLOPLAST CORNER