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

CAUSES OF FIRES IN DWELLINGS IN LONDON, BIRMINGHAM AND MANCHESTER AND THEIR RELATIONSHIP WITH THE CLIMATIC CONDITIONS DURING THE FIRST QUARTER OF 1963.

by

J. E. Gaunt and I. S. Aitken

SUMMARY

During the first 3 months of 1963 the fire incidence in occupied dwellings in London, Manchester and Birmingham was approximately 22 per cent higher than its expected value (obtained by extrapolating the fire incidence curve for the previous 5 years). There was a corresponding increase in the number of incidents involving fatalities.

There is evidence of a close association between fire incidence and minimum temperature, the relationship being approximately linear for minimum temperatures below freezing point. In fact, based on fire incidence in London, Manchester and Birmingham, in London alone when the temperature is below freezing point, for every degree ($^{\circ}F$) drop in weekly average minimum temperature there is a corresponding increase in fire incidence by about 10 fires per week.

The causes most associated with the increase in fires (and also associated with the extreme climatic conditions) appear to be oil stoves, fires in grates, electric wires and cables, unknown sources of ignition, electric blankets and bedwarmers, oil blowlamps and candles.

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INTRODUCTION

Because of the sharp increase in fire incidence in occupied dwellings during the early part of 1963 it was decided to examine the causes of fire chiefly responsible for the increase and to see how far they were related to the adverse climatic conditions experienced at that time.

It was thought that the cause pattern for the three large conurbations, London, Birmingham and Manchester, would give a good indication of the cause pattern experienced in the whole country during the first three months of the year. The analysis was therefore carried out on those three areas alone.

The first part of the report is a comparison of the fire incidence and causes of fire in 1963 with those for the previous 5 years. The causes of fires most responsible for the increase in fire incidence in 1963 are then examined in more detail. Casualties are also examined.

In the second part of the report relationships between fire incidence and the following climatic factors are investigated - (i) maximum temperature (ii) minimum temperature (iii) rainfall (iv) sunshine and (v) vapour pressure.

Relationships between certain causes of fire and certain climatic effects are examined for the London area.

SOURCES OF DATA

Information on fires occurring in occupied dwellings during the first three months of the year is based on reports of fires attended by fire brigades in the three areas concerned.

The climatic data used are daily recordings taken by the Meteorological Office at relevant Stations viz Kingsway, London; Elmdon, Birmingham; and Ringway, Manchester.

FIRE INCIDENCE IN 1963 COMPARED WITH THAT OF THE PREVIOUS 5 YEARS

Figure 1 illustrates the considerable increase in the number of fires occurring in occupied dwellings in 1963 in comparison with the previous 5 years. Until 1963 there had been a fairly constant trend in fire incidence (estimated in the manner indicated in Appendix I) but in that year a total of 1992 represented an increase of approximately 22 per cent above the expected value (obtained by extrapolating the curve).

Reference to Table 1 shows that, corresponding to the increase in fire incidence, there was also an increase in the number of incidents involving fatalities in 1963 in comparison with the previous 5 years. As the numbers are small and therefore subject to a relatively high degree of variability, (Appendix I), it is probably true to say that the number of incidents involving fatalities is about 3 times that expected in the period considered. The incidence of non-fatal injuries was also higher than expected but the change was not so great as that in fatalities.

Table 2 is a subdivision of fire incidence by cause according to the year of occurrence and although, again, the standard error in estimation is relatively high for the smaller categories (Appendix I) it appears that the seven causes listed below were those most responsible for the increase in fire incidence in 1963:-

(a) oil stoves

(b) fires in grates

(c) electric wires and cables

(d) unknown sources of ignition

(e) electric, other apparatus which is mainly electric blankets and bedwarmers

(f) oil blowlamps

(g) candles

Because of the extreme weather conditions it is not surprising that there was a sharp increase in the number of fires due to space heating. About 52 per cent of the 1963 fires were due to this single cause and were almost entirely open grate fires and oil space heaters (see Table 3).

Tables 4 and 5 give more detail about the fires due to these two groups. About 40 per cent of the open grate fires were due to carelessness of which 24 per cent involved the ignition of clothing or bedding. Other main causes of open grate fires were:-

(i) defective structures, generally resulting in ignition of timber under the hearths and

(ii) sparks and brands.

Only about 24 per cent of the reports on fires due to oil heaters specified the type of heater. The majority of these were radiant heaters.

The increase in the number of fires due to candles is probably related to electricity cuts in the early part of the year, while the increase in the number of fires due to blowlamps probably resulted from the thawing of frozen pipes etc.

Of the estimated 108 fires due to miscellaneous electrical apparatus, about 72 (67 per cent) originated from electric blankets and bedwarmers; the remainder being associated with 6 other sources of ignition.

Fires due to wire and cable and to electric blankets and bedwarmers have been analysed in detail in Table 6. About 71 per cent of these fires were due to sparks or short circuits and most of the remainder to overloading and overheating. There were 3 instances in the wire and cable fires in the sample where the sparks or short circuits had been caused by water. These fires were probably a result of burst water pipes. 5 out of the 12 blanket and bedwarmer fires in the sample were caused by overloading and/or overheating.

The miscellaneous oil appliance group consist of oil cooking appliances, oil lamps and oil-fired central heating boilers. Fires due to cooking appliances in general seem to have increased to a value above that of the previous years. This may be a sampling fluctuation or it may be due to the fact that people were using cooking appliances for purposes other than for cooking e.g. for space heating.

The 'jump' in the number of fires due to unknown sources of ignition is consistent with the overall increase in the number of fires in the period considered.

Most of the causes mentioned above which appear to be responsible for the sudden increase in fires in the early part of 1963 can thus be reasonably attributed to the extreme weather conditions. This and possible relationships between fire incidence and certain climatic factors is examined for the London region in the latter part of this report.

Occupancy is shown in relation to cause in Table 7 which illustrates certain differences between houses and flats. There appears to be more fires than expected in flats in relation to houses caused by ashes and soot, oil heaters and unknown causes and less than expected caused by chimneys, stove pipes and flues.

Table 8 shows the materials first ignited in the fires. In about 16 per cent of the fires kerosine was ignited first and in about 11 per cent of the fires it was bedding. On 14 occasions clothing being worn was ignited.

Table 9 shows that 86 per cent of the fires were contained in the room or compartment of origin. The remainder were fires of some size and 2 involved adjoining buildings.

Table 10 shows that about 50 per cent of the fires involving fatalities and about 70 per cent involving non-fatal casualties were due to space heating. In particular, most of the incidents involving fatalities were due to fires in grates and those causing non-fatal injuries to fires in grates and oil stoves.

FIRE INCIDENCE AND CERTAIN CAUSES OF FIRE IN RELATION TO CERTAIN CLIMATIC EFFECTS

Figures 2-6 show the weekly numbers of fires for the three regions London, Manchester and Birmingham plotted against j where j = (1) maximum temperature, (2) minimum temperature, (3) rainfall, (4) sunshine and (5) vapour pressure.

Noticeable curvilinear relationships are seen to exist between fire incidence and minimum temperature and between fire incidence and vapour pressure (figures 3 and 6) but there is no obvious association with sunshine or rainfall (figures 4 and 5). The relationship between fire incidence and maximum temperature is not so well defined (figure 2) as that between fire incidence and minimum temperature which suggests that the causes associated with the fires are more closely related to extreme climatic conditions i.e. to minimum rather than maximum temperatures.

Figures 2-6 show the same general patterns for each of the three towns London, Manchester and Birmingham but the apparent relationships between fire incidence and the climatic effects are more clearly defined in the case of London. This is probably because, as the London weekly fire frequencies are higher than those for Manchester and Birmingham (i.e. more fires are taken into account) the amount of chance variation is relatively lower than for the other two towns.

Significance Tests

To test the statistical significance of apparent relationships between fire incidence and the 5 climatic factors the simple model

$$y = g(f) = A + B_j x_j + z \qquad \text{...........} \quad (a)$$

was set up in the first instance where z is assumed to be a normal independent variable with constant variance σ^2; y is some function, g, of fire incidence, f, corresponding to a given value x_j of weather variable j, $(j = 1-5)$; A is a constant and B_j is the regression coefficient of y on x_j.

Thus, for z to be a normal independent variable with constant variance σ^2 it is necessary for $g(f)$ also to be independent and normally distributed with variance σ^2. Unfortunately, however, even taking the fire incidence figures, f, on a weekly basis the frequencies are still very small. This being so and due also to the fact that by taking weekly figures, the total numbers of observations for each town immediately decrease to 13, the errors for a given value of x_j are subject to a wide range of variation and tend not to be normally distributed. By transforming the data to a function $g(f)$ where $g(f) = \log (1 + f)$ they become approximately normal in the case of London where fire incidence is in the range of 50-150 fires per week but for Manchester and Birmingham where the range is between 10 and 50 the approximation is obviously not so good. For this reason most of the analysis has been confined to the London region alone using model (a) above in preference to the usual analysis of covariance technique in which effects of towns and weeks are removed. In the first instance, therefore, the data were assumed to be homogeneous with respect to weeks over the period considered. This assumption is examined in more detail in a later part of this report. Also, as any fire is obviously independent of any other fire the assumption of independence is valid.

Results

Using model (a), minimum temperature proves to be significant at the 0.1 per cent level of significance, vapour pressure at the 1 per cent level, maximum temperature and rainfall at the 2.5 per cent level and sunshine not significant at all over the period considered. Mrs. J. M. Hogg (ref. 1), considering all fires in buildings over a 12 year period, found that, overall, of the factors she considered, in order of importance, sunshine, vapour pressure and rainfall were highly significant. Throughout the period considered in this paper, the range of variation of sunshine was very small indeed, mostly being between 0 and 2 hours per day. It was therefore to be expected that sunshine would not bear much relation to fire incidence. Vapour pressure and rainfall (or precipitation) on the other hand do show up as being significant at the 1 per cent and 2.5 per cent levels respectively. The minimum temperature is the most significant factor, being significant at the 0.1 per cent level.

In the period considered minimum temperature and vapour pressure are highly related, significance for the data as a whole being at the 0.1 per cent level but, since minimum temperature is more significant than vapour pressure, further analysis was based on that climatic factor alone.

The correlation coefficients are - 0.81 between fire incidence and minimum temperature for London, - 0.84 for Birmingham and -0.85 for Manchester. The latter two towns, however, are subject to the restrictions in the normal assumption which have already been mentioned. Other correlation coefficients for London are - 0.75, - 0.64, - 0.63, + 0.14 for vapour pressure, maximum temperature, rainfall and sunshine respectively.

The assumption of homogeneity with respect to weeks

Figure 7 shows both the weekly fire incidence and the weekly average minimum temperature plotted against time. The monthly trend lines are also shown and it is noticeable immediately that there are corresponding but oppositely directed deviations about the trend lines for fire incidence and minimum temperature. The high correlation between fire incidence and minimum temperature is therefore a real and not a pseudo-effect.

The relationship between fire incidence and minimum temperature for the three towns London, Manchester and Birmingham

Figure 8 is a graph which combines the data on fire incidence and minimum temperature for London, Manchester and Birmingham.

Fires occurring in Manchester and Birmingham have been weighted according to the proportion of fires which occurred in dwellings in these towns during the previous 6 years in comparison with those which occurred in London. No account has, however, been taken of any differences between towns. The figure shows that there is a definite curvilinear relationship between fire incidence and minimum temperature and that most of the variability about the general trend line shown, is due to differences between the towns themselves, the observations for each town being depicted differently. Below freezing point (i.e. 32°F) there appears to be a definite linear relationship which shows that, in London, about 10 fires per week are caused per degree decrease in weekly average minimum temperature.

Causes in relation to minimum temperature

Since space heating was the largest single cause of fire over the period considered a similar analysis of space heating fires in relation to minimum temperatures in London was carried out. This revealed that there was significance at the 0.1 per cent level with a correlation coefficient of -0.90.

An equivalent analysis dealing with oil heaters in relation to minimum temperature showed that there was significance at the 2.5 per cent level, with correlation coefficient - 0.64.

Figure 9 illustrates the fact that fires due to space heating, to blowlamps and to wire and cable are highly related to climatic conditions. By removing these fires from the total the trend in fire incidence becomes more or less constant. The small amount of variation left can probably be accounted for by the other prominent causes of fires in 1963 in comparison to those of the previous 5 years.

CONCLUSIONS

The causes mostly responsible for the remarkable increase in fires in the early part of 1963 appear to be oil stoves, fires in grates, electric wires and cables, unknown sourced of ignition, electric blankets and bed-warmers, oil blowlamps and candles. There is evidence that most of these causes are direct results of the extreme climatic conditions experienced at that time - particularly minimum temperature conditions.

The relationship between fire incidence and minimum temperature changes at about 32°F. Above this it is curvilinear and the effect of temperature is not very marked. Below 32°F it becomes approximately linear and it appears that each degree (°F) decrease in weekly average minimum temperature is associated with an increase of about 10 fires per week in London alone.

REFERENCE

Hogg, Jane M. The relationship between fire incidence and climatological variation 1951 - 1961. Fire Research Note No. 522, Joint Fire Research Organization, 1963.

APPENDIX I

Selection of Sample and Sampling Fractions

The tables in this note are based on a stratified random sample of fire reports received from London, Manchester and Birmingham Fire Brigades. The reports for each brigade were arranged in chronological order within the three months January, February and March.

A random starting point was taken and sampling then arranged according to a chosen sampling scheme. Estimates of the population distribution were made by multiplying the sample distribution by $1/f$ where f is the sampling fraction. Sampling fractions for the years 1958 - 1963 are shown below:-

Year	Sampling Fraction (f)
1958	$1/4$
1959	$1/4$
1960	$1/4$
1961	$1/2$
1962	$1/2$
1963	$1/6$

Confidence limits

Given a finite population of fires where

M = number of fires with a given attribute in the population

$M^1 = \frac{m}{f}$ = estimate of M when m = number of fires with a given attribute in the sample

N = total number of fires in the population

$N^1 = \frac{n}{f}$ = estimate of N when n = total number of fires in the sample

$P = \frac{M}{N}$ = proportion of fires with a given attribute in the population

$p = \frac{m}{n}$ = proportion of fires with a given attribute in the sample.

As the number of fires, n, in the sample is reasonably large, the properties of the normal distribution can be used to estimate confidence limits and the 95 per cent limits for M and P are given by

a) $M^1 \pm 1.96 \sqrt{\dfrac{(1-f)\, M^1\, (N^1-M^1)}{f\,(N^1-1/f)}}$

b) $P \pm 1.96 \sqrt{\dfrac{(1-f)\, p\, (1-p)}{f\,(N^1-1/f)}}$

<u>Example</u> The estimated number of fires in occupied dwellings during the first 3 months of 1963 for the brigades, London, Manchester and Birmingham is 1992 and the estimate of the number of fires caused by oil stoves is 498. The 95 per cent confidence limits for the true number of fires caused by oil heaters are therefore calculated from the formula:-

$$498 \pm 1.96 \sqrt{\frac{5 \times 498 \times 1494}{1986}}$$

$$= 498 \pm 85$$

It may be noted that the estimated number N^1 from the 1 in 6 sample for 1963 of the total number of fires was 1992 while the actual number of fires was in fact 1975.

Regarding the number of fires caused by blowlamps, the number in London alone was actually 51 while in fact the estimated figure for the 3 towns was 42. It may be that blowlamps were more of a hazard in London but this could not be established in this present report.

APPENDIX II

<u>Tables 1 - 10</u>

Tables 1 and 2 have been obtained by multiplying frequencies obtained in the sample by $^1/f$ (see Appendix I)

The frequencies in Tables 3 - 10 have not been multiplied by $^1/f$: they are, in fact, the frequencies actually obtained in the sample.

TABLE 2

CAUSE OF FIRES ACCORDING TO YEAR OF OCCURRENCE

Cause	1958	1959	1960	1961	1962	1963
Ashes and Soot	84	72	52	84	88	78
Matches	44	60	40	82	34	84
Smoking Materials	132	88	136	154	158	120
Taper, lighted paper, sticks	16	16	16	24	22	30
Electrical appliances and installations						
Wire and cable	64	64	56	42	78	114
Wireless and T.V.	28	24	28	26	20	24
Cooking appliances	*	*	48	36	46	66
Space heating	**	**	36	60	60	54
Other	8	36	28	68	64	108
Town gas appliances and installations						
Cooking appliances	*	*	48	70	64	84
Space heating	**	**	12	14	8	18
Other	-	-	12	18	6	18
Solid fuel appliances and installations						
Chimney, stove pipe, flue	92	152	108	100	134	138
Fire in grate	**	**	212	136	210	300
Other	8	4	12	-	4	12
Oil appliances and installations						
Blowlamp	16	12	8	-	6	42
Stove	204	292	296	290	322	498
Other	8	12	-	8	4	24
Candle	24	20	12	6	10	36
Miscellaneous	8	20	12	16	36	30
Unknown	36	56	44	74	74	114
Total	1164	1288	1216	1308	1448	1992

In 1958 and 1959 cooking appliances and space heating installations are not separated by fuel.

*	Total 108 cooking appliances	1958
**	284 space heating (exc. oil)	1958
*	96 cooking appliances	1959
**	264 space heating (exc. oil)	1959

TABLE 1

NUMBER OF INCIDENTS INVOLVING CASUALTIES

Year	1958	1959	1960	1961	1962	1963
Fatal	20	12	20	16	28	84
Non-fatal	100	144	84	124	144	198
Total incidents	116	152	104	136	166	270

TABLE 3

SPACE HEATING FIRES 1963

Fuel	Incidents
Electric	9
Gas	3
Solid fuel	75
Oil	83
Unspecified fuel	1

TABLE 4

FIRES IN GRATES 1963

Material first ignited / Fires due to	Bedding, clothing	Furniture, furnishings	Timber under hearth	Other materials	TOTAL
Fire in grate - defective structure		2	12		14
- fault connected with material first ignited	1				1
- sparks and brands	3	9		2	14
- other (inc. carelessness)	12	3	1	4	20
- unknown	1				1
TOTAL	17	14	13	6	50

TABLE 5

FIRES IN OIL SPACE HEATERS 1963

Type \ Cause	Defective structure	Fault connected with material first ignited	Incorrectly adjusted or overfilled	Overturned, knocked over	Spilt, leaked	Other specified misuse	Other unspecified misuse	TOTAL
Radiant	1		2	1	2	8		14
Convection	1		1	1				3
Salamander, waste oil heater						1	1	2
Incubator, brooder, animal heater lamp							1	1
Unspecified	4	6	6	5	4	37	1	63
TOTAL	6	6	9	7	6	46	3	83

TABLE 6

FIRES ATTRIBUTED TO WIRE AND CABLE AND BLANKETS AND BEDWARMERS 1963

Fires due to \ Occurrence associated with	Sparks or short circuit due to water	Sparks or short circuit due to defective insulation	Sparks or short circuit due to unspecified cause	Overloading overheating	Unspecified electrical fault	TOTAL
Wire and cable - attached to fixed installations	2		2		1	5
- switchgear, meter, fuse etc.	1	1	3	2		7
- leads to 'portable' equipment		1	3			4
- unspecified		1	1	1		3
Blankets and bedwarmers		4	3	5		12
TOTAL	3	7	12	8	1	31

TABLE 7

OCCUPANCY IN RELATION TO CAUSE 1963

Cause \ Occupancy	Flats	Houses	Other	Total
Ashes and Soot	12	1		13
Smoking Materials	9	11		20
Wire and Cable	5	14		19
Electric blankets and bedwarmers	3	9		12
Gas cooking appliances	4	10		14
Solid fuel chimney, stove pipe, flue	2	21		23
Fire in grate	12	38		50
Oil heaters	40	43		83
Other	31	46	2	79
Unknown	10	8	1	19
Total	128	201	3	332

TABLE 8

MATERIAL FIRST IGNITED 1963

Material	Incidents
Kerosine	53
Clothing on person	14
Clothing not on person	11
Bedding	37
Upholstery	20
Curtains	8
Floor covering	15
Timber and hearth	13
Food - fat	15
Paper cardboard	9
Confined to electrical insulation	8
Insulation - material to which fire first spread unknown	8
Other	98
Unknown	23
Total	332

TABLE 9

EXTENT OF DAMAGE 1963

Confined to appliance	11
Common service spaces	2
Room of origin	272
Floor of origin	19
Building of orgin	26
Extended to adjoining buildings	2
Total	332

TABLE 10

INCIDENTS INVOLVING CASUALTIES 1963

Cause	Fatalities	Non-Fatalities	Total Incidents
Space heating			
- oil stove	1	12	13
- fire in grate	5	9	14
- other space heating	1	2	3
Smoking Materials	1	2	3
Explosion involving back boiler		1	1
Candle		1	1
Other	1	3	4
Unknown	5	3	6
Total	14	33	45

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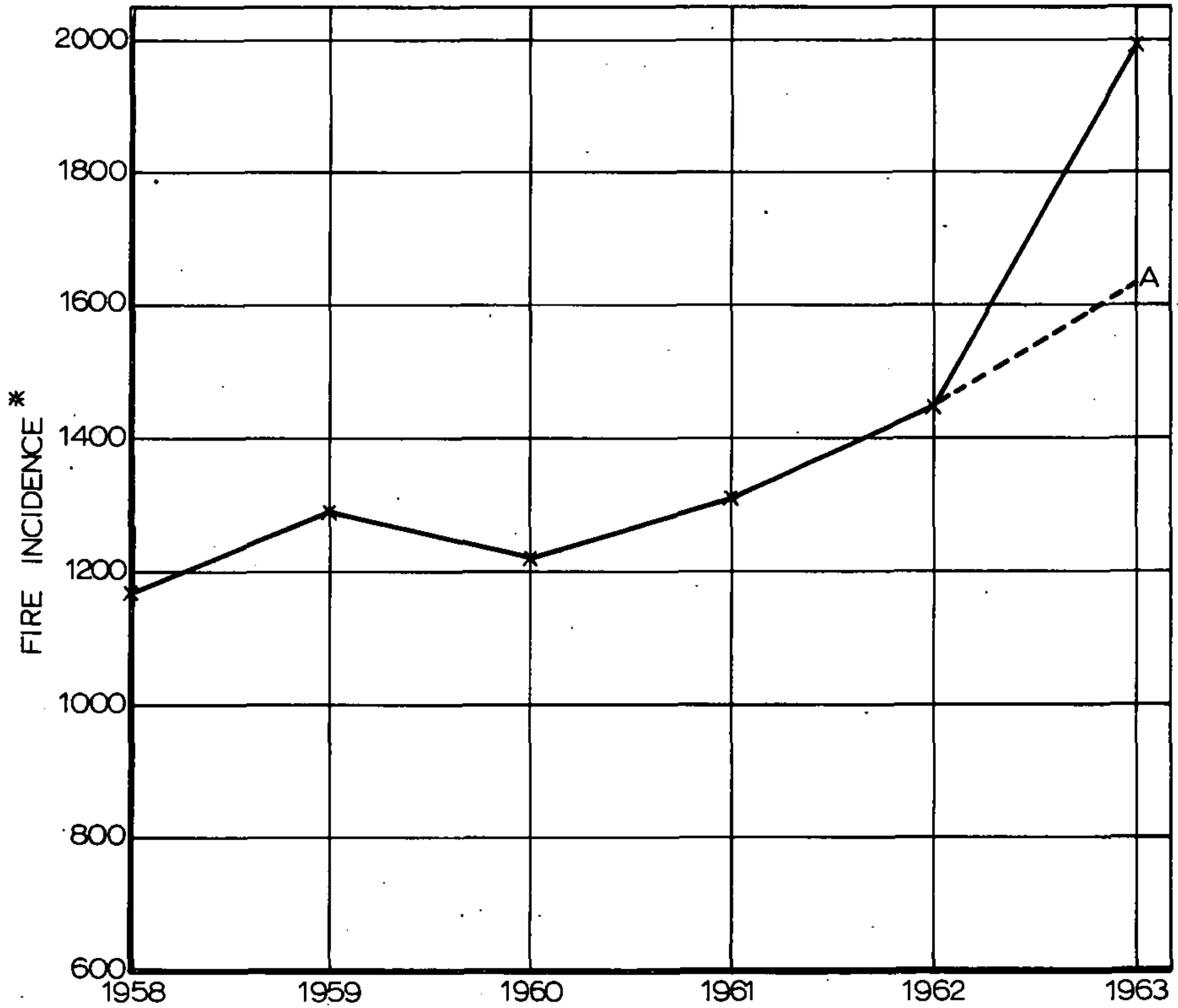

* — Estimated – see Appendix 1
A — Expected fire incidence for 1963 (obtained by extrapolating trend)

FIG. 1. DWELLING FIRES IN LONDON, MANCHESTER AND BIRMINGHAM DURING JANUARY, FEBRUARY AND MARCH

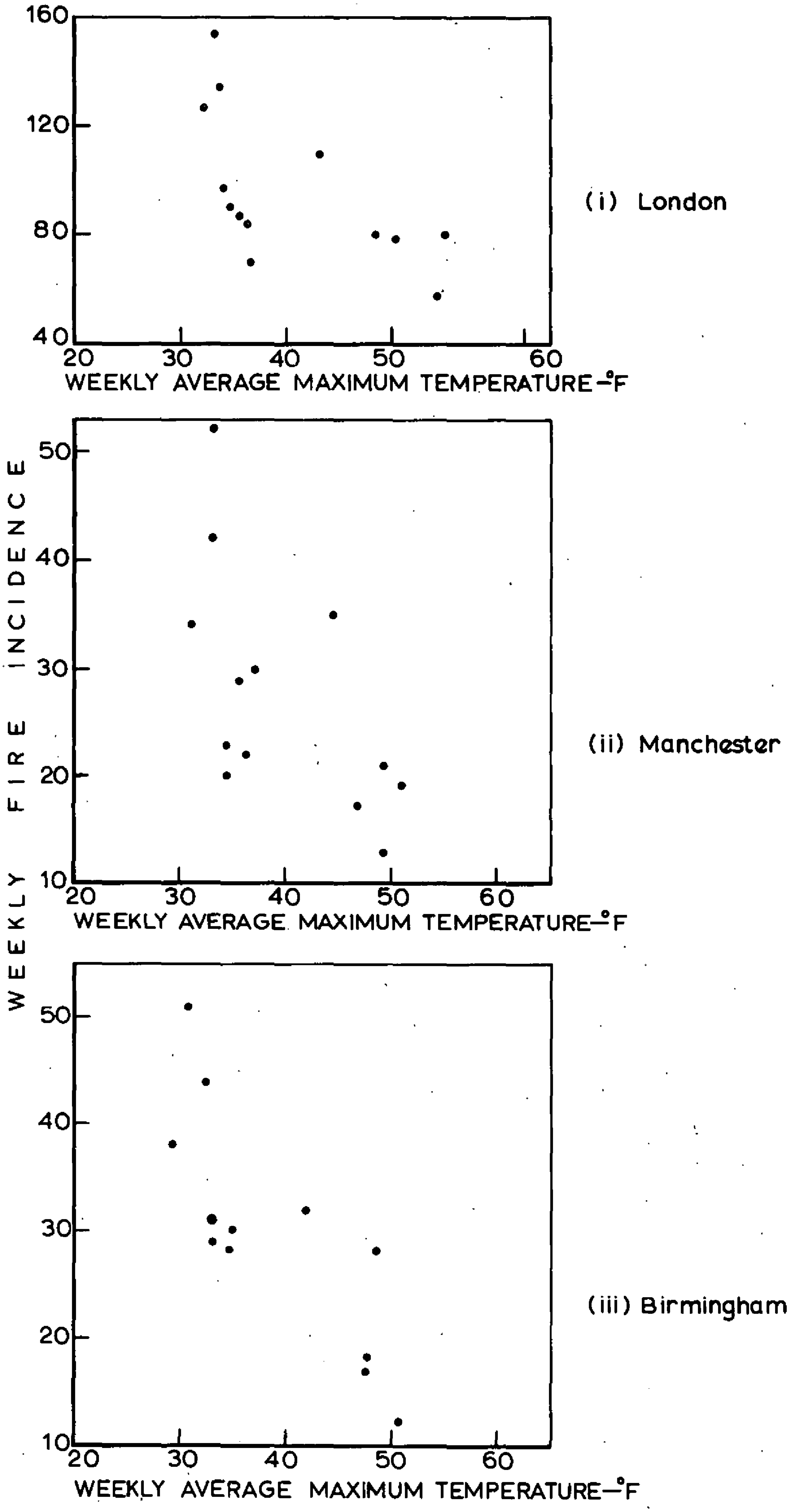

FIG. 2. RELATIONSHIP BETWEEN FIRE INCIDENCE AND MAXIMUMUM TEMPERATURE

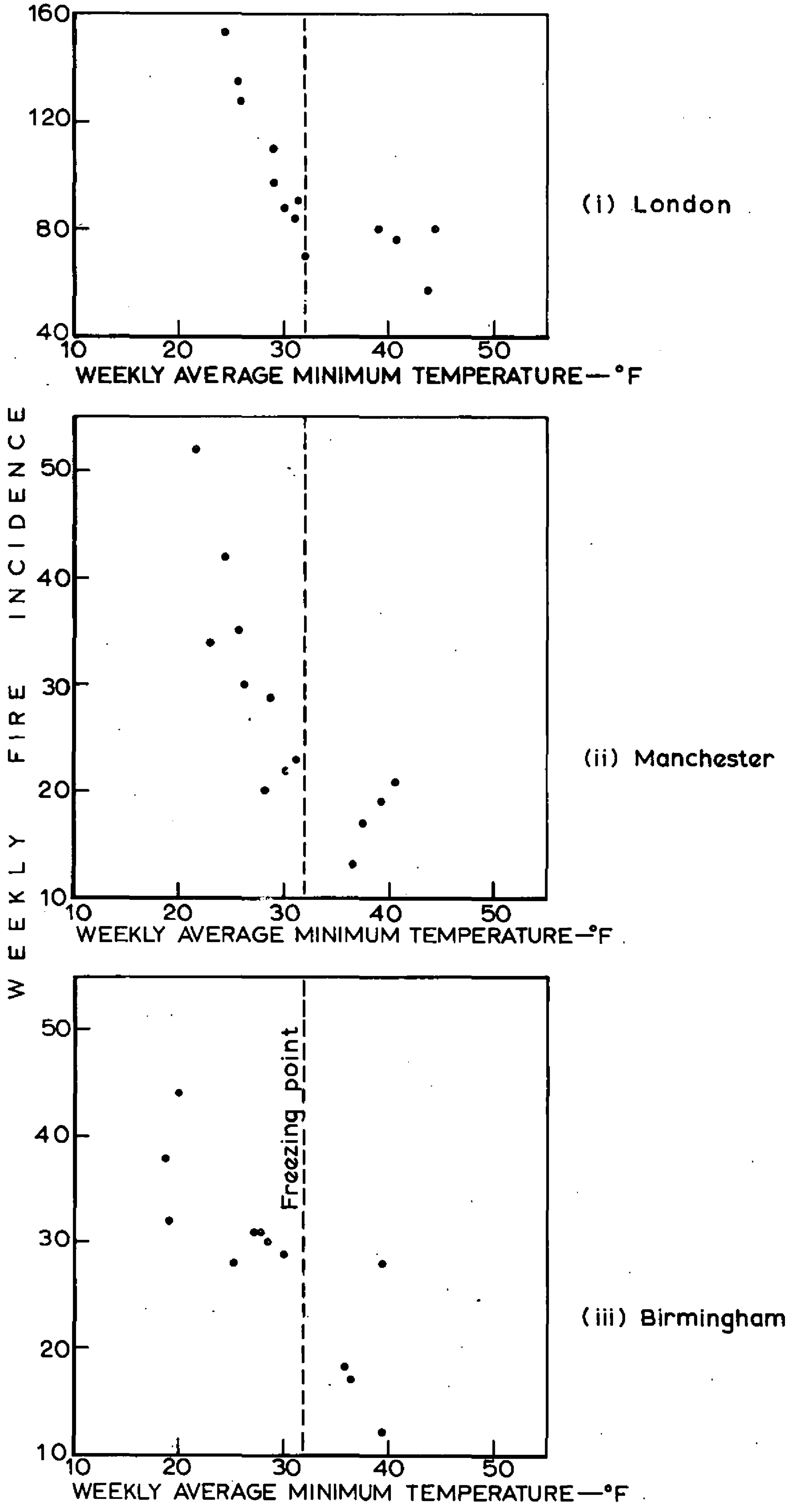

FIG. 3. RELATIONSHIP BETWEEN FIRE INCIDENCE AND MINIMUM TEMPERATURE

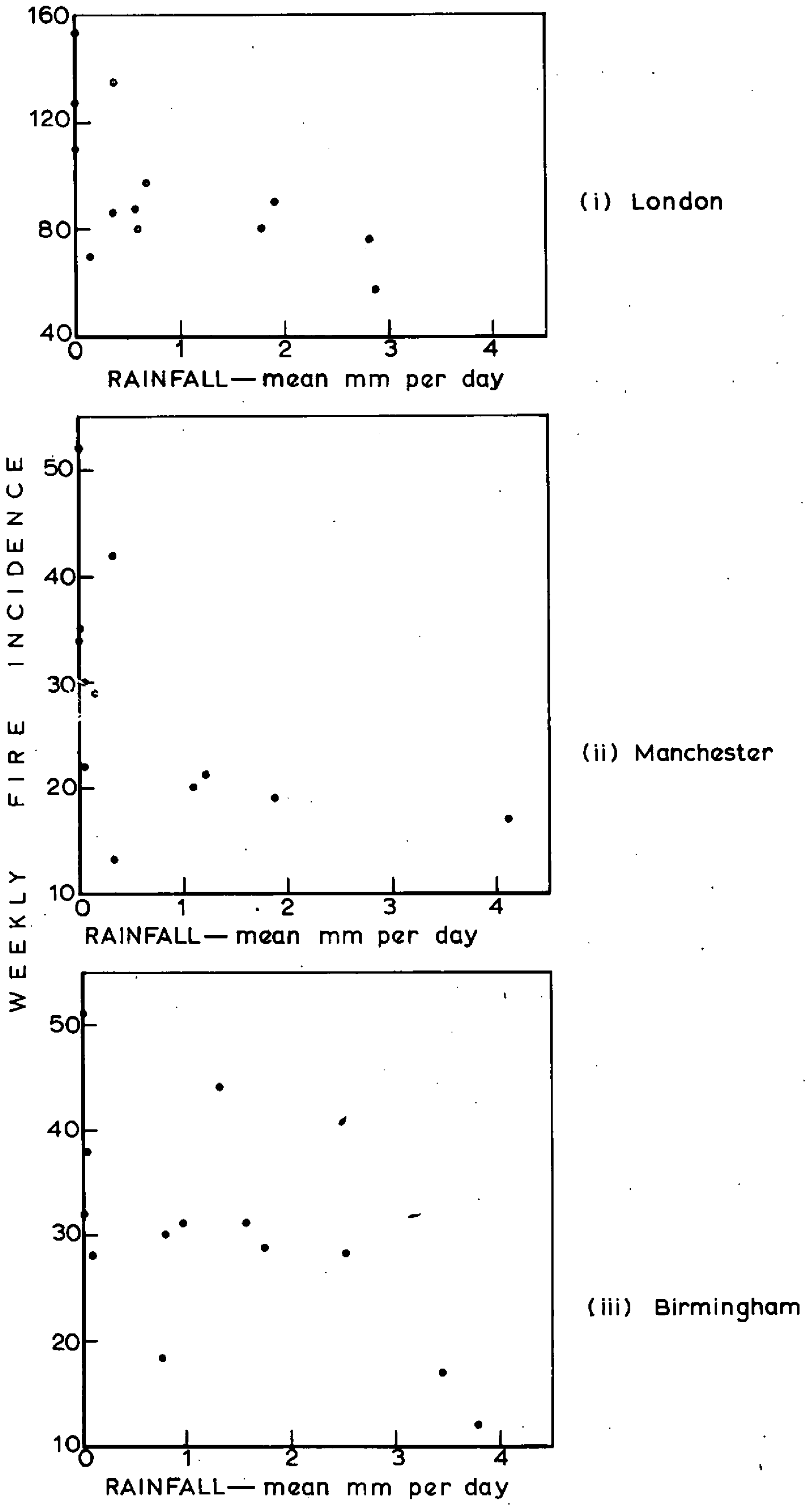

FIG. 4. RELATIONSHIP BETWEEN FIRE INCIDENCE AND RAINFALL

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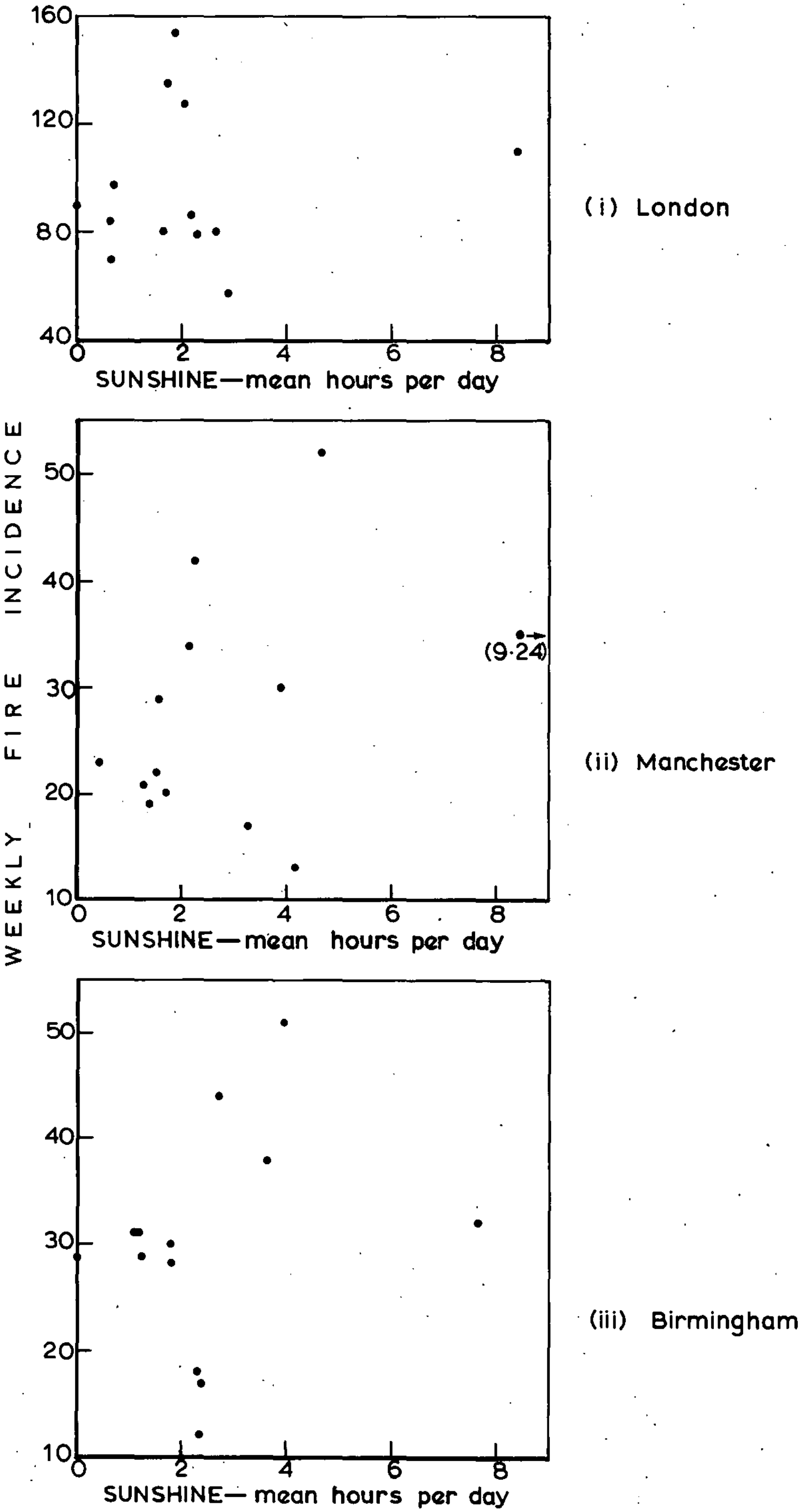

FIG. 5. RELATIONSHIP BETWEEN FIRE INCIDENCE AND SUNSHINE

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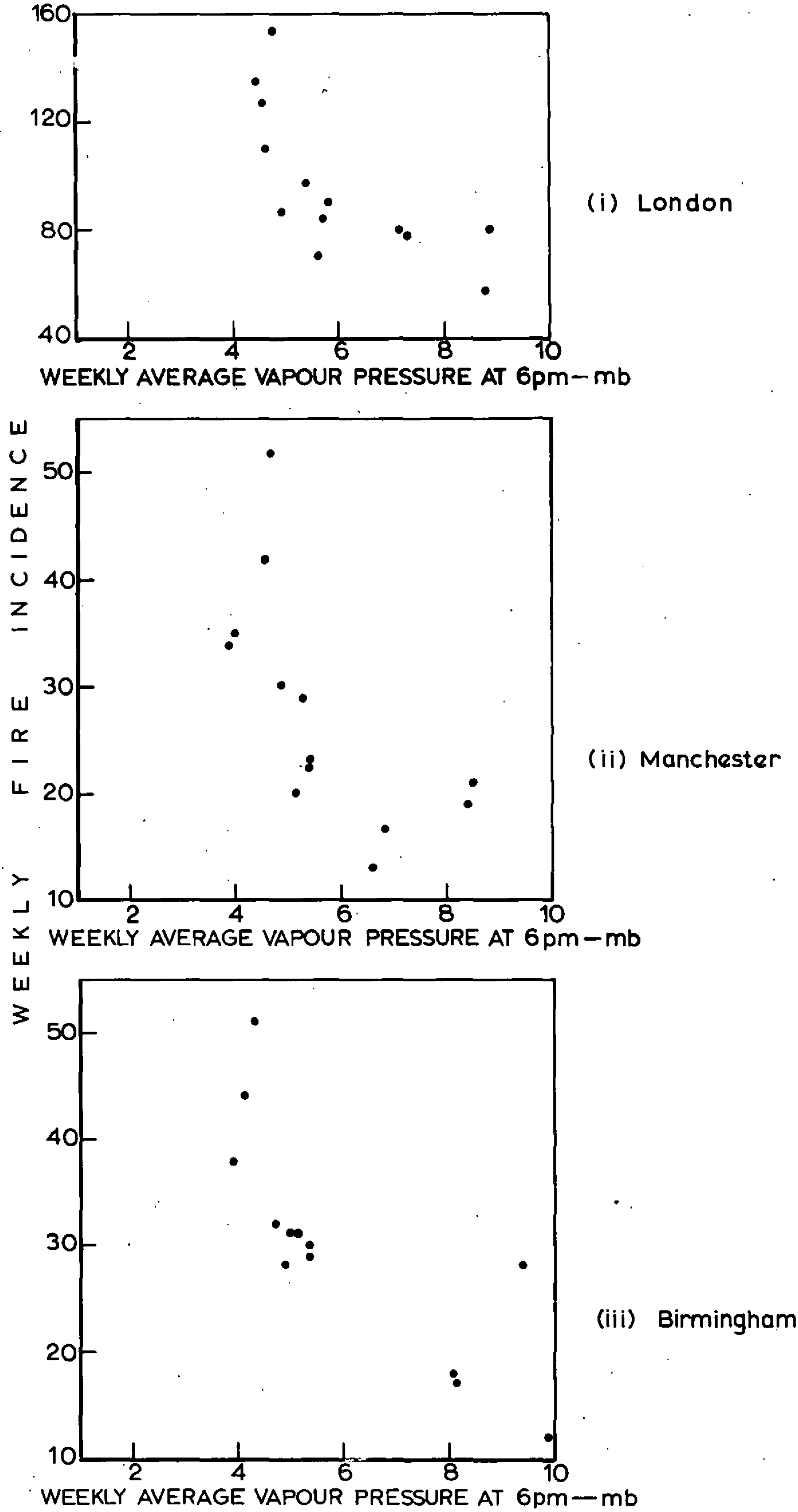

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FIG. 6. RELATIONSHIP BETWEEN FIRE INCIDENCE AND VAPOUR PRESSURE

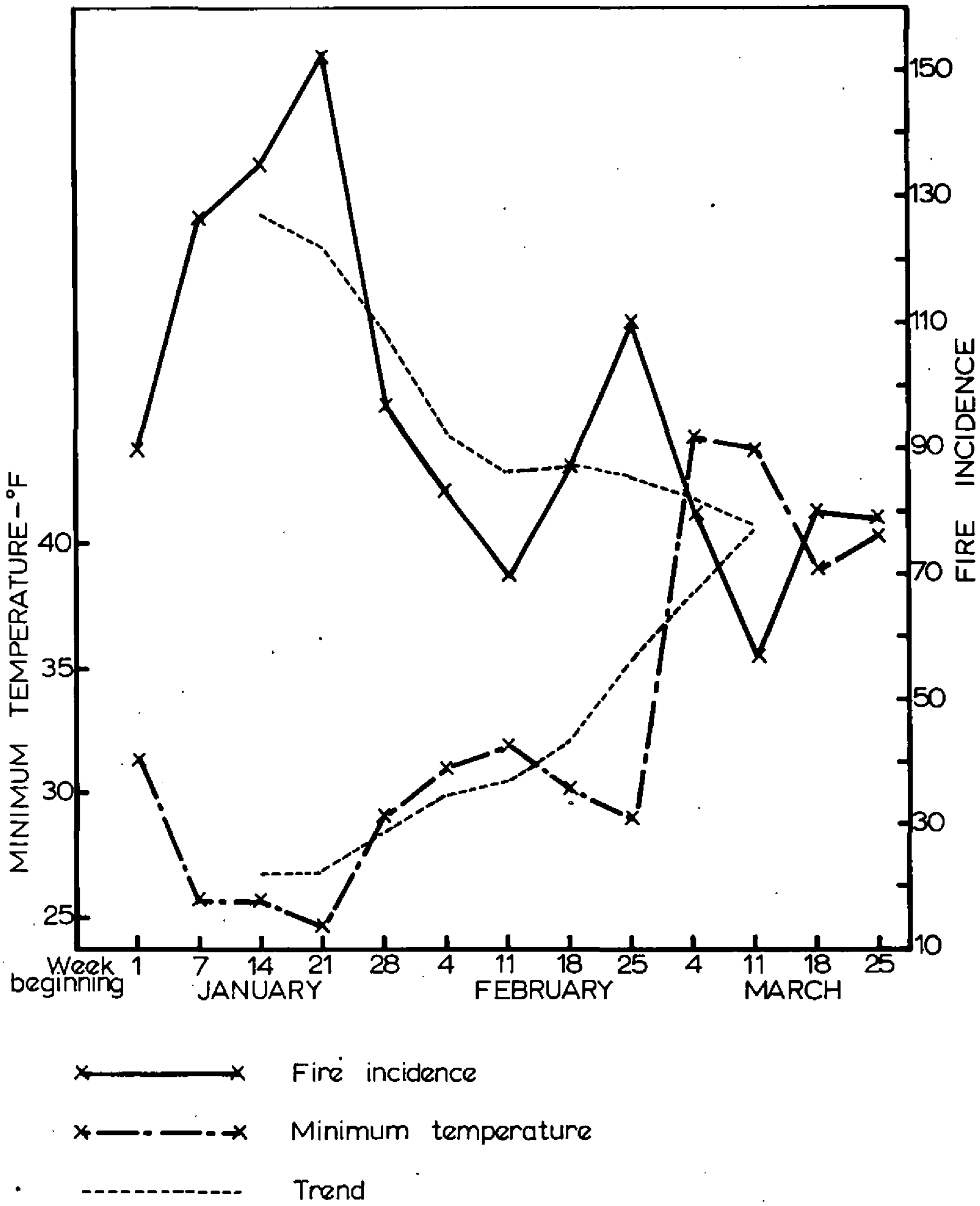

FIG. 7. FIRE INCIDENCE IN RELATION TO MINIMUM TEMPERATURE IN LONDON

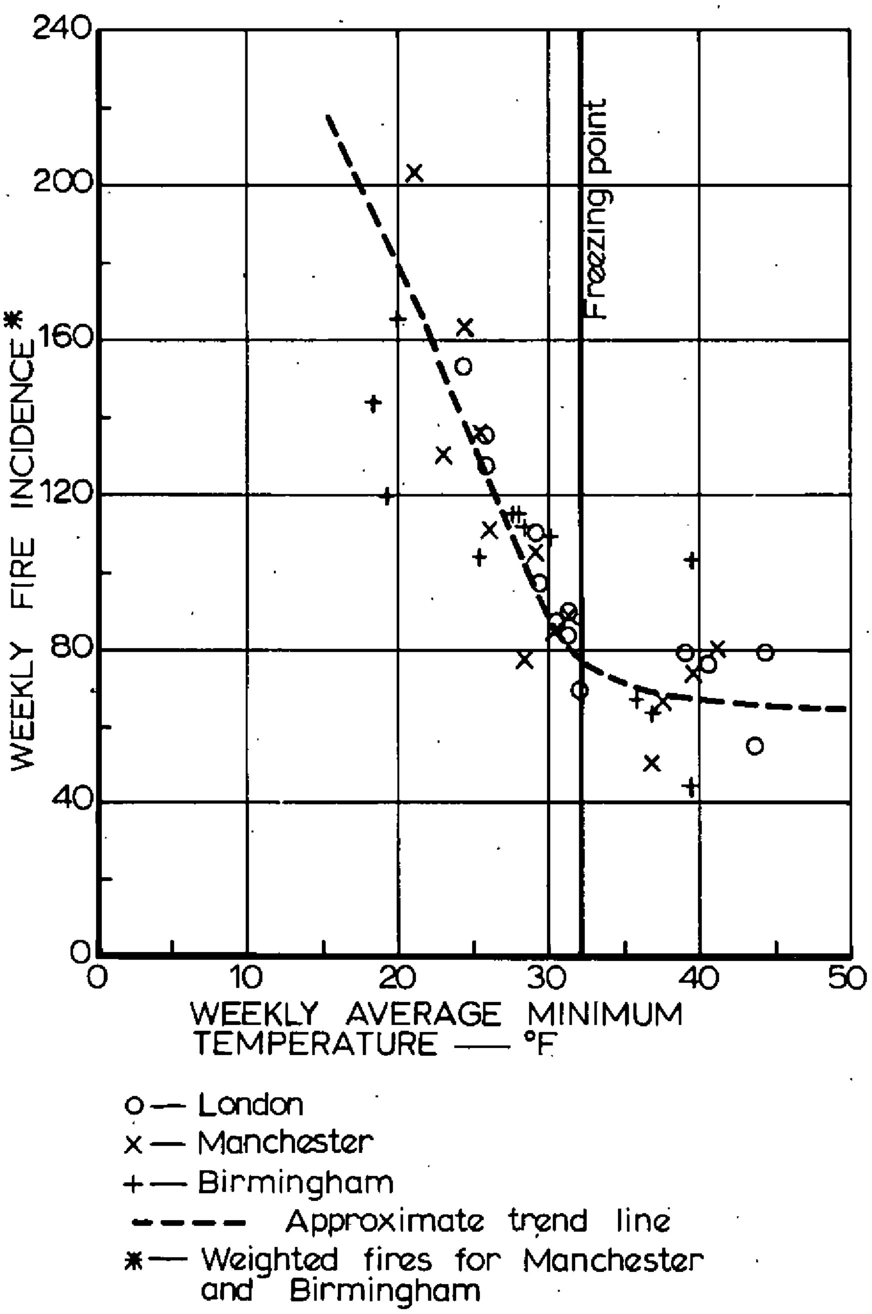

FIG. 8. RELATIONSHIP BETWEEN FIRE INCIDENCE AND MINIMUM TEMPERATURE —— LONDON MANCHESTER AND BIRMINGHAM

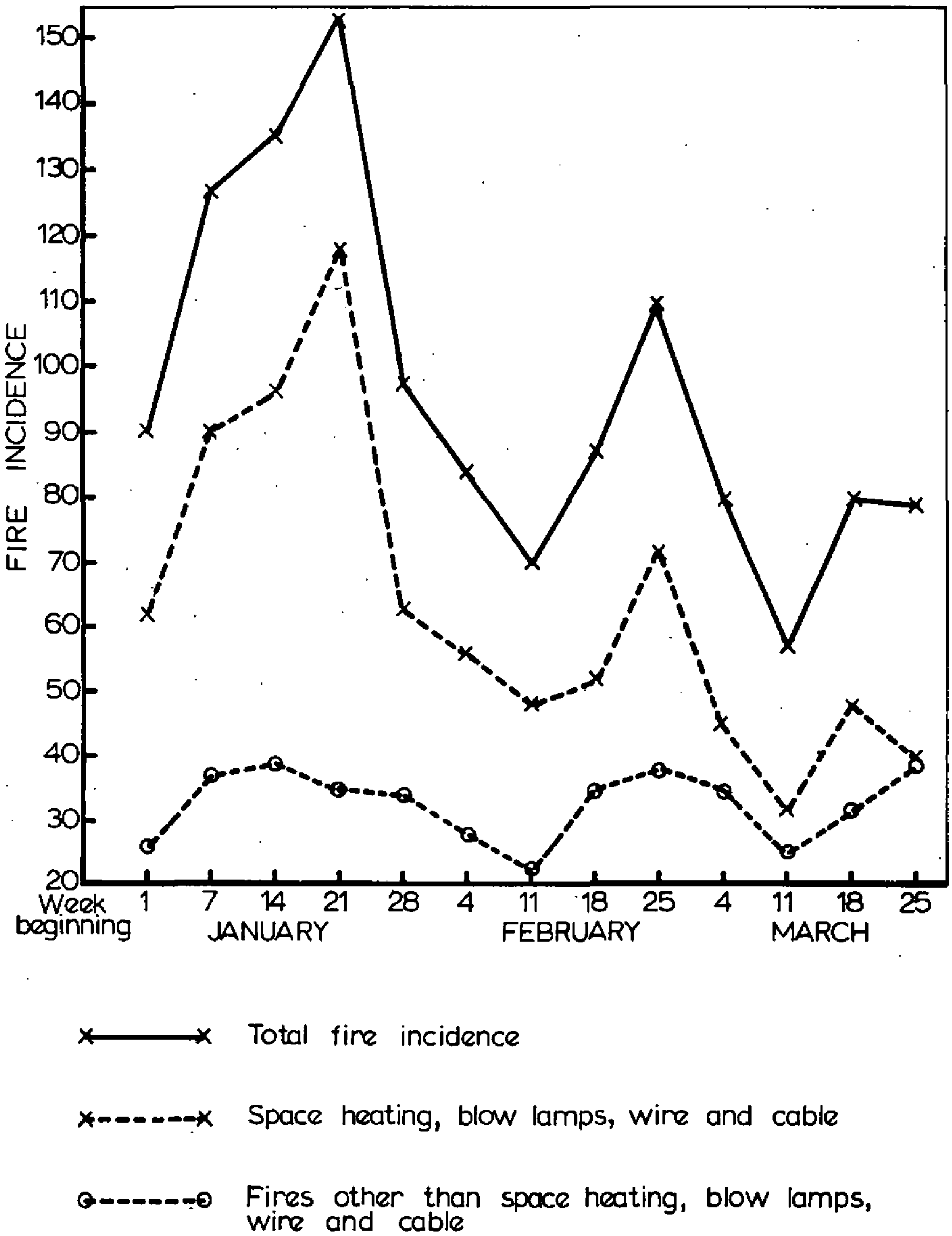

FIG. 9. FIRES IN LONDON BROKEN DOWN INTO SPACE HEATING, BLOW LAMPS, WIRE AND CABLE AND OTHER

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