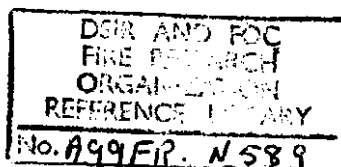


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FIRE RESEARCH NOTE

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PRELIMINARY INVESTIGATION OF FIRES FOUGHT
WITH 5 OR MORE JETS

by

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Summary

A preliminary investigation has been made of the reports of fires involving 5 or more jets in the period July 1962 - December 1963. There were 201 such fires in the second half of 1962 and 509 in 1963.

The analysis indicates that there were delays in discovery of more than half the fires. The delays were due almost entirely to buildings in which the fires occurred being unoccupied at the time of the fires. There was also a tendency for the fires to occur between the hours of 9 and 12 p.m., i.e. late at night when there are few people around. If automatic detection systems had been installed and linked directly to the fire stations or combined with security patrols within the buildings, it is very likely that there would have been a considerable reduction in the size and consequently the cost of a large proportion of the fires.

Where fire protection systems are installed it is important always to maintain them in working order. On several occasions where fires broke out, sprinkler systems, for example, had been shut down and drained.

A high percentage (more than 50 per cent) of the fires were of unknown source of ignition which might be expected owing to the fact that the source of ignition cannot easily be traced for fires that are already large on discovery. Smoking materials were the most frequently reported known source of ignition.

The value of compartmentation as an effective means of reducing spread was very apparent although the saving could have been very much greater had all doors been left in closed positions when buildings were vacated. In many instances where doors had been left open there was evidence of bad housekeeping, the doors being propped open with piles of boxes etc.

Persons were trapped in 5 per cent of the fires in 1963 and 20 people lost their lives.

PRELIMINARY INVESTIGATION OF FIRES FOUGHT WITH 5 OR MORE JETS

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1. INTRODUCTION

Every year a few hundred fires are responsible for more than half the fire wastage. In order to find out why fires become large and so cause substantial monetary loss, a special survey was initiated in July 1962 and was carried out by local authority fire brigades on all 'large' fires which are defined as fires involving the use of 5 or more jets. This population of fires at present corresponds roughly with that of fires costing £20,000 or more in direct loss.

The report is based on 201 5-jet fires in the period July-December 1962 and 509 in 1963. The total of 710 fires has been used in the analysis as far as possible but in some instances the 1962 or 1963 data have been used on their own since there were differences in the classification of the information for the two years. It was not, however, thought that the general pattern of the fires would have changed appreciably throughout the period.

2. FIRES INVOLVING 5 OR MORE JETS

The distribution of fires in 1963 according to the number of jets used in their extinction is shown in Fig.1. The distribution is of negative exponential form and, within the range of values considered, is defined by the equation

$$F = \exp. [9.6 - 0.87J]$$
$$\text{or } P = \frac{1}{N} \exp. [9.6 - 0.87J] \quad (a)$$

where F is the number of fires in 1963 that involved J jets and
 P is the proportion involving J jets of the total number of fires N .

It seems reasonable to assume that form (a) of the distribution

- (i) will not vary appreciably from year to year, and
- (ii) is very similar to that of the cost distribution.

Fires involving 5 or more jets (corresponding roughly to those of upwards of £20,000) are shown by the shaded portion in the upper tail of the curve of Fig.1. About 0.6 per cent of the fires fall into this region.

2.1. Duration of burning until control.

Figure 2 shows the distribution of the duration of burning until control of the 5-jet fires in 1962. The distribution appears to be logarithmic in form with a mean of nearly 2 hours. Fires costing upwards of £20,000 are also shown in the figure with those costing more than £100,000 specified separately.

Although there is a rough correspondence between 5-jet fires and fires costing more than £20,000 the figure shows that they are not completely identical since a number of 5-jet fires did not fall into the £20,000 category. Similarly a number of £20,000 fires in 1962 did not necessitate the use of 5 or more jets.

3. TIME OF OCCURRENCE

3.1. Month

The distribution of the 1963 5-jet fires according to the month in which they occurred is shown in Fig.3, together with comparative data for all 1963 fires in buildings. The distributions appear to be very similar implying that the proportion of all fires which develop to a stage at which 5 jets are required does not vary substantially with time of year. It would appear, therefore, that the influence of weather on the spread of fires falling into the 5-jet category is of secondary importance.

3.2. Day of week

The distribution of 5-jet fires in 1963 according to the day of the week on which they occurred is shown in Table 1 below. The table shows no evidence of a significant difference between the numbers of large fires occurring on different days. This is surprising since a large proportion of the 5-jet fires occur in industrial buildings and it might be expected that, in general, there would be a reduction of fires at weekends. The occupancy of buildings at the time of the fires is discussed in a later section of this paper.

Table 1: Day of week on which 5-jet fires occurred in 1963

Day of week	Number of 5-jet fires
Sunday	69
Monday	64
Tuesday	86
Wednesday	68
Thursday	80
Friday	74
Saturday	68

3.3. Time of discovery of fires

The time of discovery of the 5-jet fires is shown in Fig.4 together with comparative data for all building fires attended by fire brigades in 1963. The peak of the former distribution occurs between 2100 and 2400 hours whilst that of the latter lies between 1500 and 1800 hours. It would seem, therefore, that 'larger' fires are more likely to occur late at night, i.e. at a time when there are fewer people about. The fires are, therefore, likely to burn undetected for some time: if early detection were made it is likely that the size of the fires would be very much reduced. As with 3.2, this is discussed in detail in a later part of the report.

4. PLACE OF OCCURRENCE OF FIRES

4.1. Risk category area

It was agreed by the Joint Committee on Standards of Fire Cover that the best fire cover should be given to areas with the greatest fire risk⁽¹⁾. Risk category classifications were worked out by the Committee, these being special or high risk areas, risk areas A, B, C, D and rural areas.

Fig.5 compares the risk category areas of the 5-jet fires described in this paper with those for all fires in buildings in 1963. The figure shows (as would be expected) that 'large' fires were more likely to occur in the high risk areas since most of the 5-jet fires were in the A or B category whilst most of the building fires in general occurred in C areas.

4.2. Occupancies in which fires occurred

The distribution of the 5-jet fires in 1963 according to the occupancies in which they occurred is shown in Table 2. The actual frequency was highest in metal manufacture, engineering and allied industries, distributive trades (other than retail) and chemicals and allied industries. Actual frequencies of 5-jet fires do not, however, reflect the inherent hazard of a particular occupancy since they are dependent on the size of the occupancy group concerned⁽²⁾.

Table 3 shows the occupancy groups with the highest percentage of 5-jet fires. The table also shows the percentage of fires in these groups with losses exceeding £20,000 (assuming that all the loss was in fires in buildings). There is some difference between the two sets of figures showing (as might be expected) that loss is dependent upon type of occupancy. In both sets, however, the paper, printing and publishing industry ranks as number one although some 3 per cent of the fires exceeding £20,000 in loss did not involve 5-jets.

Table 2: Occupancies in which 5-jet fires occurred in 1963

Occupancy	Total
Agriculture, forestry, fishing	25
Mining and quarrying	1
Food, drink and tobacco	16
Chemicals and allied industries	35
Metal manufacture, engineering and allied industries	47
Textiles	27
Clothing, footwear, leather, fur	11
Bricks, pottery, cement, glass etc.	11
Timber, furniture etc.	26
Paper, printing, publishing	22
Other manufacturing industries	10
Construction	23
Transport and communication	21
Distributive trades - retail	25
Distributive trades - other	46
Financial, professional and misc: services	22
Educational services	8
Medical services	1
Places of public entertainment	17
Pubs, hotels, clubs, restaurants etc.	25
Public administration and defence	11
Residential houses	11
Residential flats and maisonettes	2
Non-institutional dwellings	2
Undefined, derelict, unoccupied	19
Ricks, stacks, sacks etc.	5
Grassland and heathland	1
Woods, forests, plantations, orchards	1
Ships, rivercraft and marine structures	12
Railway structures	1
Outdoor storage - timber etc.	1
" " - other	5
" " - waste	12
Outdoor plants, machinery & equipment	5
Caravans	1
Miscellaneous and undefined	1
Total	509

Table 3: Occupancies with the highest percentage of 5-jet fires

Occupancy	Percentage of fires in buildings	
	(i) where 5 or more jets used	(ii) which cost more than £20,000*
Paper, printing, publishing	5.6	8.6
Chemicals and allied industries	5.5	4.2
Bricks, pottery, cement, glass etc.	4.1	3.4
Distributive trades other than retail	3.6	4.2
Timber, furniture etc.	3.5	3.0
Textiles	3.4	4.7
Clothing, footwear, leather, fur	3.3	4.8
Food, drink and tobacco	3.1	3.9

*Assuming all loss was in fires in buildings.

The clothing, footwear, etc. and the textile industry fires were also more expensive than average while the large fires in the chemical and allied industry group were less expensive. This may be due to differences in concentration of plants, etc. in the two groups.

4.3. Areas in which fires started

Of the 201 5-jet fires in 1962 the areas in which the fires most commonly started were (i) storage (32 per cent) and (ii) production and maintenance (21 per cent). Nine per cent were outdoors and in 30 per cent of the fires the place of origin was unspecified. The remainder were in miscellaneous areas such as cloakrooms and kitchens.

5. SOURCES OF IGNITION

The sources of ignition of the fires are shown in Table 4. More than half the fires were of unknown source of ignition. This is not surprising since large fires are often well alight on discovery making it difficult to ascertain the cause of the outbreak. Of the remainder the largest single cause was smoking materials with an incidence more than twice that of any other known cause. Children playing with fire, malicious or intentional ignition, spontaneous combustion and electric wire and cable were the next commonest known causes.

Table 4: Sources of ignition of fires (July 1962 - Dec. 1963)

Source of ignition	Number of fires
Explosives, fireworks	4
Locomotives	2
Malicious or intentional ignition	25
Matches	5
Children playing with fire	28
Mechanical heat and sparks	13
Naked light - no further information given	15
Rubbish burning	9
Smoking materials	63
Spontaneous combustion	21
Chimney, stove pipe, flue (not confined to)	7
Electric appliances and installations	
Cooking appliances	1)
Space heating	8)
Wire and cable	20)
Wireless and television	2)
Blankets and bedwarmers	1)
Lighting	3)
Supply apparatus	7)
Other and Unknown	25)
Gas appliances and installations	
Cooking appliances	3)
Space heating	1)
Other	3)
Solid Fuel appliances and installations	
Fire in grate - igniting structural timber under hearth	1)
Fire in grate - igniting other materials	4)
Slow combustion stove - igniting structural woodwork	3)
Slow combustion stove - igniting other materials	3)
Oil appliances and installations	
Space heating	4)
Blow lamp etc.	7)
Water heating (central heating etc.)	2)
Other	5)
Liquefied petroleum gas	
Cutting gun, blow lamp etc.	5
Acetylene	
Oxyacetylene cutting and welding appliances	15
Appliances and installations - fuel unspecified	
Cooking appliances	2)
Cutting gun, blow lamp etc.	1)
Tar boiler	1)
Other	8)
Miscellaneous	13
Unknown	370
Total	710

6. MATERIAL IGNITED FIRST IN FIRES

As with the source of ignition, in more than half the fires the material first ignited was unknown (Table 5). The largest groups of known material were packing and wrapping and paper and cardboard.

Table 5: Material ignited first in fires (July 1962 - Dec. 1963)

Material first ignited		Number of fires
Gases	- Town gas	5
	Ethylene	1
	Other unsaturated hydrocarbons - butane, ethane	2
Liquids	- Paraffin	3
	Diesel oil, fuel oil	3
	Paint, varnish etc.	3
	Used in chemical manufacture	2
	Potable liquid	2
	Other & unspecified (inc. waste oil)	13
Carbonaceous materials and derivatives (solid)	Coal, anthracite etc.	1
	Bitumen (petroleum derived), pitch, tar	2
	Agricultural, forestry produce	
	Standing vegetation, grass, heather, bracken etc.	3
	Cut but unprocessed hay	12
	" " " straw	14
	" " " cereal (inc. grain and seed)	1
	Other (cut tree lappings etc. firewood, manure etc.)	6
	Wood - boards, planks, thin sheets	4
	Wood - dust shavings	6
Textiles	- Raw fibres	10
	Roving, yarn	1
	Clothing not on person	1
Furnishings or furniture	Bedding	6
	Upholstery	7
	Other furniture	5
	Undefined furniture and furnishings	2
Structure	- Floor, skirting board	8
	Wall partition, wall lining	6
	Ceiling, ceiling lining	1
	Roof, roof members	11
	Timber in chimney	1
	Timber under hearth	1
	Other structure	1
	Unspecified structure	7
Fittings and fixtures	- Shelves and other internal fittings	7
Miscellaneous	Insulation - material to which fire first spread unknown	12
	Dusters, rags	3
	Dust, powder, flour	10
	Food - fat	5
	Lagging	4
	Hessian, hemp, sisal, jute, cocofilm	10
	Rubber	5
	Packing, wrapping	30
	Paper cardboard	27
	Other	23
Unspecified waste	18	
Unknown		405
Total		710

7. DATE OF CONSTRUCTION OF OCCUPANCIES WHERE FIRES OCCURRED

Table 6: Date of construction of occupancy

Date of construction	Number of fires
Prior to 1900	258
1900 - 1919	127
1920 - 1939	96
1940 - 1959	74
1960 onwards	25
Unknown, not stated or not applicable	130

Two-thirds of the occupancies of known date of construction were built before 1920 and forty-four per cent before 1900 (Table 6). The figures are unadjusted for numbers at risk in the various age groups since the latter are not available. Figure 6 compares the distribution of date of construction (where known) of the 5-jet fire occupancies with that of all buildings involved in fires in 1963, and it seems that there is a greater tendency for the older buildings to be involved in 'large' fires. There is mention in some reports of changes in occupancy of industrial buildings and also of overcrowded conditions within them due to expansion of the industry. Both of these could account for the greater tendency for older buildings to be involved in 'large' fires.

8. OCCUPANCY OF BUILDINGS AT TIME OF FIRE

In the period July - Dec. 1962 more than half the fires occurred in buildings unoccupied at the time of the fire. In 1963 the picture was similar.

Table 7 shows the occupancy of buildings at the time of the fires in that year with respect to manufacturing industries. The textile, clothing, footwear etc., and the timber industry buildings, where fires of a smouldering nature often occur, were especially likely to have been unoccupied at the time of the fires whilst the 5-jet fires in the chemical industry (usually those with rapid spread) appear to have broken out when there were people around. The latter industry is, however, on which is usually in continuous production and which is not normally unoccupied. In the metal manufacture, engineering and allied industries the fires broke out with more or less equal frequency whether the buildings were occupied or not.

Table 7: Occupancy of industrial buildings at time of fires (1963)

Occupancy of building at time of fire	Normal number of staff	Reduced number of staff	Unoccupied	Not stated or unknown	Total
Manufacturing industry					
Food, drink and tobacco	4	4	7	1	16
Chemicals and allied industries	16	9	8	2	35
Metal manufacturing engineering and allied industries	15	7	23	2	47
Textiles	3	5	19	-	27
Clothing, footwear, leather, fur	1	-	9	1	11
Bricks, pottery, cement, glass etc.	2	3	6	-	11
Timber, furniture etc.	3	3	19	1	26
Paper, printing and publishing	6	5	9	2	22
Other manufacturing industries	4	1	5	-	10
Total	54	37	105	9	205

If the occupancy of the buildings by a reduced number of staff is ignored, then almost twice as many industrial buildings were unoccupied at the time of the fires as were occupied. It is not surprising, therefore, that there were delays in discovery of most of these fires. This is further discussed in the next section.

9. DELAY IN DISCOVERY OF FIRES

Table 8: Delay in discovery of fires (July 1962 - Dec. 1963)

Delay in discovery of fires	Number of fires
No employees at point of origin of fire	23
No-one on the premises at the time of fire	296
Other	43
No delay	215
Not stated or unknown	133
Total	710

There were delays in the discovery of more than half the fires (see Table 8), which was due almost entirely to the fact that buildings were unoccupied at the time of the fires.

Where buildings were occupied, by security patrols etc., it is stated on some reports that fires broke out but were unobserved by the patrol for some time. The patrols were not, therefore, always particularly efficient by themselves in detecting the fires. Had early detection been made, e.g. if the buildings had been fitted with automatic detection systems, linked directly to the fire stations or combined with security patrols, then it is very likely that the size and consequently the cost of a high proportion of the fires would have been considerably reduced. Thirty per cent of the fires are stated to have spread very rapidly and became large, even though there was no delay in discovery.

10. DELAY IN CALLING THE FIRE BRIGADES

In 85 of the 710 5-jet fires in the period July 1962 - Dec. 1963 there were delays in calling the fire brigade once the fires had been discovered. In 78 instances delays were said to have been due to works fire brigades or employees attempting to cope with the fires themselves and in the remaining incidents communications with the brigades failed. Had the brigade been able to tackle the fires sooner in these instances it is likely that there would have been a reduction in spread.

11. SPREAD OF FIRE

Building fires in 1962 were analysed according to whether they had spread to other hazards or buildings and the results are shown in Table 9. Sixty-eight per cent of the fires were confined to the building of origin. The remaining fires spread to other buildings or hazards.

Table 9: Spread of fire in buildings (July - Dec. 1962)

Spread of fire	Number of buildings and/or hazards fire spread to:-								
	0	1	2	3	4	5	6 or more	Not stated	Total
Confined to building or origin	125	-	-	-	-	-	-	-	125
Extended to adjoining buildings	-	18	5	1	-	1	-	1	26
Extended to separate buildings	-	5	2	-	2	-	1	1	11
Extended to adjoining and separate buildings	-	-	2	3	1	-	-	3	9
Extended to separate buildings and other hazards	-	-	2	1	1	1	1	-	6
Extended to other than above	-	3	1	-	1	-	-	1	6
Total	125	26	12	5	5	2	2	6	183

12. FIRE PROTECTION DEVICES

Table 10: Fire protection devices (1963)

Fire protection devices	Number of fires	Remarks
None installed	346	
Automatic fire detectors	3	1 - operated 1 - failed to operate 1 - fitted but not in operation
Fire stop doors	55	37 - effective in reducing spread 16 - ineffective because (i) they had been left in open positions. (ii) they were out of the area of the fire (iii) there were openings around doors in party walls. On two occasions the fire resistance of the door was insufficient for the fire to be held longer than about 30 minutes. There was evidence of bad housekeeping in many of these reports. 2 - unknown.
Fire stop walls	12	10 - effective 1 - ineffective due to open under floor ducts of considerable size and to unprotected openings giving access to ventilation system space. There was no fire separation in ventilation ducting or in the space through which this ducting passed. 1 - ineffective as there was no separation of roof level.
Sprinklers	11	5 - effective 6 - ineffective because the system had been shut down or because the sprinklers were situated in property other than that in which the fire started and there was insufficient heat to actuate the heads
Roof vents	4	2 - effective 2 - ineffective because the venting systems were inadequate
Other (mainly steam injection systems in ships)	10	
Combination	32	29 - effective 1 - in which the safety curtain in a theatre remained in raised position 1 - in which the fire door was prevented from closing by obstructions. The roof vents in this fire were inadequate and the wall vents (manually operated) were closed. The vents in any case were fitted only in the working area and thus there was incomplete protection in the building. 1 - unknown
Not stated or unknown	36	

In 1963, 346 (or 68 per cent) of the 5-jet fires occurred in buildings with no fire protection device. In 89 (or 18 per cent) of the fires, protection devices helped reduce spread but in 34 instances the devices did not help. There is strong evidence of the value of compartmentation (fire stop doors, walls and the combination category in Table 10) and where these were not effective in reducing spread the reason was mainly that the doors had been left open or were out of the area of the fire. Sprinklers helped control the fire where they were installed and where these did not control the fire it was generally because the systems had been shut down.

13. PERSONS TRAPPED AND KILLED

The distribution of persons trapped in 5-jet fires in 1963 is shown in Table 11 below.

Table 11: Person trapped (1963)

Persons trapped	No. of incidents
0	483
1	10
2	4
3	2
4	4
5	2
6	1
8 or more	1
Not stated or unknown	2

Trapping of occupants was a feature of 5 per cent of the incidents, and 20 people lost their lives. One incident especially worth note was that of a London hotel fire in which 4 people lost their lives and 7 received non-fatal injuries. The deaths of three of the 4 fatalities were believed due to carbon monoxide poisoning and that of the fourth fatality to multiple injuries which resulted from jumping out of a 4th floor window. Four rescues were effected by fire brigade personnel and one person escaped along the 4th floor parapet. The supposed reasons for there being so many casualties were (1) that a fire detector which operated satisfactorily was connected to an electrical circuit which failed to actuate the 3 audio-alarms in the hotel. The hotel guests were therefore alerted by word of mouth. (2) the main staircase and enclosure in the hotel were involved in a rapid and undetected spread of fire. (3) a fire resisting door on the 2nd floor landing had been left open and had thus failed to reduce the fire spread.

14. DIFFICULTIES ENCOUNTERED BY FIRE BRIGADE

Table 12: Difficulties encountered by fire brigade (July 1962 - Dec. 1963)

Difficulties encountered	Number of fires
Collapse of roof	59
Smoke logged atmosphere	134
Other	31
More than one of above	35
Not stated or not applicable	451
Total	710

A smoke logged atmosphere (necessitating the use of breathing apparatus) was the main difficulty encountered by fire brigades. A collapsing roof was also encountered in 8 per cent of the fires.

15. CONCLUSIONS

Had automatic detector systems been installed in all buildings and linked directly to the fire stations or combined with security patrols in the vicinity it is very likely that the size and consequently the cost of many of the fires would have been greatly reduced.

The value of compartmentation as an effective means of reducing spread is very apparent. Doors should always be left in closed positions when buildings are vacated and care should be taken to see that there is good housekeeping in industrial areas.

It is important to maintain all fire protection devices in working order all the time. On several occasions fires broke out in buildings where, for example, sprinkler systems had been shut down and drained.

Trapping of occupants is not a serious feature of large fires, there being trapping in 5 per cent of the incidents in 1963.

Twenty people lost their lives in 5-jet fires in that year.

16. REFERENCES

- (1) Report of the Joint Committee on Standards of Fire Cover. Central Fire Brigades Advisory Councils for England and Wales and Scotland.
- (2) HOGG, JANE M. and FIRTH, J. M. The ranking of some industries in Great Britain in accordance with their relative fire hazard. D.S.I.R. and F.O.C. Joint Fire Research Organization. F.R. Note No.558/June 1964.

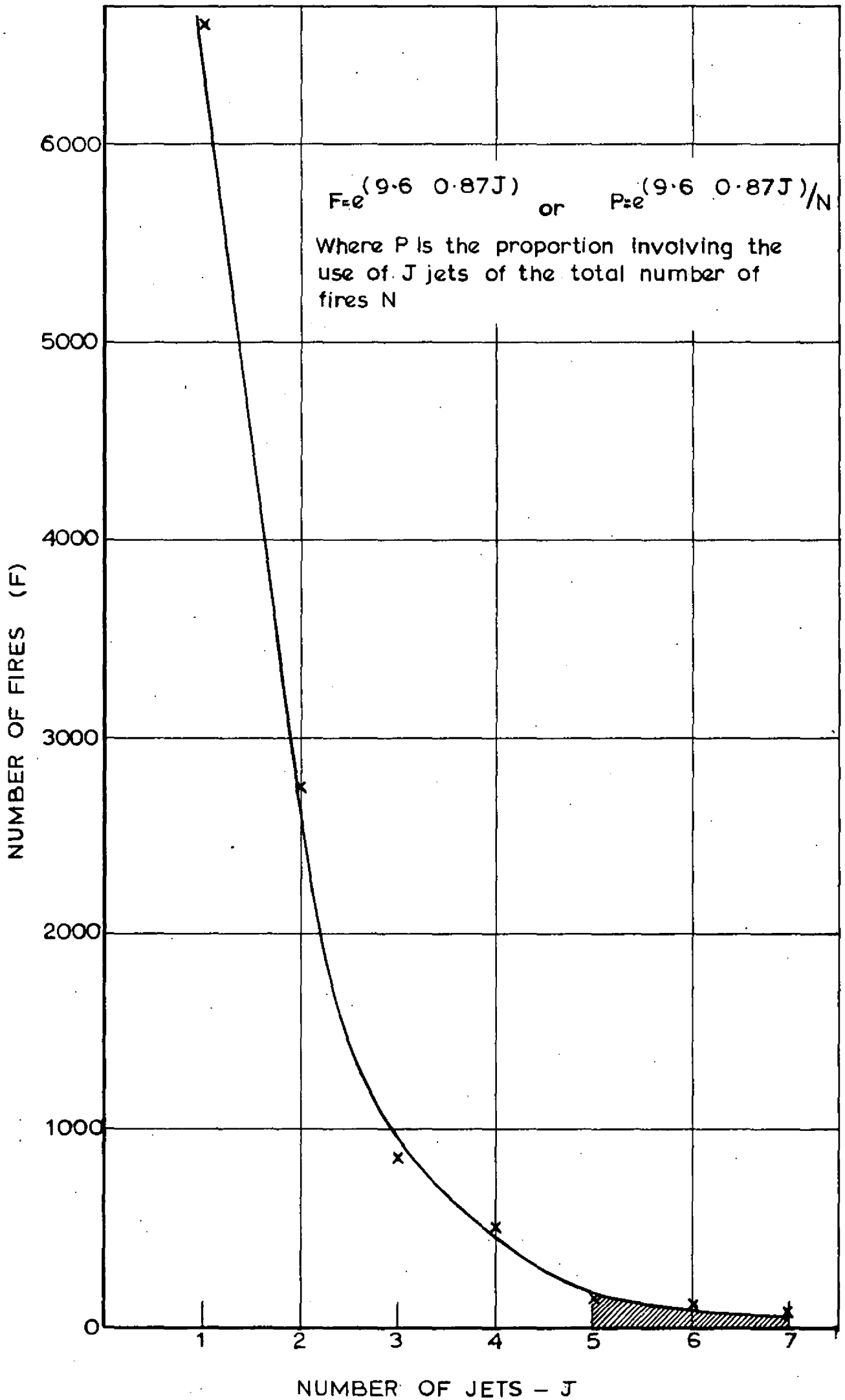


FIG.1. FIRES INVOLVING 5 OR MORE JETS IN 1963

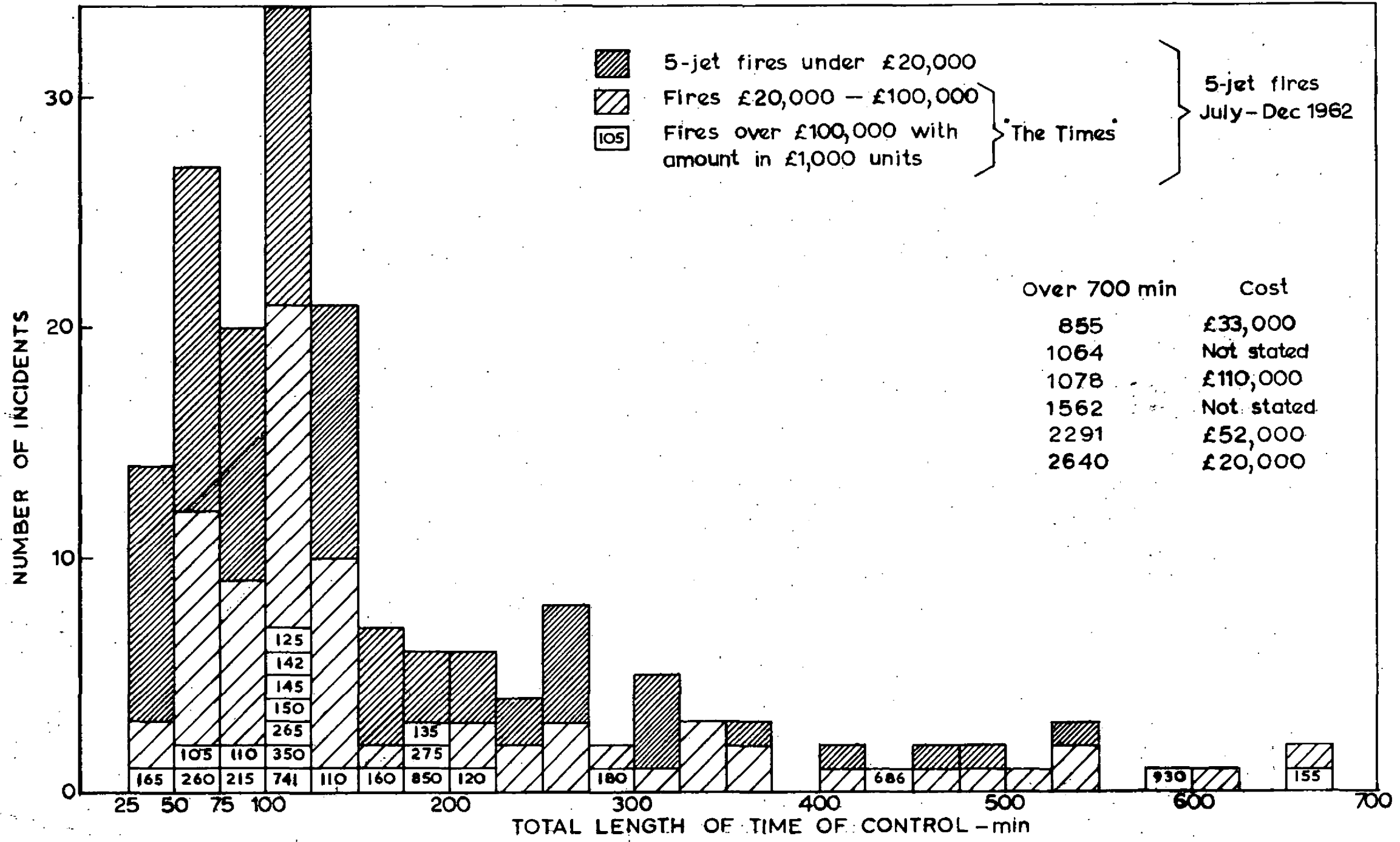


FIG.2. DURATION OF BURNING UNTIL CONTROL OF FIRES IN 1962

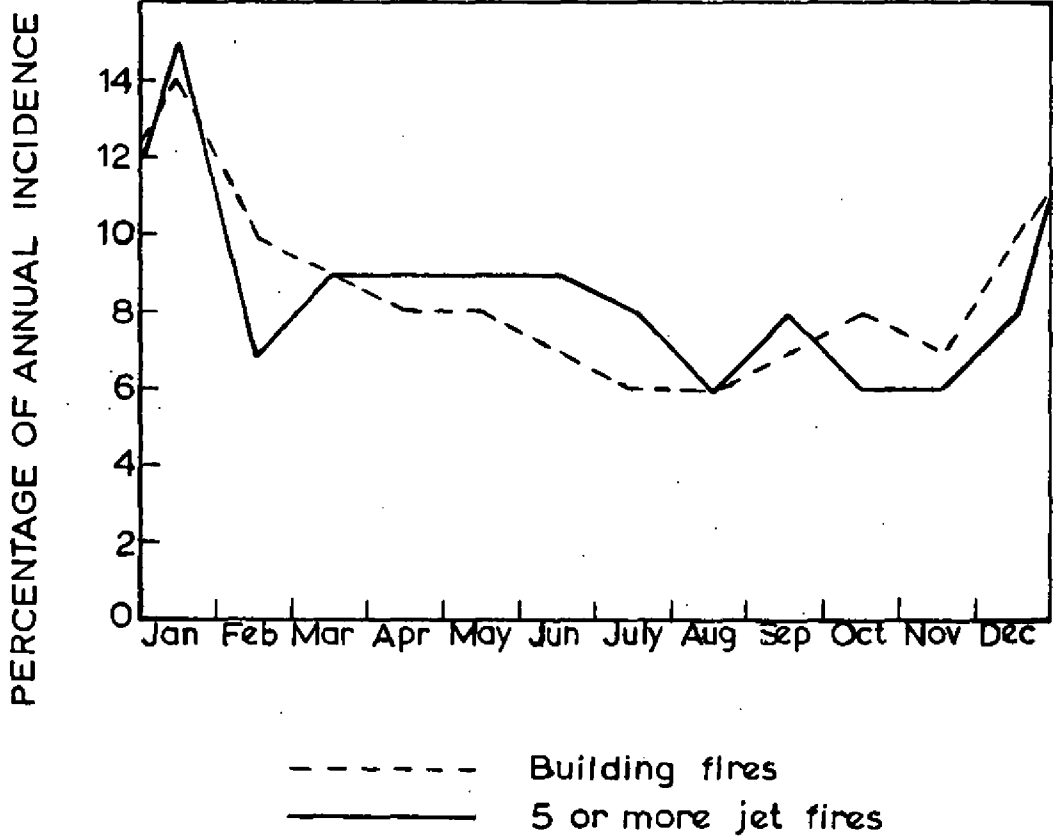


FIG. 3. MONTH OF OCCURRENCE - 1963

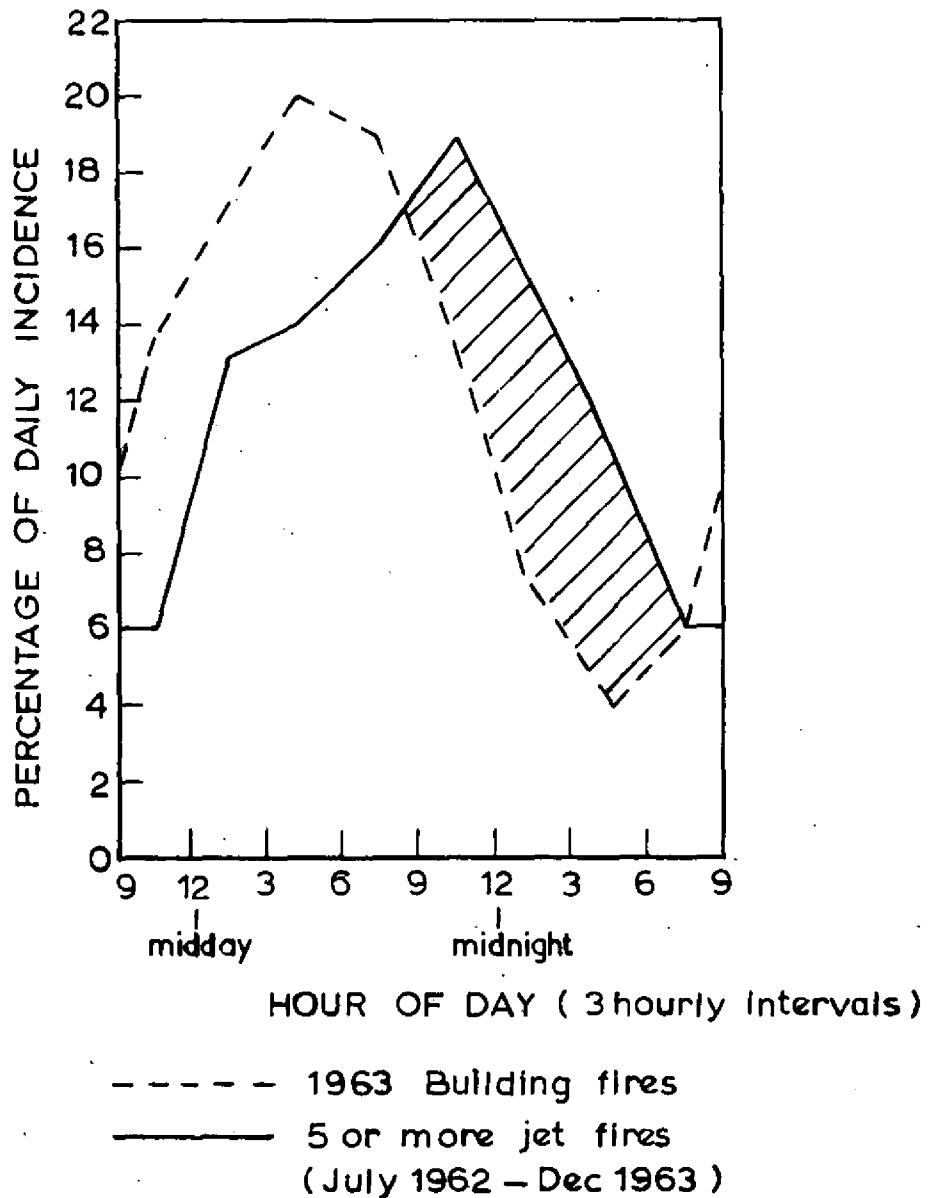
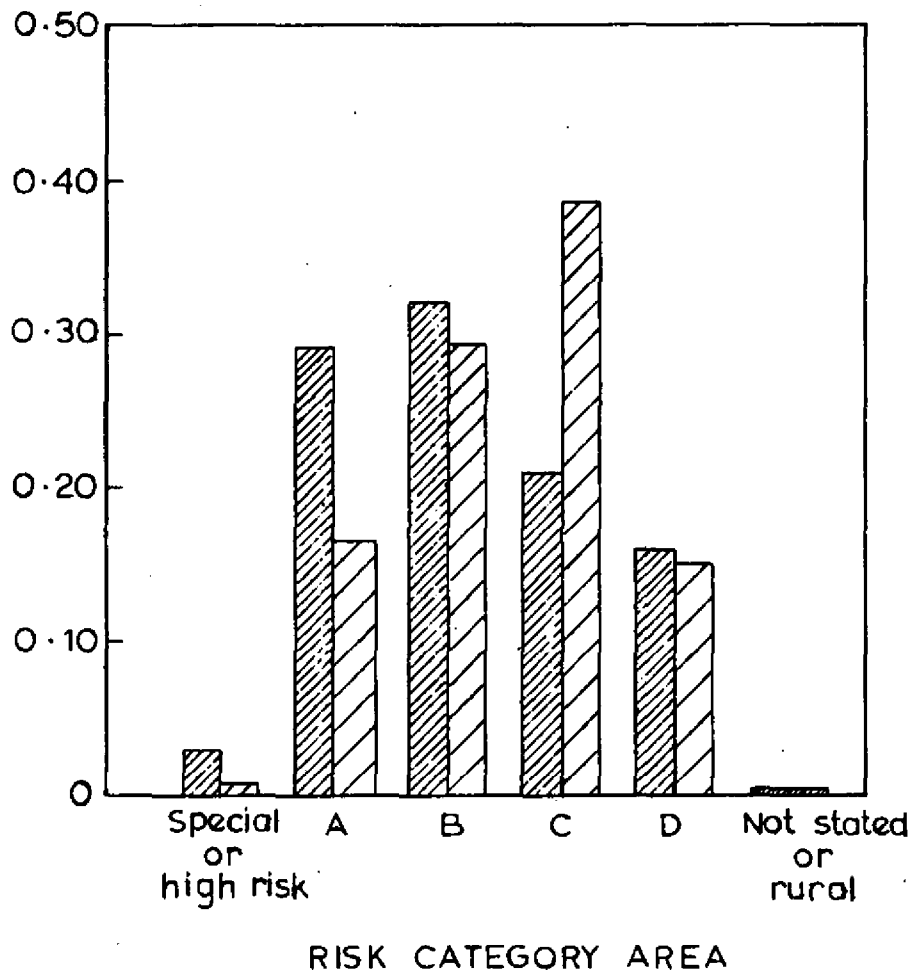


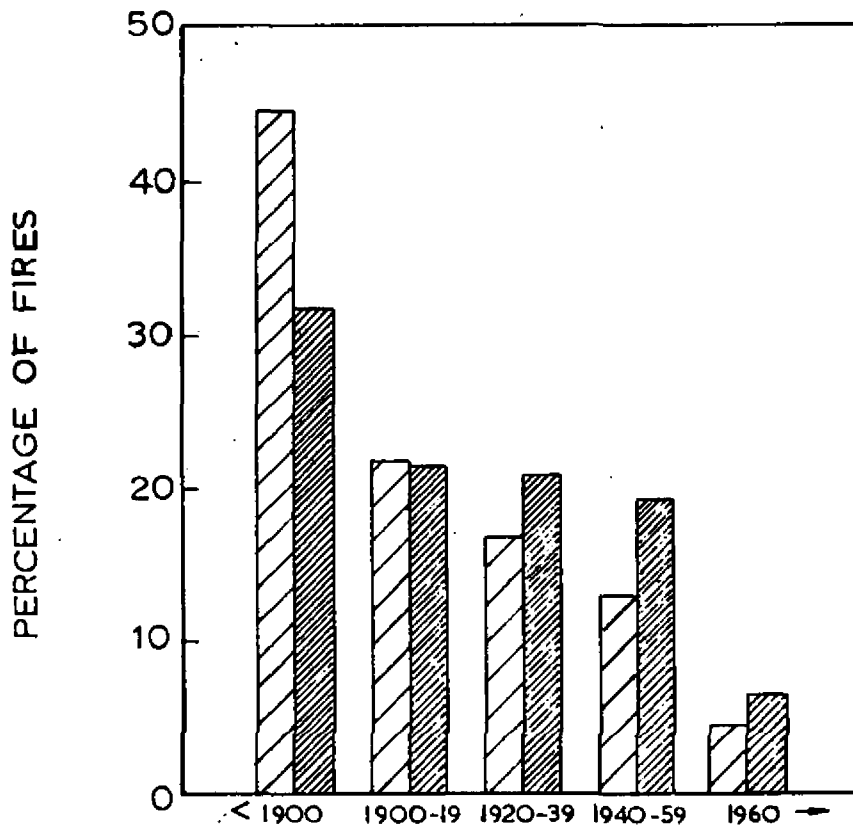
FIG. 4. TIME OF DISCOVERY OF FIRES (JULY 1962 - DEC 1963)

PROPORTION OF TOTAL IN PARTICULAR RISK AREA



- Fires fought with 5 or more jets (July 1962 - Dec 1963)
- ▨ All fires in buildings 1963

FIG.5. THE RISK CATEGORY AREA
(JULY 1962 - DEC 1963)





 Fires in buildings fought with 5 or more jets (July 1962 - Dec 1963)
 All fires in building 1963

FIG.6. DATE OF CONSTRUCTION OF BUILDINGS (JULY 1962 - DEC 1963)

