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To All Chief Fire Officers

14 June 1972

Dear Chief Officer

FIRE FIGHTING IN AUTOMATED HIGH BAY WAREHOUSES

Following consultation with the Central Fire Brigades Advisory Councils, 2 working parties were set up to examine the problems associated with, respectively, fire fighting and fire prevention in automated warehouses, and to make recommendations.

I enclose a copy of the report of the fire fighting working party which has recently been approved by the Advisory Council for England and Wales. Because of the wider issues involved, the report of the fire prevention working party is still in preparation, but it will be published as soon as possible.

Yours sincerely

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No.20/1972

CENTRAL FIRE BRIGADES ADVISORY COUNCIL FOR ENGLAND AND WALES

SCOTTISH CENTRAL FIRE BRIGADES ADVISORY COUNCIL

REPORT OF A WORKING PARTY ON FIRE FIGHTING IN AUTOMATED HIGH-BAY WAREHOUSES

CONTENTS

INTRODUCTION

1. The working party was set up by the Central Fire Brigades Advisory Councils for England and Wales and for Scotland with the following terms of reference:-

> "To examine and make recommendations on the problems associated with fire fighting in automated high-bay warehouses",

in parallel with another working party considering fire prevention matters.

2. We have met four times, once at the invitation of the Berkshire and Reading Fire Brigade, when two warehouses belonging to the John Lewis Partnership Limited were visited. Thanks are therefore due to the fire authority and the brigade and to John Lewis' for their kind co-operation.

3. Further we are indebted to the SM Consulting Group Limited for permission to reproduce the diagram of a high-bay distribution centre, the main contractors for which were Messrs Simon-Carves Limited.

4. This report deals with fire fighting in three main parts, namely Pre-planning, Operational Work and Salvage. Reference is made to both purpose-built and to traditional-style warehouses adapted for high stacked storage, and whilst our concern has been primarily with the larger, more fully automated, purpose-built structures, it is felt that many of our remarks have a more general application.

A. USE AND DESCRIPTION

5. Warehousing, like other industries, has developed as new techniques have been made available. For instance, the advent of the fork lift truck changed methods of storage by permitting the introduction of pallet storage and of high stacking.

6. The changing pattern of retail distribution also calls for more sophisticated supply arrangements to service the retail outlets, and the answer which some companies have arrived at is the "high-bay" warehouse, equipped with mechanical handling facilities to varying degrees of automation. In some cases, this has meant a totally automated handling system, thus enabling the labour force at the warehouse, and stock levels at the shops, to be kept to a minimum, and mitigating handling costs per items stored.

7. Automated high-bay warehouses are constructed in two basic ways:

(a) the integrated structure, where the racking constitutes the support for the roof and has attached to it the wall-cladding, which usually consists of light alloy sheets with some form of insulation to maintain desirable conditions internally. These are the bigger variety - heights of 100 feet (30 metres) are becoming common, and warehouses of up to 150 feet (45 metres) are being built in Europe; and

(b) where the racking is separate from and does not support, the walls and roof. These tend to be smaller - between 35 and 40 feet (10.6 and 12 metres) in height.

Sometimes a conventional warehouse can be converted to this type of storage by the removal of all internal features not essential to the support of the walls and roof, and the installation of racking and goods-handling equipment.

8. In most cases, the result is a series of high racks (usually cellular in construction), and long narrow aisles (usually between 4 feet and 8 feet (1.2 and 2.4 metres wide)), with no internal dividing walls. In the United

Kingdom, the floor area of these warehouses is likely to vary between 5,000 square feet and 80,000 square feet (465-7450 square metres), their height to range from 20 - 110 feet (6-33 metres), though even greater areas and heights are distinctly possible. There are few doors and usually no windows, though in some cases "break in" points for firemen may be provided at ground level along the side of the building.

9. Frequently, the storage and retrieval operations are remotely controlled by a push-button system, or by an appropriately programmed computer. In some cases, staff travel on the cranes to pick out goods, whilst in others, conveyor belts may be used to transport goods to and from the docking point.

10. Fires in these buildings present special hazards: once inside firemen could be faced with a fire high above ground level, approachable only through a maze of unprotected steelwork. Access may be further impeded by conveyors near the section involved, and the high density storage means that a serious risk is always present. Buildings of all types will sometimes be found without adequate ventilation, and with varying amounts of installed fire protection equipment.

11. The main fire fighting problems presented by these buildings can be summarised as follows:

(a) their sheer size, in terms of volume, since they are basically a single compartment;

(b) difficulty of access and to firemen finding their way around;

(c) congestion within the warehouse;

(d) problems of locating the seat of the fire and subsequent fire fighting;

(e) dangers encountered if the premises are smoke-logged;

(f) the electrical risk which is unlikely to be less than in most factories;

(g) disintegration of racking and danger from falling stock; and

(h) speedy collapse of entire structure.

B. PRE-PLANNING

12. The complexity of fire fighting in automated warehouses means that careful pre-planning is required. This aspect of operational work is recognised as an essential feature of the overall plan, since it gives the opportunity to examine a variety of possible tactics, and the course of action decided upon after a close study of the fire fighting problem is more likely to be successful than a decision taken at short notice on the fireground.

13. A detailed plan of the premises, incorporating fire fighting information, should be maintained in a place readily accessible to the fire brigade, and a study of this would yield valuable information. Particular attention should be paid to the construction of the building, internal and external access facilities, and the fire fighting equipment available.

14. Information should be obtained about the nature of the contents, especially with regard to the fire load. Areas of high fire hazard should be noted, but it should be borne in mind that in transit stores particularly, areas of high fire hazard may change every week, if not every day. The rate of variation will also be influenced by the extent to which the racking is adjustable, and at the time of a fire warehouse staff will not always be available for consultation. Pre-planning should have special regard to these features, as they could involve problems affecting access, means of escape and also lead to disorientation of crews.

15. It is important to ensure that the first attendance to a fire is adequate for the risk, and it follows that appliances for "make up" should be pre-determined in sufficient strength to deal with a rapid spread of fire. The attendance of the Fire Officer responsible for giving fire prevention advice and possessing a detailed knowledge of the building and fire equipment installed, would be of value. Similarly, liaison arrangements should make provision for the officer in charge of the first attendance to be met by a representative of the management who is in a position to give information about personnel in the building and not accounted for, the presumed location of the fire, and any equipment in use.

VISITS TO PREMISES

16. Complementary to general liaison work, the opportunity should be taken to visit the premises, as provided for by Section 1(1)(d) of the Fire Services Act 1947. During these visits, personnel should:

(a) determine the hardstanding available for the siting of pumps, turntable ladders or hydraulic platforms and, particularly, identify safe working positions in relation to possible structural collapse;

(b) examine the cladding of the building to ascertain if external entry can be made high up to facilitate the use of monitor jets from turntable ladders or hydraulic platforms;

(c) become acquainted with the ventilating system and obtain a knowledge of the manual method of operation, which is vital if quick action is to be taken;

(d) become familiar with access within the building;

(e) gain knowledge of the type of structure and the nature of the contents - this is important, as a collapse of the racking could block the gangways;

(f) seek information about the electrical and electronic equipment installed, which will possibly be of a sophisticated type, and the location of central switches. The opportunity should be taken for the management to explain the implications of it. The overhead conductor rails, especially if unprotected, constitute a risk to firemen, and when considering electrical isolation measures, the number of independent circuits involved is important;

(g) note the hydrant and water supplies in the vicinity. It is important that an assessment should be made of the number of pumps that can be got to work. The available supplies should be related to the number of branches and possible nozzle sizes;

(h) consider the effect of the opening of a number of sprinkler heads in relation to the volume of water available from hydrants and the water demands likely to be made by sprinklers. Liaison with the

water undertaking is useful at this stage as it would enable them to assess the scale of the problem and prepare contingency plans for maintaining an adequate water supply;

(i) observe the accessibility of supplementary water supplies which must be taken into account and the details incorporated in the water plan;

(j) study the internal fire equipment, as small outbreaks may be held in check by these facilities. The Fire Service might well have to make use of these appliances and a knowledge of their positions is essential;

(k) note the position of sprinkler and/or high-expansion foam control valves;

(l) ascertain the location of the indicator board of the automatic fire alarm system;

(m) observe the exposure hazard which will almost certainly arise in the event of a serious fire and partial or total collapse of the structure;

(n) ensure that there is adequate means of sending a prompt call to the fire brigade; and

(o) ascertain whether fire drills have been instituted and obtain details of any evacuation scheme that has been introduced.

TACTICAL EXERCISES

17. As a follow up to 1(1)(d) inspections, tactical exercises should be organised on the site. The sending of an early call to the fire brigade is of such importance that this feature should be used to initiate the exercise.

18. The opportunity should be taken to test pre-planned Breathing Apparatus procedures, including the setting up of Entry Controls. Likewise, it would be prudent to check the efficiency of portable radio equipment operating within, or close to, the main warehouse. Screening caused by the heavy concentration of structural steelwork may seriously affect radio communications.

C. OPERATIONAL WORK

19. As for any fire, the initial action to be taken on arrival should be rescue work and to establish that all employees are accounted for. Tally systems which provide for detailing the whereabouts of employees within the building should be checked immediately. Pre-planning measures will have provided for an official (if available) to meet the brigade and to give the officer in charge of the first attendance any available information relating to the location of the fire, the action taken, and the internal equipment in operation.

20. During the initial stages of operations, the question may arise as to the extent to which loading pallets can be used to assist the attack. In consultation with management, it may be possible to use an unmanned picker-crane to retrieve merchandise which has been on fire and controlled by the sprinkler system. The risks of a load of partially burnt packages bursting open, falling and spreading the fire, should be foreseen and guarded against by the positinning of crews at ground level in the aisles, with equipment such as charged lines of hose.

METHODS OF ATTACK AND ASSOCIATED HAZARDS

21. The working party has given careful consideration to the use of manned pallets or mobile cranes for fire fighting operations and as a means of access to high racking, where fixed alternative means such as high level gangways are not provided. It was recognised that the officer in charge must have discretion as to his method of attack, and that his decision is likely to be influenced by consultation with senior representatives of the warehouse staff. The use of manned pallets or cranes could be a hazardous practice, and the extent to which the equipment installed in any particular warehouse might safely be used should be determined at the pre-planning stage.

22. Generally speaking, officers should bear in mind that only slight distortion of the racking due to uneven heating could prevent the movement of goods-handling equipment. A failure of the power supply could also result in crews being stranded at a high level. It is recommended that a pallet or crane so used should be fitted with a safety harness and self-rescue equipment, and if the crane is fitted with a cat - ladder, this would provide an alternative means of escape. These items should be regularly inspected by the fire brigade to ensure their adequacy and safety. Some means of communication between the crew and the officer in charge is also highly desirable.

23. It was felt that the manned use of goods-handling facilities should be confined to:-

(a) rescue work, where no other means is available;

(b) the working out of a partially extinguished fire;

(c) where, by removing flammable material adjacent to the seat of ignition, the fire may be isolated.

In all cases the system should be fully operational with a dependable power supply. Other points to bear in mind are whether the crane operator's view is clear enough, and whether the crew will be visible from the ground where this is thought necessary. In the absence of suitable installed fire fighting equipment capable of dealing adequately with the fire situation, it was thought preferable to use $1\frac{3}{4}$"(45mm) hose, with a hand controlled branch, hauled up to the pallet or crane.

24. Buildings which have been adapted to provide some of the sophisticated loading and retrieval equipment, but lacking built in fire precautionary measures and equipment, present special problems for firemen. A bold assessment should be made of the level of fire fighting effort needed to support the first attendance, which itself should be adequate and provide for sufficient manpower and equipment for Stage 2 Breathing Apparatus operations. If the fire cannot be located within about 5 minutes of arrival, and contained by means of hosereel or hand equipment, the likelihood is that personnel will be rapidly driven out of the building.

25. In purpose-built warehouses, where sprinklers and/or automatic fire alarms are installed, reference to the alarm indicator board could prove useful in locating the seat of the fire, especially if the board has the facility of indicating the first alarm to be tripped. Ultimately, however, the seat of the outbreak must be verified by firemen. If a sprinkler system is operating, accepted sprinkler drill should be followed. If a high expansion foam system is installed, continuity of foam application is essential to deal with a serious fire, and steps should be taken to ensure that this system is not shut down without the authority of the officer in charge of the fire.

26. Early reference to plans showing floor layout, location of various service shut-off points and means of entry will prove invaluable. Care should be taken in the early stages of fire fighting to ensure correct siting of appliances; this will avoid the need to move appliances to a position of safety in the event of a fire spreading beyond original expectations. Whilst efforts are being made to locate the fire, appropriate fire fighting equipment should be laid out. Having regard to the narrow and congested gangways to be negotiated within the warehouse, 1½"(45mm) diam. hose may be preferred to 2¾"(70mm)hose. If the fire is high up in the warehouse, it may, even if the sprinkler system is in operation, be possible to bring a jet of water to bear and prevent a large scale spread of fire. Scaling the racking by manual means is almost impracticable under normal conditions, let alone during a fire. If the outbreak is within 30ft.(9.1m) of the floor, it may be possible to mount an attack from an extension ladder. Firemen are experienced in dealing with difficult situations and every advantage should be taken of structural features such as catwalks and ladders to reach the seat of the fire.

27. Heavy smoke logging of the warehouse will probably be encountered and there will be a need for constant and close supervision of men within the building. It is important that escape routes should receive priority of attention as the need for a rapid evacuation of the building has always to be considered. This aspect should be impressed on officers in charge of Breathing Apparatus teams, and the normal guideline procedures should be established and followed. In addition to dense smoke, the difficulties of working in a concentration of high expansion foam should not be forgotten; special attention should be paid to the following :

(a) inability to communicate in foam: some types of breathing apparatus communication equipment, distress signal units and warning whistles are rendered ineffective;

(b) loss of sense of direction, vision and hearing; and

(c) lack of sound penetration, thus giving firemen no prior warning of hazards, eg collapsing racks etc.

Where Breathing Apparatus teams are sent in, a team should be asigned to penetrate one aisle only. They should not cross between aisles, unless specifically instructed by the officer in charge to do so. Entry Controls should be set up for each aisle.

28. A question to be considered is the extent to which the ventilation arrangements may be capable of assisting fire fighting by the removal of heat and smoke. It is necessary for the fire brigade to take immediate control of these arrangements on arrival. For a fire to be controlled, rapid location is necessary and it is in achieving this end that effective ventilation is valuable. Clearly, the concentration of smoke and heat must be reduced, and if the ventilation facilities cannot achieve this, removal of exterior cladding may be necessary. This is an expedient which should be taken into account in pre-planning measures.

29. The safety of personnel will be jeopardised by reason of the structure of the warehouse. In most high storage rack systems so much steel is used that it is put to work as the roof supporting structure. Where cladding is attached to the exterior rack framework, in place of traditional walls, the result is that if under fire conditions the racking gives way, total collapse of the building is a possibility. This should be borne in mind when considering the need for firemen to go on to the roof of the building. A heavy load on a rack structure

occurs at the bottom; if stock at this point is highly absorbent, the overloading in fire conditions could be severe at a considerable distance from the fire, due to absorption of water. The increasing use of polystyrene packaging, and PVC in various forms from electrial cable sheathing to decorative finishes, gives rise to serious problems for firemen. The former provides early conditions for "flash-over"; the toxic combustion products from the latter are well known. (That is, Carbon Monoxide and Hydrogen Chloride, both gases, the second of which mixes readily with water to form Hydrochloric Acid). The difficult heat and smoke conditions call for a high degree of supervision - men should be instructed to work in teams under the supervision of junior officers. These officers should be responsible for giving initial warning in the case of structural collapse, and keep senior officers advised of the overall position.

30. It is unlikely that the computer room in purpose-built warehouses would be directly menaced, as doubtless fire loading in the vicinity would be kept to a minimum, but steps should be taken to ensure that it is protected from radiated heat. Screening branches should be laid out in anticipation of emergency action being required. Ancillary buildings, which could include a cold store, may be seriously menaced and officers in charge should anticipate a spread of fire and be prepared to deal with it as the situation dictates. If the fire has originated in an ancillary building, the immediate action to be taken will be apparent, priority being given to measures to prevent fire spread into the main structure.

31. In the event of a serious spread of fire requiring the evacuation of fire fighting personnel from the building, it will be necessary to mount a large scale external water attack. This will involve the use of turntable ladders and/or hydraulic platforms, the crews of which, as a result of pre-planning, should know how and where to penetrate the cladding to give effective results from the monitors. The setting up of relays to supplement water supplies will probably be inevitable to maintain an effective attack, especially if the sprinkler system is still in operation. Whilst it would be inappropriate to attempt to set down in detail how the attack should be handled it may be possible, under certain circumstances, to maintain an internal fire fighting attack by the use of unmanned water monitors or lashed branches, at least until hose lines were severed by falling debris or burning and it was impracticable to attempt replacement.

32. The working party has considered whether or not a large scale high-expansion foam attack might be possible. Our conclusion is that this depends to a great extent upon the degree of structural compartmentation within the storage area, when circumstances may be such that a high-expansion foam attack is justifiable. It should be ascertained at the pre-planning stage whether or not these particular circumstances are favourable, but in the event of a fire, the development of the fire situation will also influence the final decision. Members were however conscious of the fact that at present, the majority of brigades do not have available sufficient equipment to mount such a large scale attack, bearing in mind the formidably large volumes of storage space likely to be encountered.

33. If the fire remains uncontrolled, total collapse of the building must be expected, together with the creation of a severe exposure hazard which must be met by accepted fire service measures.

D. SALVAGE

34. In the case of a serious fire involving the upper part of the building, it is unlikely, due to the difficult conditions visualised, that salvage work

could be attempted. In smaller outbreaks, possibly held in check by the discharge of sprinklers, some work could probably be undertaken to restrict water damage. The behaviour of this water will depend to some extent on the type of racking in use: for example, solid floor racking would probably afford some protection to the goods beneath. Water would however run down all sides of the racks and some damage in the lower bays would almost certainly be sustained in this way. Goods stowed in the centres of these bays would, feasibly, be partially protected.

35. Covering the contents of the bays with waterproof sheets would almost certainly be restricted to 2 or 3 bays in height from the ground. This, of course, would represent only a small portion of the stock likely to be involved and because of the restricted construction of the racking, would probably only be partially effective.

36. Damage caused by the horizontal spread of surface water is likely to be brought about by the absorption of water from the floor by stocks in the lowest bays, and the spread of water into adjoining buildings. The latter probably constitutes the greatest risk of extended damage.

E T Hayward

Chairman

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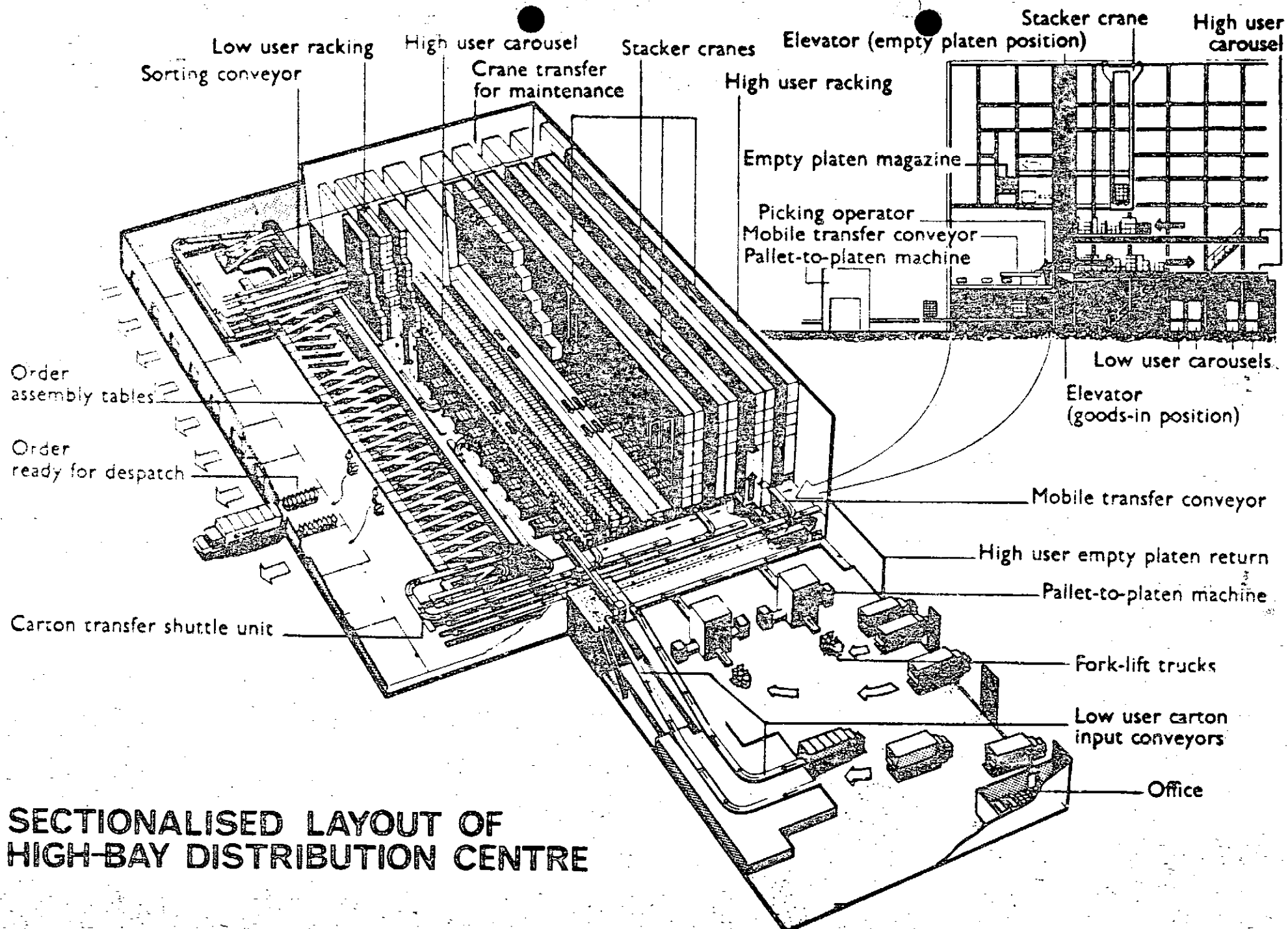

SECTIONALISED LAYOUT OF HIGH-BAY DISTRIBUTION CENTRE

APPENDIX 'A'

SUMMARY OF RECOMMENDATIONS

The following items summarise the recommendations made in this report:

(i) A detailed knowledge of the method of construction of any particular warehouse and of the equipment installed is essential. (See paragraphs 7 - 11)

(ii) In the light of this knowledge, careful pre-planning should be undertaken in respect of both fire fighting tactics, and equipment to be used. Tactical exercises should be organised on the site.
(See paragraphs 12 - 18)

(iii) Close supervision of men entering a warehouse is essential - for example in respect of Breathing Apparatus teams (para. 27), and possible escape routes should receive priority of attention.
(See paragraphs 19 - 29)

(iv) Other precautions to be taken regarding possible structural collapse include a readiness to mount a large scale water attack and to undertake recognised action to protect the precincts of the building from a severe exposure hazard.
(See paragraphs 29 - 33)

APPENDIX 'B'

MEMBERSHIP OF THE WORKING PARTY

Chairman:	E T Hayward Esq OBE KPFSM	– HM Inspector of Fire Services
	K C Bridges Esq QFSM	– County Councils Association
	G P Cooper Esq QFSM	– Scottish Fire Services
	P H Darby Esq QFSM	– Chief Fire Officers Association
	B M Doherty Esq	– Fire Brigades Union
	J J Haughney Esq	– Scottish Home and Health Dept.
	R J H Miller Esq	– Greater London Council
	T L Plumer Esq	– London Salvage Corps
	Dr D J Rasbash	– Joint Fire Research Organisation
	N F Richards Esq MBE QFSM	– Institution of Fire Engineers
	F Taylor Esq CBE QFSM	– Association of Municipal Corporations
	F W Wallace Esq	– National Association of Fire Officers
	P S Wilson-Dickson Esq MBE (Chairman of the Working Party on Fire Prevention in Automated High-Bay Warehouses)	– HM Inspector of Fire Services
Secretaries:	D W Asquith Esq D H Evans Esq	– Home Office