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FIRE & FIRE PROTECTION— A SURVEY OF MANUFACTURING INDUSTRY

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FIRE AND FIRE PROTECTION: A SURVEY OF MANUFACTURING INDUSTRY

by

Mary B J Clark

SUMMARY

As part of a major study of fire protection in buildings, a survey of fire and fire protection in manufacturing industry was mounted. The results of the analysis of the survey data are presented in this report. This report contains the detailed results on the probability of fire in buildings of different sizes in different sectors of manufacturing industry, the reporting of fires to the brigades and the extent of fire protection (ie sprinklers and detectors) in manufacturing industry.

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1. INTRODUCTION

The Scientific Advisory Branch of the Home Office (SAB) has undertaken a major study of fire protection in buildings. As part of this study additional information, which was not otherwise available, has had to be obtained by means of a survey of firms in manufacturing industry. The results required for the study of fire protection in buildings have been incorporated into the report of the main study but the results from the survey were thought interesting and useful enough to justify a report in their own right.

This report presents results derived from the survey data on the probability of fire in buildings of different sizes (Section 3), the provision of fire protection (Section 5) and the numbers of fires reported and unreported to brigades (Section 4).

2. THE ORGANIZATION OF THE SURVEY

2.1 The sample structure

The survey covered a sample of manufacturing units.* The units of manufacturing industry approached for this survey were part of a structured sample drawn for SAB by the Business Statistics Office from their register of businesses in the production sector; this register is used by the Business Statistics Office for various censuses and includes all manufacturing units with 20 or more employees.

The sample was stratified according to the type of industry (ie by Standard Industrial Classification (SIC) Order) and size of establishment (as measured by the number of employees), thus ensuring a well-balanced and efficient sample. Another consideration taken into account when choosing the sampling fractions was that the number of small firms included in the survey should be low to reduce the burden of clerical work on such firms. The general principle of the survey sample design was that there should be an overall sampling fraction of 1/10; the designed sampling fraction was 1/20 in establishments with 20-99 employees, 1/10 in those with 100-499 employees and 1/2 in those with 500 or more employees. These sampling fractions were increased for small industries to provide a minimum sample size in each group. One industry, Mechanical Engineering, was considered in more detail and a 1/5 overall sample size was taken.

2.2 The sending out of questionnaires

The survey questionnaires with a covering letter were sent to 4,700 units of manufacturing industry. Appendix A contains a copy of the questionnaire and the covering letter; a Freepost envelope was also attached. The original questionnaires were sent out at the beginning of November 1977 and reminder letters (example also in Appendix A) with a further copy of the original questionnaire were despatched at the beginning of December 1977 to non-respondents among the larger firms in the SIC groups of the most interest.

2.3 Response to the survey

A total response rate of about 68% was achieved after the reminder campaign. Included among the replies were spoilt papers of various types; for example

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* A manufacturing unit comprises all the buildings belonging to the same company at a single site. A single building may therefore accommodate more than one manufacturing unit, and a large company may have factories at different sites and therefore, comprise a number of manufacturing units.

questionnaires without the floor area of buildings filled in or with neither the name of the firm or the number of employees entered. However the majority of returned forms appeared to be filled in satisfactorily.

Some difficulties arose from the questionnaire design. The most important of these was the tendency of some firms to put down details about only 5 of their buildings as the form provided only 5 columns for reply. In the analysis, this problem was overcome by only using figures from forms recording details of fewer than or more than 5 buildings. Information from firms declaring 5 buildings was used only for those firms which had had the reminder letter which clarified this point. The omission of the returns from those firms which recorded exactly 5 buildings is unlikely to have caused any bias in the final results. Unless the "5 building" firms were different in character from other firms (which is unlikely) the omission of these returns is simply equivalent to using a smaller sample size and the size of each part of the sample is taken into account in the scaling up procedure (see section 2.4 below).

Other minor difficulties which were encountered include the definition of a "building", the lack of coverage of smaller firms, and the under-reporting of fires. These problems are discussed later in the report.

Table 1 below gives, in column 1, the actual numbers of usable returns received from manufacturing units in each SIC Order and, in column 2, the total numbers of manufacturing units in each SIC Order (excluding units with fewer than 11 employees) in the United Kingdom in 1974[1]. These 2 columns can be compared to give an idea of the sample size actually available for analysis.

2.4 Scaling up the survey results

In order to make use of results from the survey it was necessary to scale them up and thus make them representative of the whole of manufacturing industry. A breakdown of the total number of manufacturing units by SIC Order and size (as measured by the number of persons employed) was available from the Business Statistics Office (BSO). The survey results were tabulated in the same way, and scaled up using the known number of manufacturing units in each size and SIC Order group from the BSO table. By scaling up the survey results in this way allowance is made for the different response rates from firms of different sizes and in different industries. The available sampling frames do not include manufacturing units employing fewer than 20 persons so the survey did not include such units. Estimated numbers of small units are available from other sources but are not reliable and their use might introduce errors rather than eliminate them. However as long as it is recognised that the survey data relating to small manufacturing units is less reliable, this can be taken into account in specific areas of the analysis.

2.5 Definition of building usage

Separate results were required for production buildings, storage buildings and "other" buildings. The buildings were classified according to the major use of the building.

On the survey questionnaire each firm was asked to enter the total floorspace of each of its buildings and to record the percentage of the total space devoted to production, storage or other purposes (such as offices, canteens etc). From this information a judgment could be made about the major use of the building and the building classified as "production" (covering production, repair and maintenance), "storage" or "other". Thus, for example, there will be buildings classified as "production" but which also include some storage area and some area used for other purposes.

This definition of building usage is similar to the definition used on brigade fire reports and used to classify the fire statistics.

3. THE PROBABILITY OF FIRE

3.1 The definition of terms

The definition of a fire can vary according to context but in the following discussion the only fires considered are those to which the fire brigade is called.

In the present work, the phrase "probability of fire" is used to mean the expected number of fires which will occur in a building of given size per year. The expected number of fires is a figure averaged out over a large number of buildings and therefore does not generally have an integral value. As this definition of probability is applicable, the probability of fire can take a value larger than 1 (as a given building can have more than one fire in a year).

3.2 Data

The 1973 K433* fire statistics and the information about building floorspaces collected from the survey provided the data for obtaining the formula from which the probability of fire in any size building could be calculated. It was assumed that the number and sizes of the buildings in manufacturing industry did not change significantly between 1973, (the latest year for which the fire statistics were available at the time of the analysis) and 1977, the year of the SAB survey of fire and fire protection in manufacturing industry. More recent fire statistics have since been published and these have shown that the numbers of fires attended by the brigade in 1974, 1975 and 1976 were very similar to the 1973 figure.

The building floorspace information was grouped according to the size of building using a logarithmic scale (see Appendix B for distribution histograms) and classified by size of manufacturing unit, SIC Order and primary usage of the building. These frequencies were scaled up in the way described in section 2.4 using, for each industry and size of manufacturing group, individual scaling factors obtained by taking into account the sample size in each group compared with the corresponding entry in the 1974 BSO frequency tabulation of size of manufacturing units by SIC Order.

The 1973 fire statistics were analysed to determine the number of fires which occurred in buildings of each usage, each size and each SIC group. The probability of fire was then estimated by dividing the number of fires which occurred in each group by the total number of buildings in that same group.

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* A K433 is the fire brigade report form on each fire attended.

It must be recognised that the estimated probabilities for the smaller buildings are likely to be subject to error. This is because some firms recorded small buildings (such as sheds, gatehouses etc) on their survey forms while others did not due to their different interpretation of the questionnaire.(See Appendix A).

An additional problem with data referring to small buildings was that it may in fact only apply to part of a larger building, the whole of which may not belong to one firm. Also the survey did not include small firms which, in the main, have small buildings so coverage of these buildings was incomplete. Therefore, in the analysis, the probabilities for the smaller buildings were omitted because of their unreliability.

5.3 Non-linearity of the probability of fire

In order to derive a relationship of the form

Probability of fire = p(t)

where t is the building floorspace (m^2) of the building for which the probability is to be calculated, it was necessary to decide on the functional form of this relationship. The estimated probabilities show that the relationship is non-linear ie the probability of fire does not increase in proportion to the building size. This may be partially explained by noting that if a building is doubled in size, the sizes of its boiler room, electricity and gas supplies and canteen facilities, for example, do not increase proportionally; such common services as these are places where fires often occur,

Another possible factor contributing to the observed non-linearity of the probability of fire is the difference in the character and management of buildings in large firms compared with small firms. This may mean that, for example, large firms (with large buildings) may be better protected or are more likely to have works fire brigades so that fire is less likely to break out or if it does, can be sooner extinguished so that the fire brigade may not have to be called.

Additionally, the enormous diversity in the type of firm engaged on work within an industry covered by one SIC Order is likely to mask the true form of the probability function to some extent. For example, SIC Order XIII covering the Textiles industry includes cottage industry lace-making and huge carpet factories. However, by omitting small buildings from the analysis, this problem may in part be avoided.

3.4 The probability of fire in different buildings

To take account of the non-linearity of the probability of fire, a curve of the form

$$p(t) = At^c$$

(where p is the probability of fire, t is the building floorspace, and A and C are constants) was fitted to the data; the method used was a weighted log. log. regression with p, the probability of fire, as the dependent variable and t, the building floorspace as the independent variable. An example of such a regression and the points to which it was applied is given in Figure 1. This analysis was used to derive expressions for the probability of fire in manufacturing industry as a whole (Table 4) and by SIC Order (Table 2), production buildings in manufacturing industry as a whole (Table 4) as well as in the production buildings of 8 separate industries (Table 3). The curve parameters (A, the multiplying parameter and c, the power parameter) have been tabulated in Tables 2-4 together with typical points on the curves (namely for buildings with floorspaces of $500m^2$, $1200m^2$, and $1500m^2$) to provide some idea of the actual probabilities represented by these curves.

In Tables 2 and 3, it can be seen that the industries with a higher than average probability of fire are Metal Manufacture (only present in Table 2), Chemical and Allied Industries, Other Manufacturing Industries (this Order includes rubber and plastics manufacture which both carry a high fire risk), Timber, Furniture etc and Textiles. Another point apparent from the tables is that in almost every industry the probability of fire is greater or far greater in the production buildings on the site and considerably lower in storage buildings.

The magnitude of the power parameter, c, varies considerably between industries. A low power parameter for an industry's probability of fire function indicates a greater non-linearity in the probability of fire. Such low parameters occur in the manufacturing industries covered by the SIC Orders for Textiles, Food, Drink and Tobacco and Chemical and Allied Industries. For Chemical and Allied Industries. the probability of fire is consistently high and does not show a large increase for larger buildings. This may be because the processes involved are inherently prone to fire and are similarly dangerous throughout all sizes of undertaking but any multiplying effect to the number of fires occurring in larger buildings may be masked by more stringent precautions being taken. Similar comments may also apply to the Textiles industry which also has a probability of fire which does not vary much with the size of the building in which the processes are carried out.

If the power parameter for the probability of fire function is high (ie tends to 1 in value) then there is a tendency towards larger buildings having proportionally more fires than the smaller buildings. Table 2 shows Instrument Engineering as having a power parameter of 0.96; this may be caused by the small sample size for this industry.

3.5 Comparison of present results with earlier work

European researchers[2] (d'Addaio, Blandin, Ferrara, Benktander etc) working on data from Italy, Sweden and France have obtained an expression for the claims frequency (which is proportional to the probability of outbreak of fire) in the form

$$F(S) = AS^{\alpha}$$

where S = sum insured (which is proportional to the building size) and A and α are constants. The following values for α have been obtained

= 0.77594 (Swedish statistics)
= 0.51 (Italian statistics, 1963-67)
= 0.5 (Italian statistics, 1968-69)
$\sim$ 0.5 (French statistics, 1968-70).

These results are very close to those obtained from the data of the present survey.

4. FIRE INCIDENCE

4.1 Response to survey question on fires

This chapter deals with results obtained from the survey question about firms' fire records. Difficulties arise when asking about fires because one person's definition of what constitutes a fire may be very different from another's opinion on the same point. For example, if a large firm has a fairly sizeable fire which is quickly put out by staff using fire extinguishers and hence causes a negligible financial loss, that firm may not regard this as a fire of any importance. However, if a small firm calls the fire brigade to a small smouldering fire, say, a burnt-out electric motor, that firm might well consider this to have been a fire.

On the questionnaire, firms were asked to record details of 1975 and 1976 fires on their premises to which the fire brigade was called or in which sprinklers or automatic detectors operated or in which there was a significant amount of damage. It was also stated that minor fires and fires which did not affect buildings should be omitted.

The survey returns showed fewer fires than would be expected for the number of buildings declared. There are 2 possible reasons for the under-reporting. Either the firms which responded to the survey did not admit all their fires (due to natural reticence or a misunderstanding of what was required), or the firms which replied were those firms which had fewer fires. The second explanation, if true, would mean that the respondents were an unrepresentative sample of firms and this might bias the results.

The under-reporting was therefore investigated by comparing, for a sample of firms, the fires reported in the survey with the fires attended by the fire brigade and reported on the K433 fire report. A sample of 3 brigade areas was selected and all the 1975 and 1976 fire reports examined to find any fire reports for firms which had returned the survey questionnaire. The firms' reporting of fires could then be compared with the brigade reports. For this small sample, the percentage of fires reported by survey respondents was calculated to be about 30% of those they had actually suffered whereas in the whole survey sample a rough estimate of the value of this same percentage was about 60%. This information taken together with the fact that, in the small sample of firms who had had fires, the response rate was 75% (compared with that of 68% for the whole survey) confirmed that firms who had suffered fires replied to the survey but did not necessarily record all the fires they had had. Thus all the under-reporting can be accounted for by the

fact that respondents did not report all their fires, and there is no evidence to suggest that the sample of respondents is unrepresentative. The under-reporting of fires does not affect the final results as the only survey information on fires which was used was the information on sprinklered fires. Sprinklered fires are a more easily identifiable group and, in any case, the representativeness of the reported sprinklered fires was checked (see Section 4.3).

4.2 Percentage of fires reported to brigades

As most of the information about fire incidence comes from fire brigade statistics, there is very little information available on the number of fires not reported to brigades. It is obvious that a definition of what actually constitutes a fire is necessary for any valid estimate of the percentage of fires not reported to brigades. However in this exercise the only unreported fires which are of interest are those in which sprinklers operated, and this is an obvious group of fires to identify. The survey results were that for 183 sprinklered fires reported in the survey, 92% of these fires were reported to the fire brigade.

4.3 Check with other work to verify the validity of sprinklered fires data

The survey question on firms' fire records also asked how many sprinkler heads operated at each fire recorded on the form. This information was used to check the reliability of other details given by firms about fires they had suffered. Details of numbers of sprinkler heads operating at fires were taken from completed questionnaires and a graph of **P(N)** (the percentage of fires in which N or more sprinkler heads operated) against N (the number of sprinkler heads which operated in fires) was drawn (see Figure 2). Comparison of these results with those of Rasbash[3] gave a definite agreement as shown in Figure 2 where graphs from the 2 sources are superimposed.

This parallel between the present work and that already carried out by other researchers on independent statistics adds credibility to the information derived from replies to the survey about the proportion of sprinklered fires reported to brigades.

5. FIRE PROTECTION - SPRINKLERS AND DETECTORS

5.1 Sprinklers and detectors in manufacturing industry

In the survey of manufacturing industry, firms were asked about their sprinkler and detector fire protection systems and in this chapter, the results obtained from their replies are presented. Tables 5-9 give summaries of the information derived on the extent of sprinkler and detector systems fitted in manufacturing industry. The analysis includes details of whether the protection covers the whole building or just part of it and estimates of the percentage of buildings and the percentage of industrial floorspace covered by fire protection devices are given.

It should be noted that the extent of protection has been expressed in terms of the number of buildings covered rather than the number of systems installed as a building may be covered by more than one system.

Tables 5 and 6 respectively give the percentages of buildings in each size group covered by complete and partial sprinkler installations and by complete sprinkler installations. Figures 3-12 give the same information but in a graphical form for those industries with the largest amount of sprinkler protection; these graphs show the tendency for the larger buildings to be fitted with sprinklers. The unexpected peaks in these graphs are caused by random fluctuations in the data because of small sample sizes. Tables 7 and 8 give similar information about the numbers of buildings fitted with detectors.

In Table 9 are presented summary figures for each industry giving the percentages of buildings of all sizes installed with sprinklers and the percentages of buildings of all sizes fitted with detectors; also detailed are the percentages of the total floorspace in each industry covered by sprinklers and detectors. It can be seen that the most heavily sprinklered industry is "Other Manufacturing Industries", the SIC Order which includes the manufacture of various rubber and plastic goods, both highly inflammable materials. Other industries with a higher than average sprinkler coverage are those concerned with the manufacture and making up of fabrics and hides, eg clothing and footwear. The industry with the greatest percentage of detectors installed is that covered by the SIC Order "Chemical and Allied Industries". This is an industry with advanced technology and is therefore, more likely to fit detectors; also it is an industry which often has 24 hour coverage because of the processes involved and also has efficient works fire brigades so that the detection of fires by automatic methods rather than their extinction by such methods is required.

In summary, about 14,000 buildings in manufacturing industry are completely fitted with sprinklers and a further 4,000 buildings are partially equipped; the corresponding figures for detectors are about 5,000 buildings with complete installations with a further 2,000 buildings being partially equipped. From the survey results, it has been estimated that there are about 109,000 buildings in manufacturing industry as defined by SIC III-XIX.

5.2 Measurements of building size

In order to calculate the percentages presented in section 5.1, it was necessary to consider the distributions of building size in each industry and also the floor areas of the buildings. Appendix B contains the building size distribution histograms.

The survey results give an estimate of the total floor area in manufacturing industry in the United Kingdom in 1977 to be 294,000,000 square metres. The only figures available for comparison are the Department of the Environment Floorspace Statistics[4]; these statistics only cover England and Wales and are divided under the headings "Commercial Offices", "Shops and Restaurants", "Warehouses (covered)" and "Industrials". The SAB survey estimate of total floor area in manufacturing industry includes that part of storage in industry which is actually on the same site as the manufacturing unit therefore an estimate slightly in excess of the DOE "Industrials" figure would be expected. The SAB estimate for the UK was scaled down to give a figure for England and Wales which did agree very well with the DOE results.

5.3 Age distribution of sprinkler installations

In reply to the survey questionnaire on when sprinklers were fitted, data on the age distribution of sprinkler installations was obtained and is presented as a histogram in Figure 13. Almost half the sprinklers in current use in 1977 were fitted before 1968 and in subsequent years, 5 or 6% of the total in 1977 were fitted annually with a peak year in 1970 when about 8% were installed.

6. CONCLUSION

The purpose of the study was to collect information on fire incidence and fire protection from a structured sample of UK manufacturing industry. The results are presented in this report.

The main findings on the probability of fire in buildings of different sizes in each sector of manufacturing industry are presented in Tables 2-4 inclusive. A further result gained from the analysis of the survey data is that 92% of sprinklered fires are reported to brigades. However, a major part of the study was concerned with the extent of fire protection (ie sprinklers and detectors) in manufacturing industry; the results of this work are tabulated in Tables 5-9 inclusive.

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SPR(FS)(76)8

TABLE 1: Final sample size compared with actual numbers of manufacturing units.

SIC Order	Number of usable returns received	Total number of manufacturing units in UK in 1974
Food, drink and tobacco	186	5050
Coal and petroleum products	30	176
Chemicals and allied industries	82	2118
Metal manufacture	67	2210
Mechanical engineering	589	8499
Instrument engineering	113	1267
Electrical engineering	196	3342
Shipbuilding and marine engineering	40	694
Vehicles	115	2135
Metal goods not elsewhere specified	178	6988
Textiles	141	4478
Leather, leather goods and fur	26	777
Clothing and Footwear	124	5774
Bricks, pottery, glass, cement etc	64	2377
Timber, Furniture etc	79	4825
Paper, printing and publishing	159	5863
Other manufacturing industries	107	3118
TOTAL	2296	59691

Notes: i. The analysis follows the Orders of the Standard Industrial Classification 1968.

ii. Figures for total number of units include only those with 11 or more employees. Reliable figures for units employing fewer than 11 persons are not available at Business Statistics Office. It is estimated, however, that there were about 50,000 such units in 1974 with total employment of approximately 250,000.

TABLE 2: Curve parameters for the probability of fire function for buildings in manufacturing industry tabulated by SIC Order

Industry (SIC Order)	A	c	Probability of fire in a building with floorspace 500m^2	1200m^2	1500m^2
Food, Drink and Tobacco III	0.0054	0.33	0.041	0.054	0.058
Coal and Petroleum* IV					
Chemical and Allied Industries V	0.017	0.27	0.089	0.11	0.12
Metal Manufacture VI	0.011	0.36	0.097	0.13	0.14
Mechanical Engineering VII	0.00036	0.59	0.014	0.024	0.027
Instrument Engineering VIII	0.000027	0.96	0.011	0.025	0.031
Electrical Engineering IX	.0011	.49	.023	.035	.040
Shipbuilding and Marine Engineering X	0.0062	0.30	0.040	0.051	0.055
Vehicles XI	0.00030	0.74	0.029	0.056	0.065
Metal Goods not Elsewhere Specified XII	.0027	.46	.047	.070	.078
Textiles XIII	0.0036	0.42	0.050	0.072	0.079
Leather, Leather Goods and Fur* XIV					
Clothing and Footwear XV	.0017	.40	.020	.029	.032
Bricks, Pottery, Glass, Cement etc XVI	0.0013	0.54	0.037	0.059	0.067
Timber, Furniture etc XVII	0.00074	0.64	0.039	0.067	0.077
Paper, Printing and Publishing XVIII	0.00010	0.85	0.021	0.043	0.052
Other Manufacturing Industries XIX	0.0023	0.54	0.068	0.11	0.12
SIC III - XIX	0.0019	0.50	0.042	0.064	0.072

Notes:

i. The analysis follows the Orders of the Standard Industrial Classification 1968

ii. The columns headed A and c give the parameters for the curves $p(t) = At^c$ where $p(t)$ = probability of fire in a building with floorspace t (metres^2).

iii. * Survey sample too small for accurate analysis.

TABLE 3: Curve parameters for the probability of fire function for buildings in the production sector of manufacturing industry

Industry (SIC Order)	A	c	Probability of fire in a building with floorpsace $500m^2$	$1200m^2$	$1500m^2$
Food, Drink and Tobacco III	0.0011	0.60	0.044	0.075	0.086
Chemical and Allied Industries V	0.0069	0.46	0.12	0.19	0.21
Metal Goods Not Elsewhere Specified and Mechanical Engineering XII and VII	0.00088	0.54	0.026	0.042	0.047
Vehicles XI	0.00012	0.86	0.024	0.052	0.062
Textiles XIII	0.0075	0.35	0.066	0.090	0.097
Timber, Furniture etc XVII	0.00037	0.77	0.043	0.084	0.10
Paper, Printing and Publishing XVIII	0.000069	0.91	0.020	0.044	0.054
Other Manufacturing Industries XIX	0.0084	0.41	0.11	0.16	0.17
SIC III - XIX	0.0017	0.53	0.046	0.074	0.083

Notes:

i. The analysis follows the Orders of the Standard Industrial Classification 1968.

ii. The columns headed A and c give the parameters for the curves $p(t) = At^c$ where $p(t)$ = probability of fire in a building with floorspace $t(metres^2)$.

TABLE 4: Curve parameters for the probability of fire function for buildings in manufacturing industry

SIC III - XIX	A	c	Probability of fire in a building with floorspace $500m^2$	$1200m^2$	$1500m^2$
All uses	0.0019	0.50	0.042	0.64	0.072
Production buildings only	0.0017	0.53	0.046	0.074	0.083

Notes:

i. The analysis follows the Orders of Standard Industrial Classification 1968

ii. The columns headed A and c give the parameters for the curves $p(t) = At^c$ where $p(t)$ = probability of fire in a building with floorspace t $(metres^2)$.

Table 5: Percentages of buildings in manufacturing industry with complete and partial sprinkler installations by size of building

Industry \ Building Floorspace(m^2)	1	55	314	518	665	854	1097	1408	1808	2322	2981	3828	4915	6311	8103	10405	13360
Food, Drink and Tobacco	0	6.06	5.08	17.72	0.70	8.95	2.04	6.58	4.47	2.01	17.92	11.00	11.04	63.43	8.31	29.51	16.98
Coal and Petroleum Products																	
Chemical and Allied Industries	0	13.47	13.42	14.75	0	25.00	8.24	18.98	47.94	16.70	53.06	38.59	44.49	19.74	53.66	72.73	80.37
Metal Manufacture																	
Mechanical Engineering	0	0.55	3.97	1.74	0.36	0.79	6.06	6.21	4.75	4.69	9.68	8.27	7.06	11.08	15.00	40.68	26.22
Instrument Engineering																	
Electrical Engineering	0	2.71	2.17	6.32	2.22	2.02	8.43	6.28	15.04	30.00	29.67	44.51	20.24	47.89	43.23	44.66	70.17
Shipbuilding and Marine Engineering																	
Vehicles	0	5.30	0.57	10.45	15.19	2.22	0	4.68	8.90	25.30	6.61	21.16	26.05	10.53	11.34	25.97	48.42
Metal Goods Not Elsewhere Specified	0	0.15	1.19	0.66	0	4.88	3.78	0	5.46	20.73	8.19	12.83	58.00	13.79	44.69	30.19	17.95
Textiles	22.89	14.45	15.03	16.72	43.93	19.83	35.21	35.67	50.72	70.72	45.45	83.93	46.13	57.19	8.22	89.95	95.79
Leather, Leather Goods and Fur																	
Clothing and Footwear	0	22.74	14.08	11.90	34.24	44.33	17.83	49.80	64.4	62.28	35.54	20.00	56.40	77.27	87.50	88.24	100.00
Bricks, Pottery, Glass, Cement Etc																	
Timber, Furniture, etc	0	11.64	13.92	44.23	49.83	38.58	32.04	17.33	11.90	63.71	78.19	70.44	66.91	100.00	47.92	97.92	77.88
Paper, Printing and Publishing	0	2.95	10.69	11.37	9.60	7.29	15.52	28.29	13.85	32.39	35.07	47.37	42.16	94.15	73.00	89.92	97.34
Other Manufacturing Industries	0	11.59	7.51	22.49	32.09	67.87	46.16	30.83	58.33	72.95	86.01	95.04	77.14	96.15	77.50	62.07	100.00
SIC III-XIX	0.99	7.04	8.84	11.96	10.72	15.41	14.35	12.05	20.12	30.27	33.74	33.73	33.53	43.18	30.38	44.34	46.28

Notes

i. This analysis follows the orders of the Standard Industrial Classification 1968

ii. The scale used for the building floorspace groups is a logarithmic one.

iii. Industries without entries in this table have very few sprinkler installations

Table 6: Percentages of buildings in manufacturing industry with complete sprinkler installations by size of buildings

Industry \ Building Floorspace (m^2)	1	55	314	518	665	854	1097	1408	1808	2322	2981	3828	4915	6311	8103	10405	13360
Food, Drink and Tobacco	0	5.84	4.77	17.41	0.70	5.53	1.49	6.58	2.37	2.01	11.25	11.00	6.75	63.43	7.20	27.32	7.31
Coal and Petroleum Products																	
Chemical and Allied Industries	0	13.47	13.42	14.75	0	20.57	8.24	14.60	45.69	16.70	53.06	35.33	41.85	14.16	46.34	63.64	69.16
Metal Manufacture																	
Mechanical Engineering	0	0.55	3.97	1.74	0.36	0.59	5.43	5.97	0.59	4.47	7.26	6.38	6.47	6.33	10.42	6.78	16.76
Instrument Engineering																	
Electrical Engineering	0	2.71	1.79	6.32	2.22	2.02	8.43	6.28	13.27	18.96	21.95	39.63	20.24	46.32	41.29	30.10	56.72
Shipbuilding and Marine Engineering																	
Vehicles	0	1.09	0.57	10.45	15.19	2.22	0	2.34	8.90	25.30	4.85	19.05	22.69	6.43	11.34	25.97	35.24
Metal Goods Not Elsewhere Specified	0	0.15	1.19	0.66	0	4.88	3.78	0	1.47	20.73	2.49	10.70	58.00	13.79	37.61	30.19	15.38
Textiles	0	1.07	0	0	10.68	6.70	2.05	0	0	0	5.90	0	0	0	0	0	17.15
Leather, Leather Goods and Fur																	
Clothing and Footwear	0	22.74	14.08	11.90	34.24	44.33	17.83	49.80	64.40	62.28	35.54	2.50	56.40	77.27	87.50	88.24	100
Bricks, Pottery, Glass, Cement Etc																	
Timber, Furniture, etc	0	11.64	13.92	44.23	49.83	38.58	32.04	17.33	11.90	61.56	78.19	65.02	66.91	50.68	47.92	97.92	58.41
Paper, Printing and Publishing	0	2.95	8.59	11.37	9.60	7.29	15.52	28.29	13.85	32.39	27.38	43.72	25.00	94.15	70.00	79.07	75.00
Other Manufacturing Industries	0	8.41	20.09	22.07	14.97	67.04	44.84	29.25	45.51	72.95	77.37	92.91	77.14	93.27	75.63	62.07	80.00
SIC III-XIX	0	5.85	7.26	11.33	8.42	14.01	11.42	9.38	11.96	22.47	26.98	23.30	25.06	32.33	26.97	29.31	30.27

Notes

i. This analysis follows the orders of the Standard Industrial Classification 1968

ii. The scale used for the building floorspace groups is a logarithmic one

iii. Industries without entries in this table have very few sprinkler installations

Table 7: Percentages of buildings in manufacturing industry with complete and partial detector installations by size of building

Industry \ Building Floorspace(m^2)	1	55	314	518	665	854	1097	1408	1808	2322	2981	3828	4915	6311	8103	10405	13360
Food, Drink and Tobacco	2.59	0.54	1.17	1.83	2.92	1.45	0	7.37	34.61	16.07	12.92	3.83	15.95	1.85	57.34	49.76	9.43
Coal and Petroleum Products																	
Chemical and Allied Industries	2.45	8.88	26.37	19.78	90.14	21.20	31.42	30.66	19.85	4.28	28.57	38.59	7.93	12.45	50.00	18.18	28.97
Metal Manufacture	0	4.82	0	4.19	0	4.49	0	4.87	1.86	5.38	5.04	0	4.35	6.90	0	3.39	4.40
Mechanical Engineering	0.25	0.27	1.87	1.89	1.08	0.20	3.07	5.97	5.05	5.03	5.44	7.80	2.35	6.96	5.83	6.78	12.43
Instrument Engineering	0	7.45	0.63	27.22	1.41	0	3.31	1.29	7.59	0	11.76	28.57	26.32	17.65	0	50.00	42.31
Electrical Engineering	0	3.22	3.58	9.67	6.39	4.80	31.33	8.52	12.61	10.42	11.79	12.80	20.24	24.21	13.55	7.77	24.37
Shipbuilding and Marine Engineering																	
Vehicles																	
Metal Goods Not Elsewhere Specified	0	0.41	0.30	22.77	0	2.44	4.79	0.69	2.31	13.68	2.49	2.14	53.00	25.00	0	0	12.45
Textiles	0	8.78	0	9.29	5.83	0	9.59	7.32	10.08	1.20	16.71	14.86	8.00	0	16.44	7.54	23.62
Leather, Leather Goods and Fur																	
Clothing and Footwear																	
Bricks, Pottery, Glass, Cement Etc																	
Timber, Furniture, etc																	
Paper, Printing and Publishing	0	1.32	1.23	3.91	21.08	3.57	9.03	6.59	5.23	44.32	22.40	14.57	15.20	18.71	43.5	13.95	18.09
Other Manufacturing Industries	0	0.80	6.18	1.41	0	9.97	0.40	10.67	23.08	0	0	4.25	2.86	0	0	0	17.60
SIC III-XIX	0.68	2.07	2.45	5.57	8.89	2.88	7.11	5.54	12.20	7.25	9.78	14.71	11.24	9.59	18.34	20.31	14.77

Notes

i. This analysis follows the orders of the Standard Industrial Classification 1968.

ii. The scale used for the building floorspace groups is a logarithmic one.

iii. Industries without entries in this table have very few detector installations.

Table 8: Percentages of buildings in manufacturing industry with complete detector installations by size of building

Industry \ Building Floorspace(m^2)	1	55	314	518	665	854	1097	1408	1808	2322	2981	3828	4915	6311	8103	10405	13360
Food, Drink and Tobacco	2.59	0.54	0.59	1.52	2.92	1.45	0	6.84	34.6	16.07	12.92	1.91	6.75	1.85	55.40	48.78	4.72
Coal and Petroleum Products																	
Chemical and Allied Industries	2.45	8.88	26.37	19.78	89.00	21.20	31.42	12.41	14.61	1.28	13.47	10.87	2.64	0	24.39	9.09	14.49
Metal Manufacture																	
Mechanical Engineering	0.25	0.11	1.54	1.31	0.90	0.20	1.81	4.14	1.49	2.91	0.81	4.73	2.35	0.63	1.67	1.69	1.62
Instrument Engineering	0	7.45	0.63	13.92	0.35	0	3.31	12.87	7.59	0	11.76	28.57	26.32	5.88	0	50.00	38.46
Electrical Engineering	0	2.19	3.20	9.67	6.39	3.79	18.88	8.52	4.87	10.42	11.79	10.98	11.90	17.37	5.16	7.77	7.98
Shipbuilding and Marine Engineering																	
Vehicles																	
Metal Goods Not Elsewhere Specified	0	0.41	0.30	11.72	0	2.44	4.79	0.69	2.31	13.03	2.49	0	49.00	13.79	0	0	7.33
Textiles	0	8.78	0	9.29	5.83	0	7.53	7.32	10.08	1.20	9.09	6.02	4.00	0	8.22	0	4.85
Leather, Leather Goods and Fur																	
Clothing and Footwear																	
Bricks, Pottery, Glass, Cement Etc																	
Timber, Furniture, etc																	
Paper, Printing and Publishing	0	1.32	1.23	3.91	21.08	3.57	9.03	6.59	5.23	42.05	19.23	14.57	12.25	18.71	40.50	3.10	2.13
Other Manufacturing Industries	0	0.80	6.18	1.41	0	9.97	0.40	2.77	23.08	0	0	2.13	0	0	0	0	14.4
SIC III-XIX	0.68	2.02	2.31	4.47	8.70	2.45	6.36	4.06	9.58	6.49	7.12	9.33	7.58	5.20	14.85	16.45	5.03

Notes

i. This analysis follows the orders of the Standard Industrial Classification 1968

ii. The scale used for the building floorspace groups is a logarithmic one.

iii. Industries without entries in this table have very few detector installations.

Table 5. Summary figures to show the extent of sprinkler and detector coverage in manufacturing industry

Industry (SIC Orders 1968)	% of buildings with complete sprinkler installations	% of buildings with complete or partial sprinkler installations	% of buildings with complete detector installations	% of buildings with complete or partial detector installations	% of floor area covered by complete sprinkler protection	% of floor area covered by complete and partial sprinkler protection	% of floor area covered by complete detector protection	% of floor area covered by complete and partial detector protection
Food, Drink and Tobacco	8.11	9.32	8.47	9.03	11.97	17.05	16.69	19.37
Coal & Petroleum Products	3.39	4.24	4.80	6.21	18.89	19.02	6.08	9.80
Chemical & Allied Industries	19.31	20.68	20.96	24.84	46.58	53.14	14.11	25.78
Metal Manufacturers	4.31	4.31	1.79	3.18	3.39	3.39	0.68	3.87
Mechanical Engineering	3.10	3.94	1.29	2.61	9.73	14.63	1.82	7.66
Instrument Eng	4.17	5.72	7.00	8.71	20.72	25.30	20.98	23.14
Electrical Eng	13.63	16.34	7.13	10.19	39.58	48.18	8.86	18.47
Shipbuilding and Marine Eng	8.82	9.59	6.28	7.16	28.93	29.24	5.53	14.96
Vehicles	10.07	12.34	2.96	5.51	26.92	35.69	4.83	12.30
Metal Goods Not Elsewhere Specified	4.62	5.16	3.38	4.37	14.92	17.03	6.17	9.02
Textiles	2.10	35.98	5.37	7.49	7.35	67.38	4.70	14.55
Leather, leather Goods & Fur	31.32	34.34	4.77	4.77	22.50	30.80	12.66	12.66
Clothing and Footwear	30.34	30.62	2.56	2.99	51.00	51.79	5.74	8.21
Bricks, Pottery, Glass, Cement etc	3.20	3.52	0	1.32	0.93	11.30	0	4.17
Timber, Furniture etc	28.84	29.72	2.41	2.63	51.08	58.65	5.10	7.77
Paper, Printing & Publishing	16.23	18.02	6.85	7.63	52.73	63.23	10.81	17.81
Other manufacturing Industries	40.25	43.44	2.99	3.60	69.84	79.76	6.46	8.10
SIC III-XIX	17.89	16.60	4.94	6.25	24.45	35.73	7.03	12.62

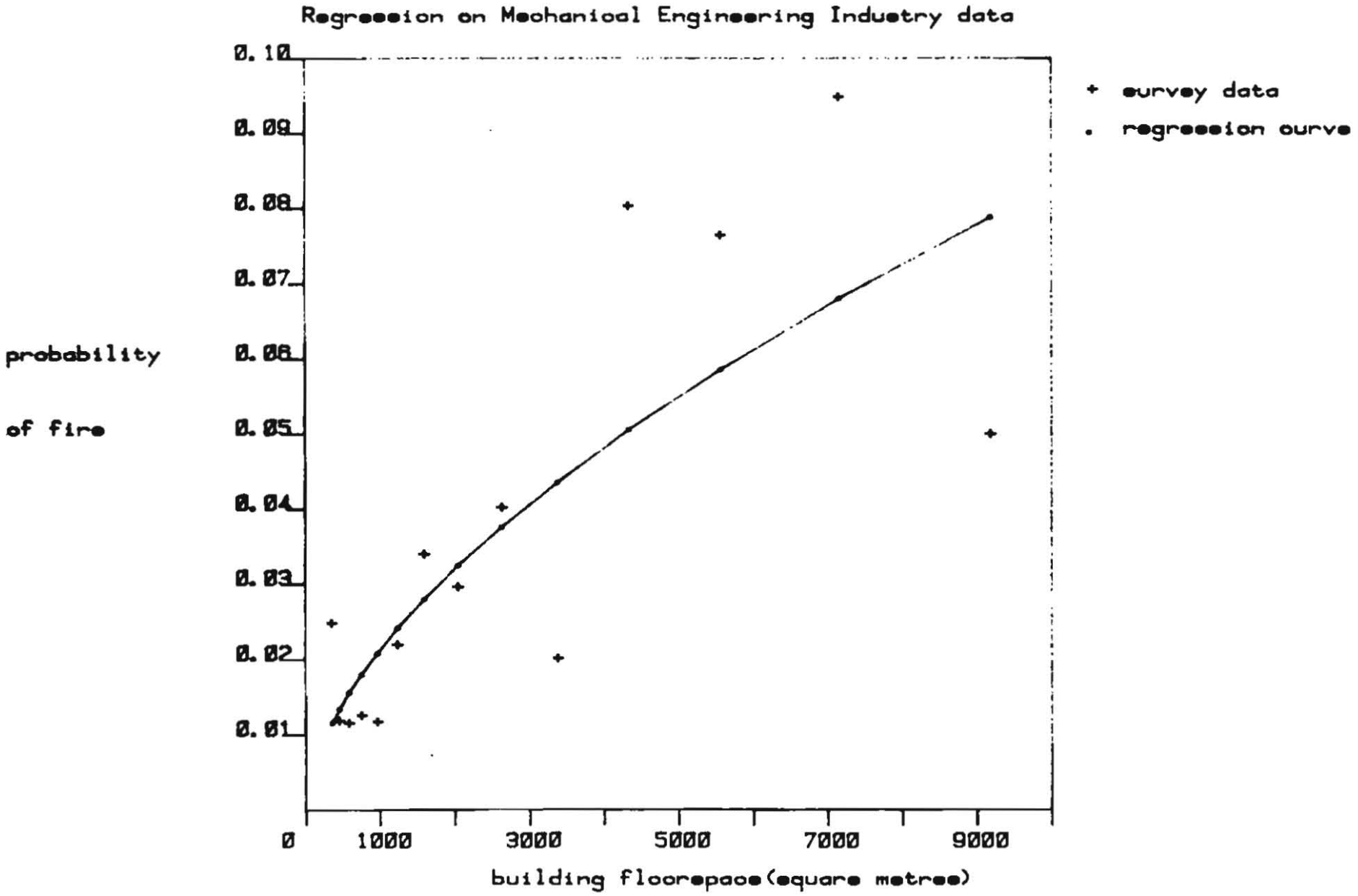


Figure 1: Regression on Mechanical Engineering Industry data

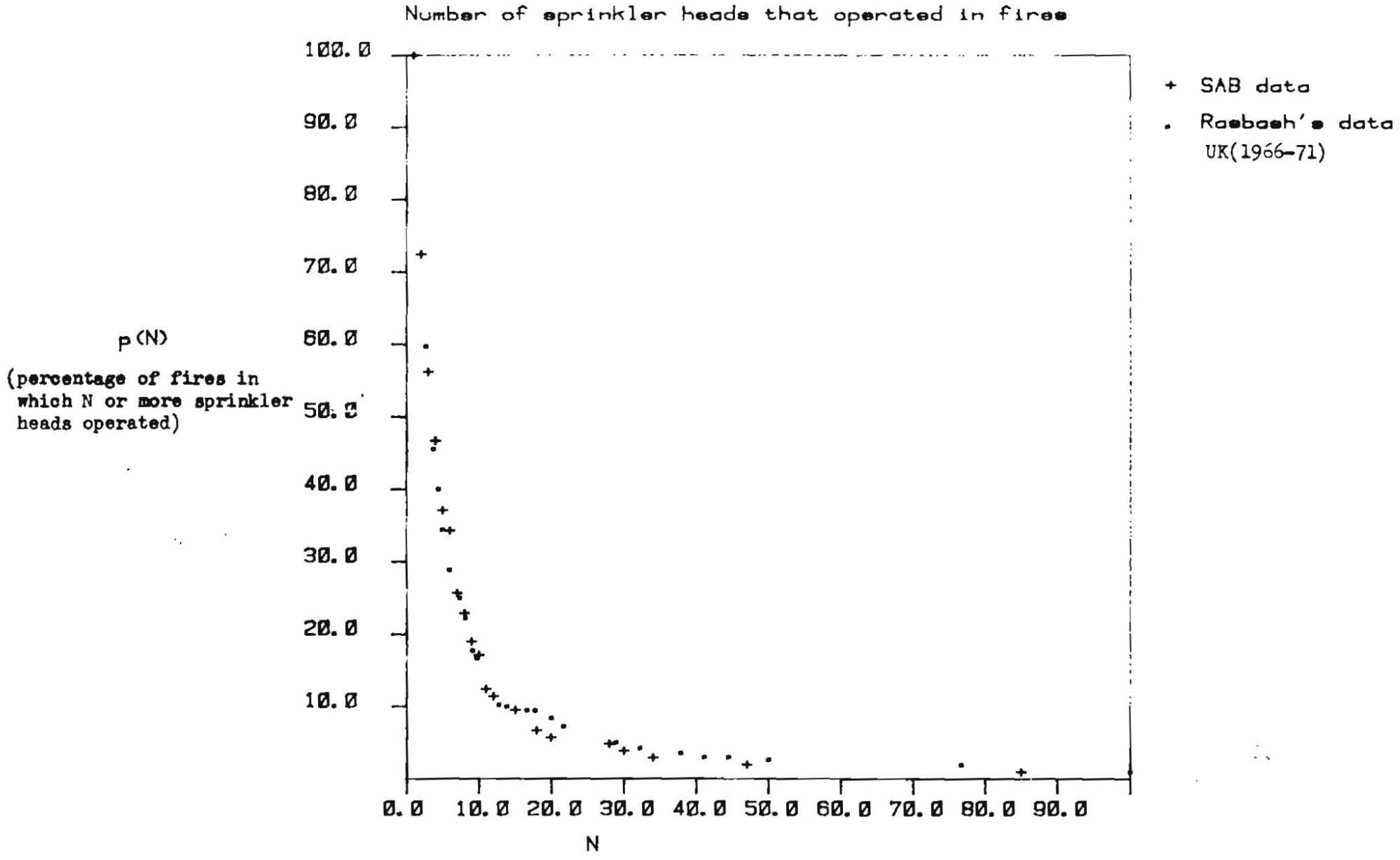


Figure 2: Number of sprinkler heads that operated in fires

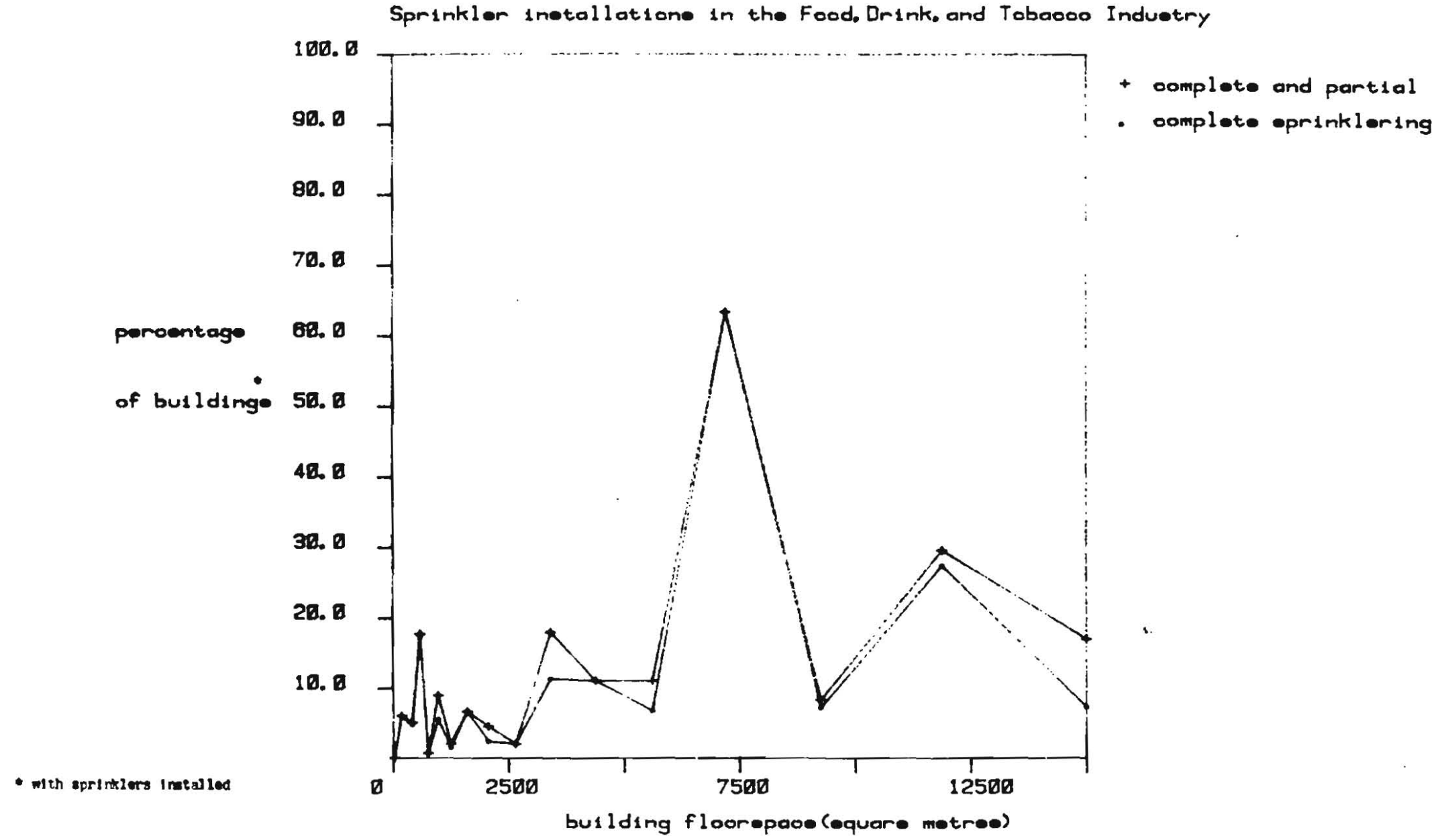


Figure 3: Sprinkler installations in the Food, Drink and Tobacco Industry

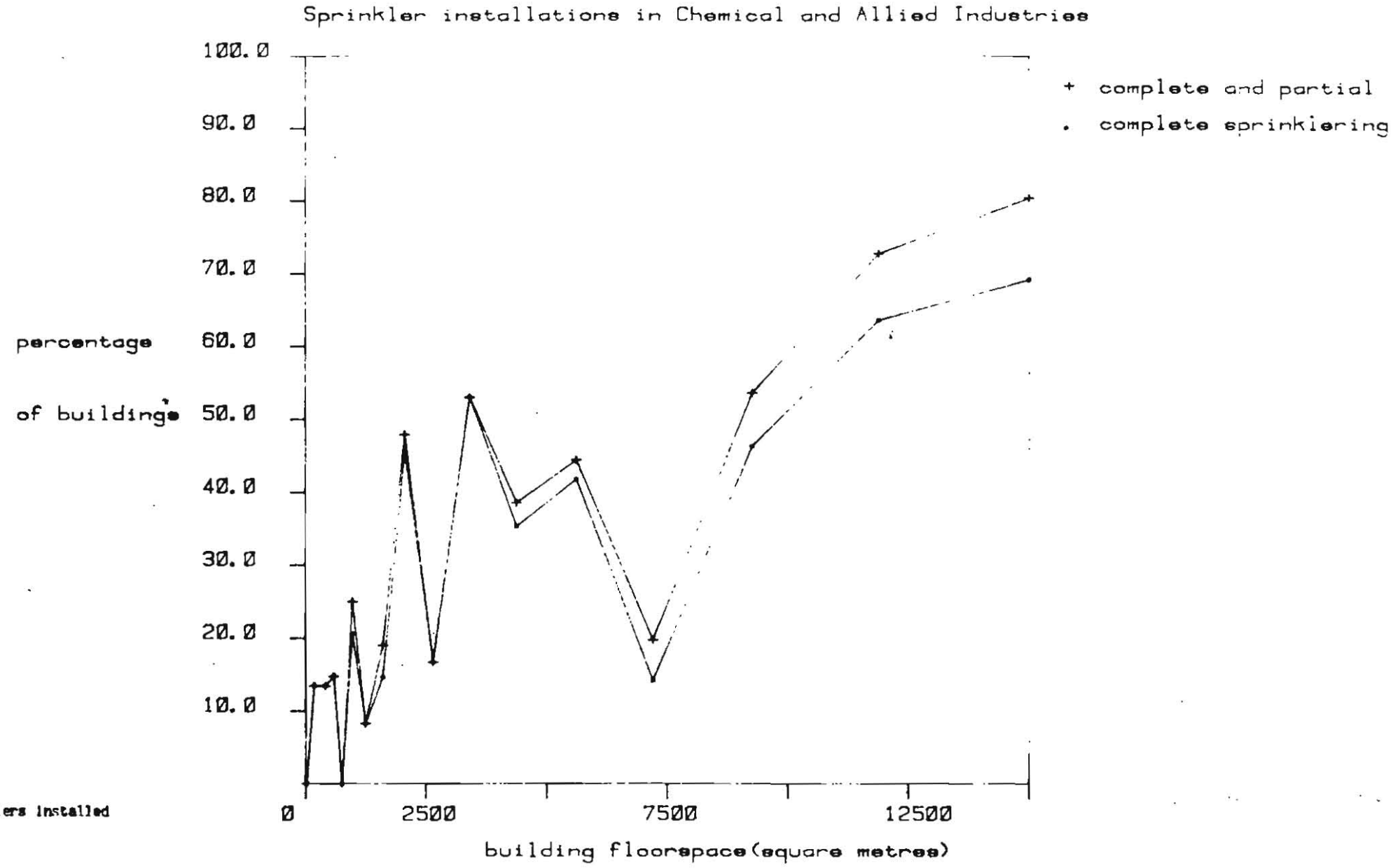
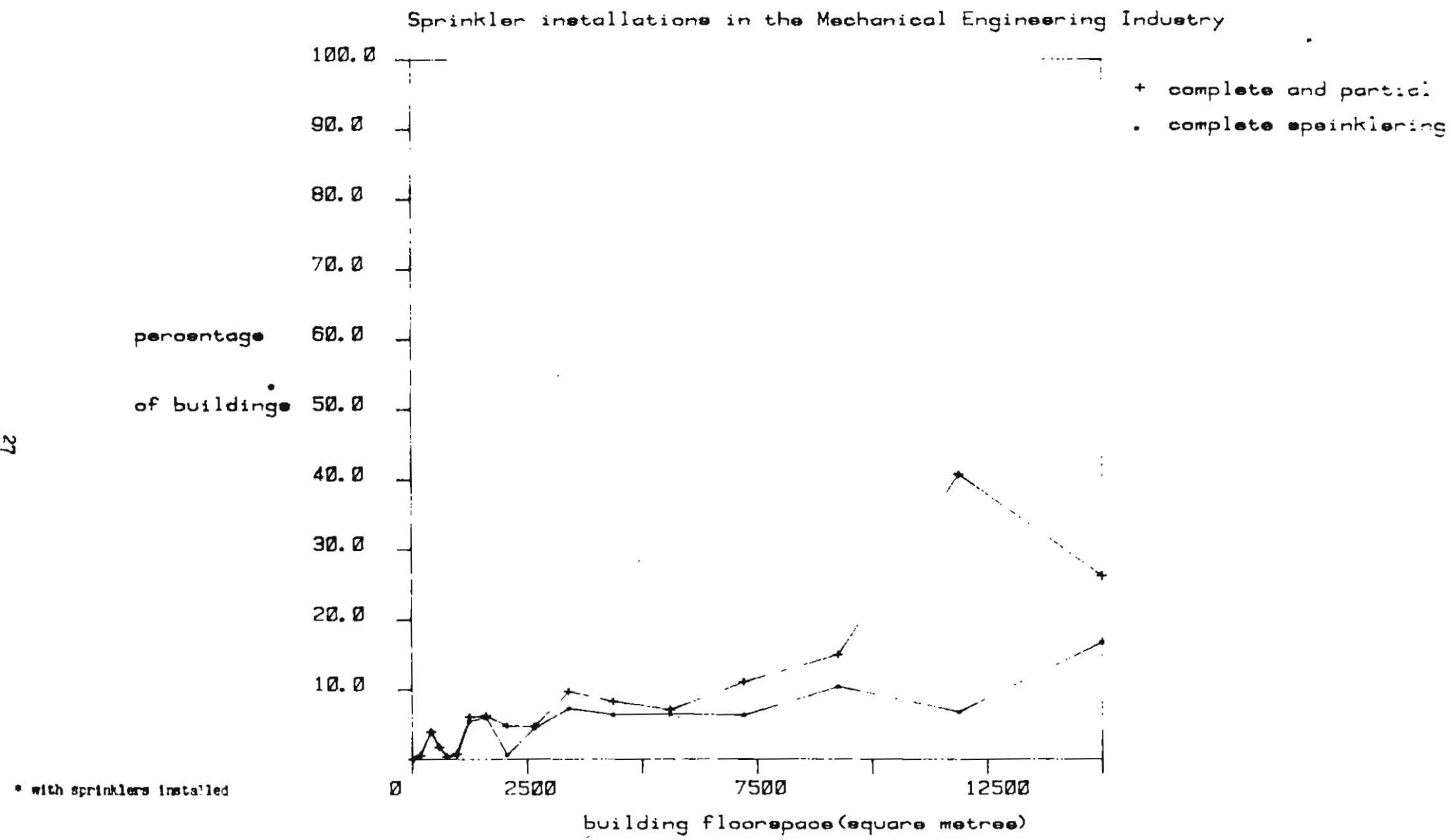


Figure 4: Sprinkler installations in Chemical and Allied Industries



* with sprinklers installed

Figure 5: Sprinkler installations in the Mechanical Engineering Industry

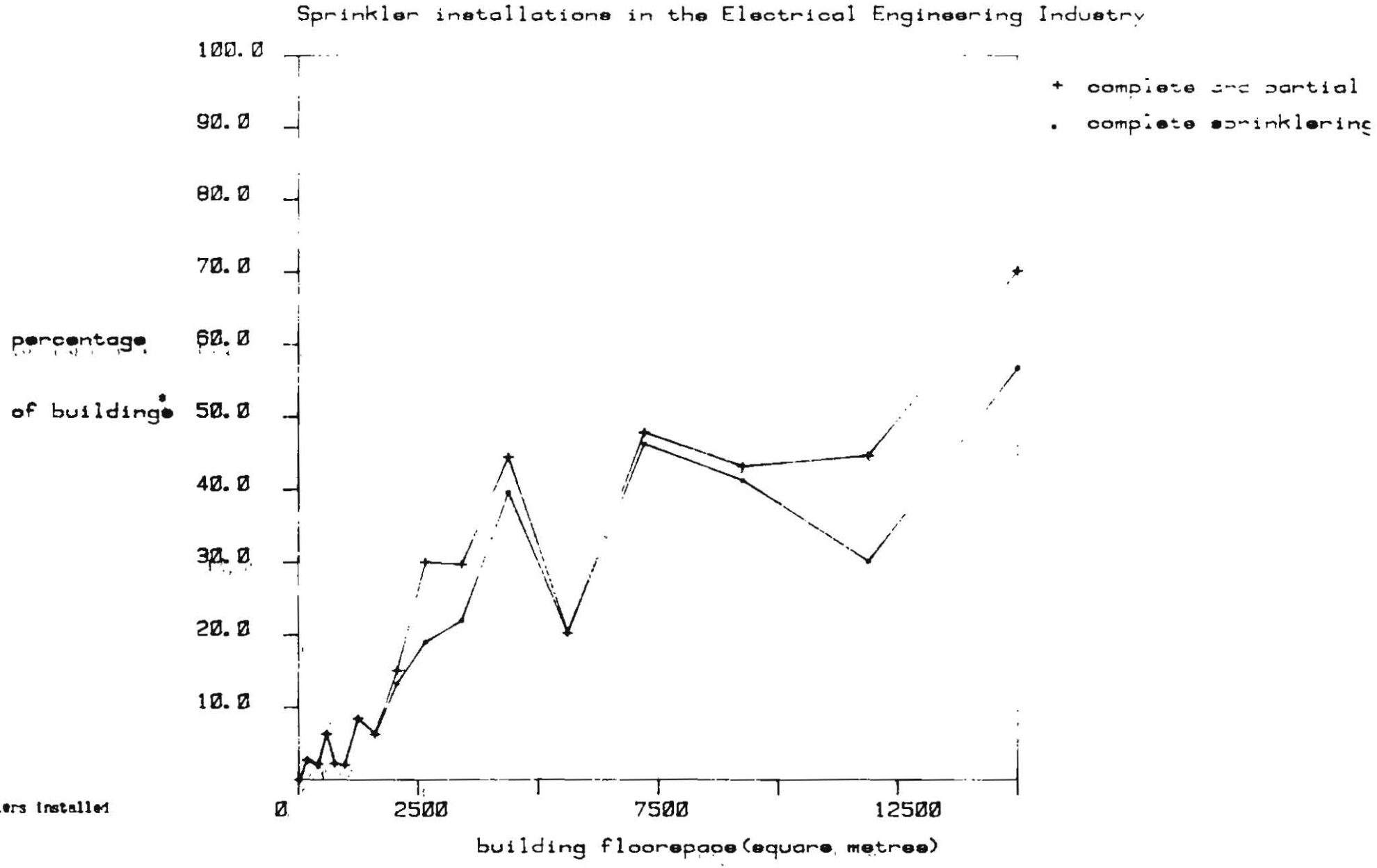
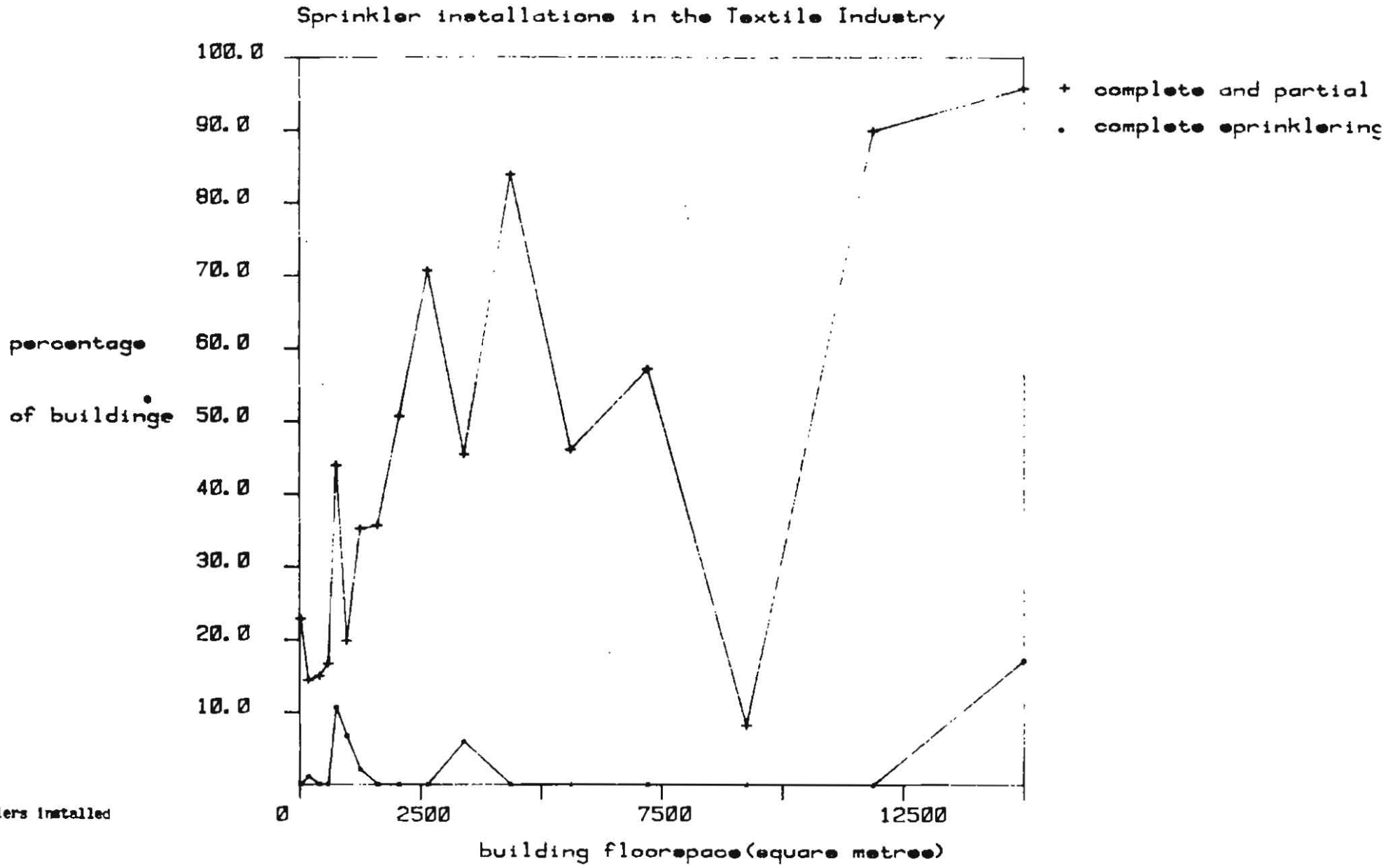


Figure 6: Sprinkler installations in the Electrical Engineering Industry



* with sprinklers installed

Figure 7: Sprinkler installations in the Textile Industry

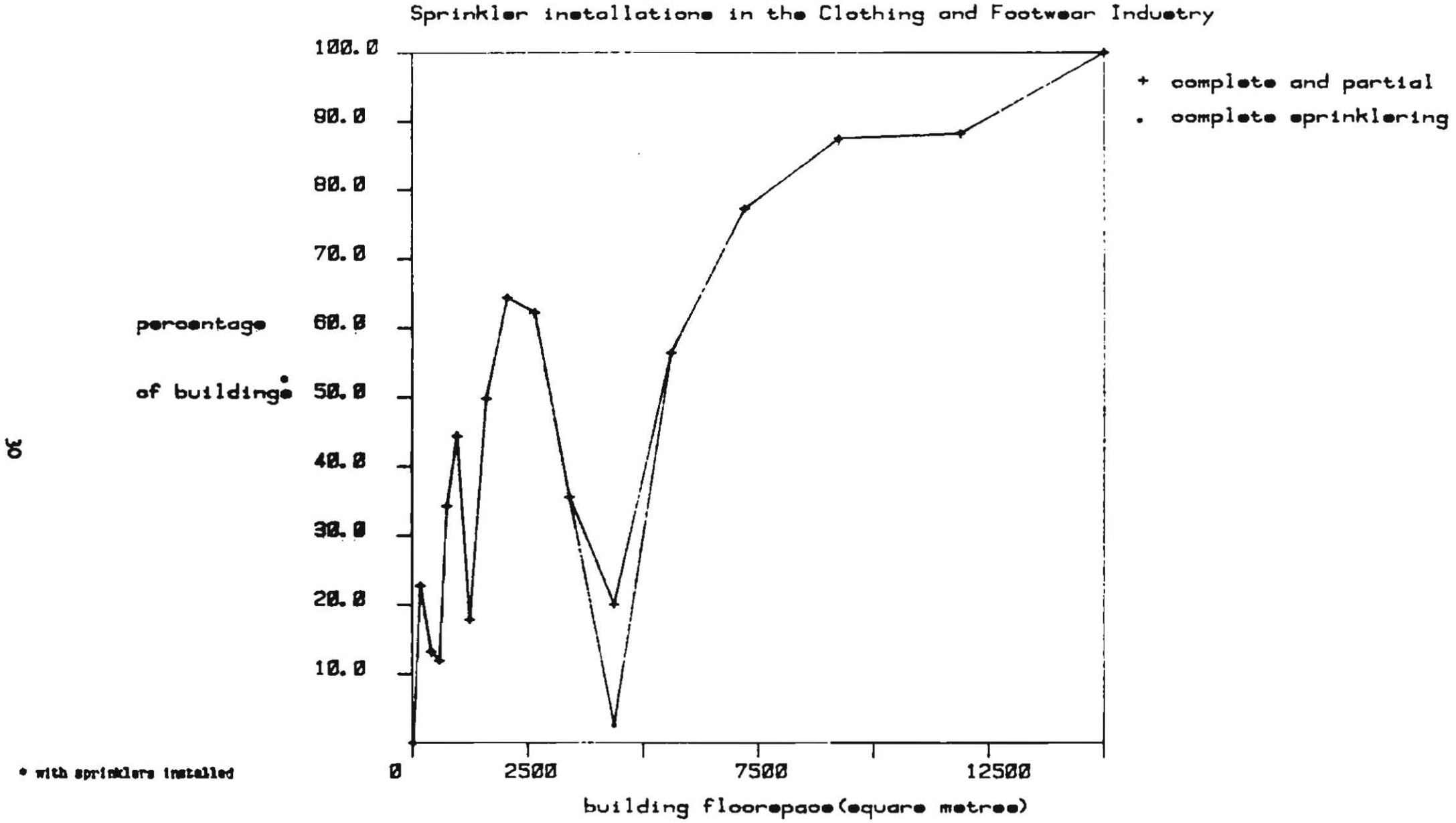


Figure 8: Sprinkler installations in the Clothing and Footwear Industry

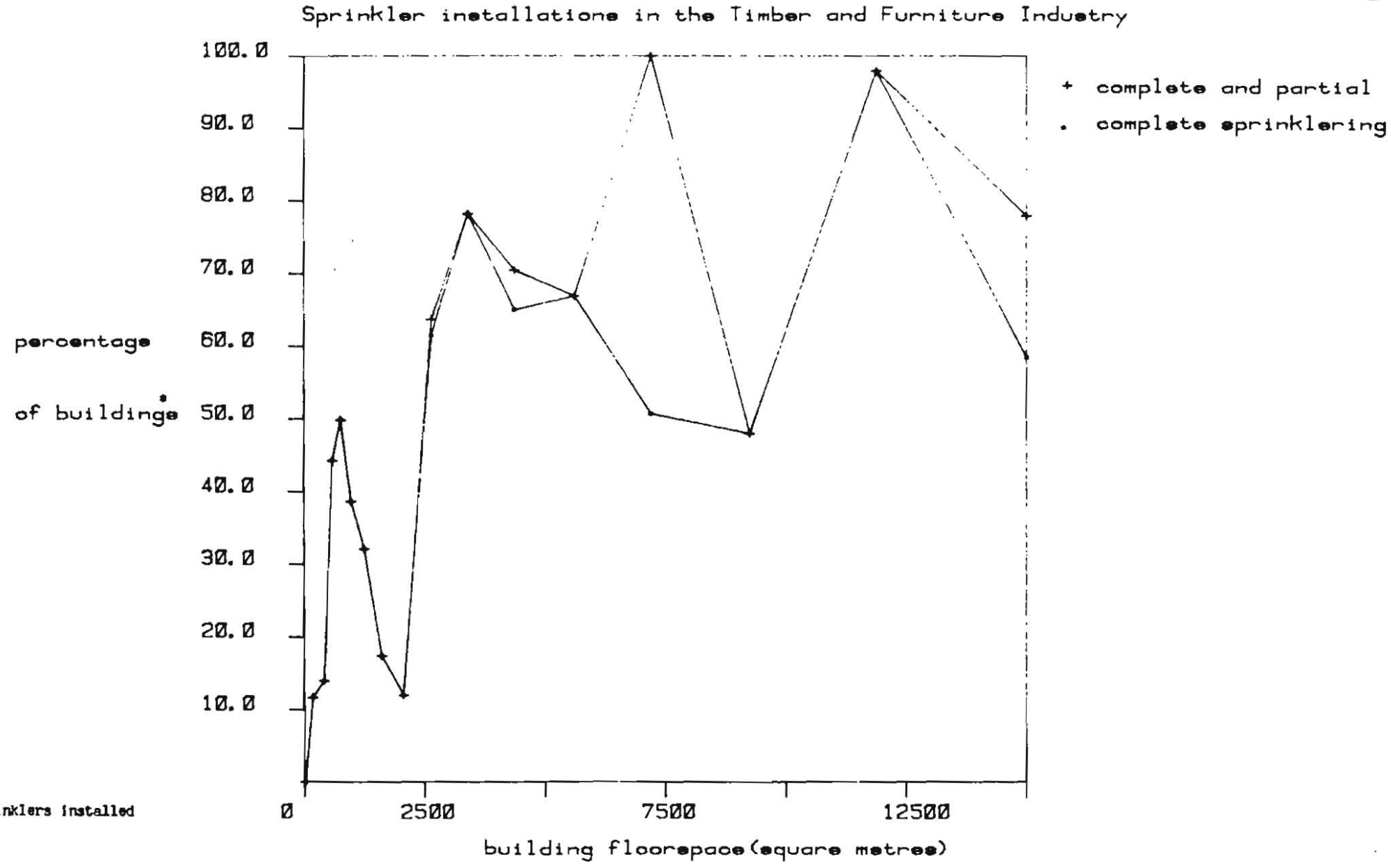
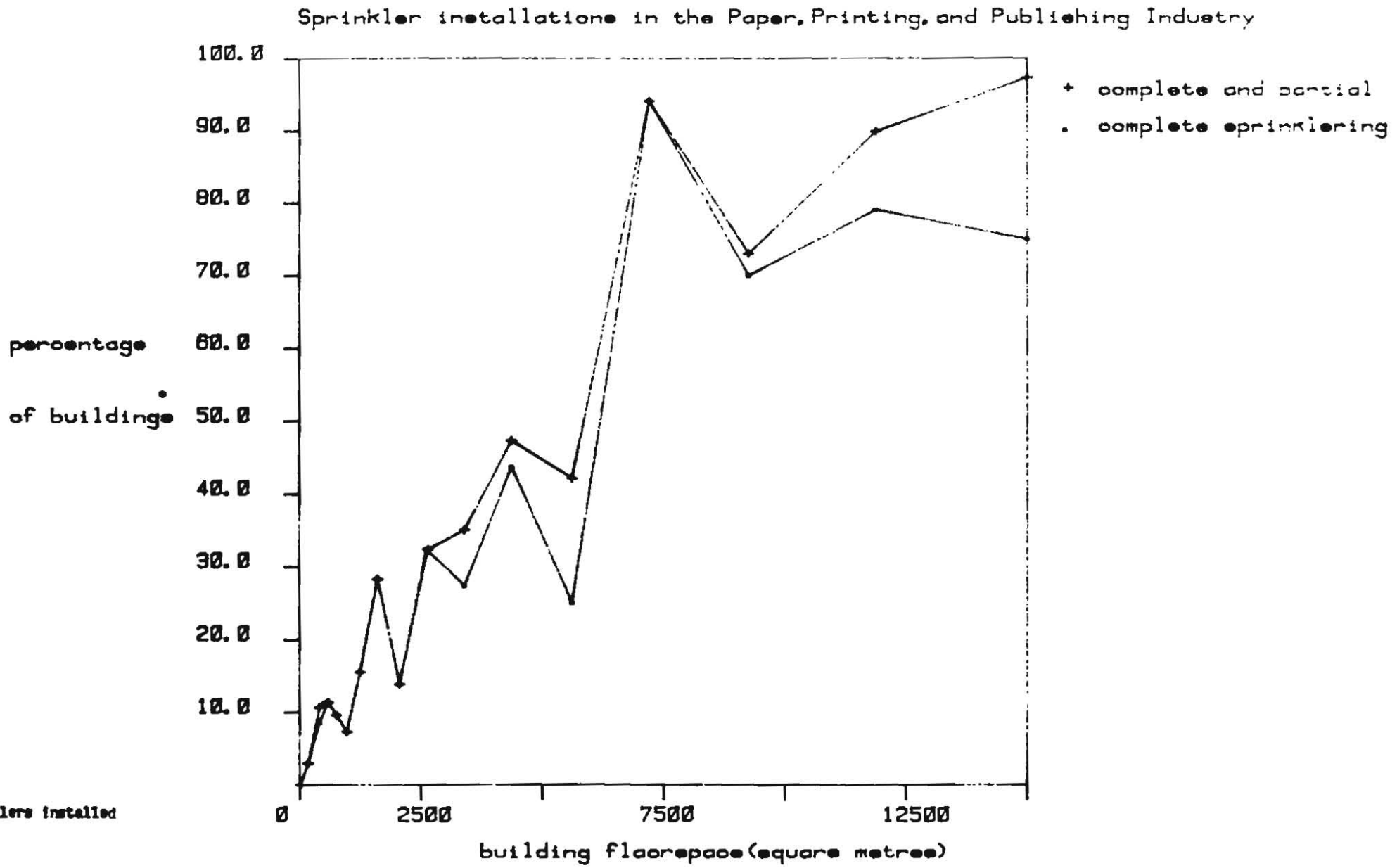


Figure 9: Sprinkler installations in the Timber and Furniture Industry



• with sprinklers installed

Figure 10: Sprinkler installations in the Paper, Printing and Publishing Industry

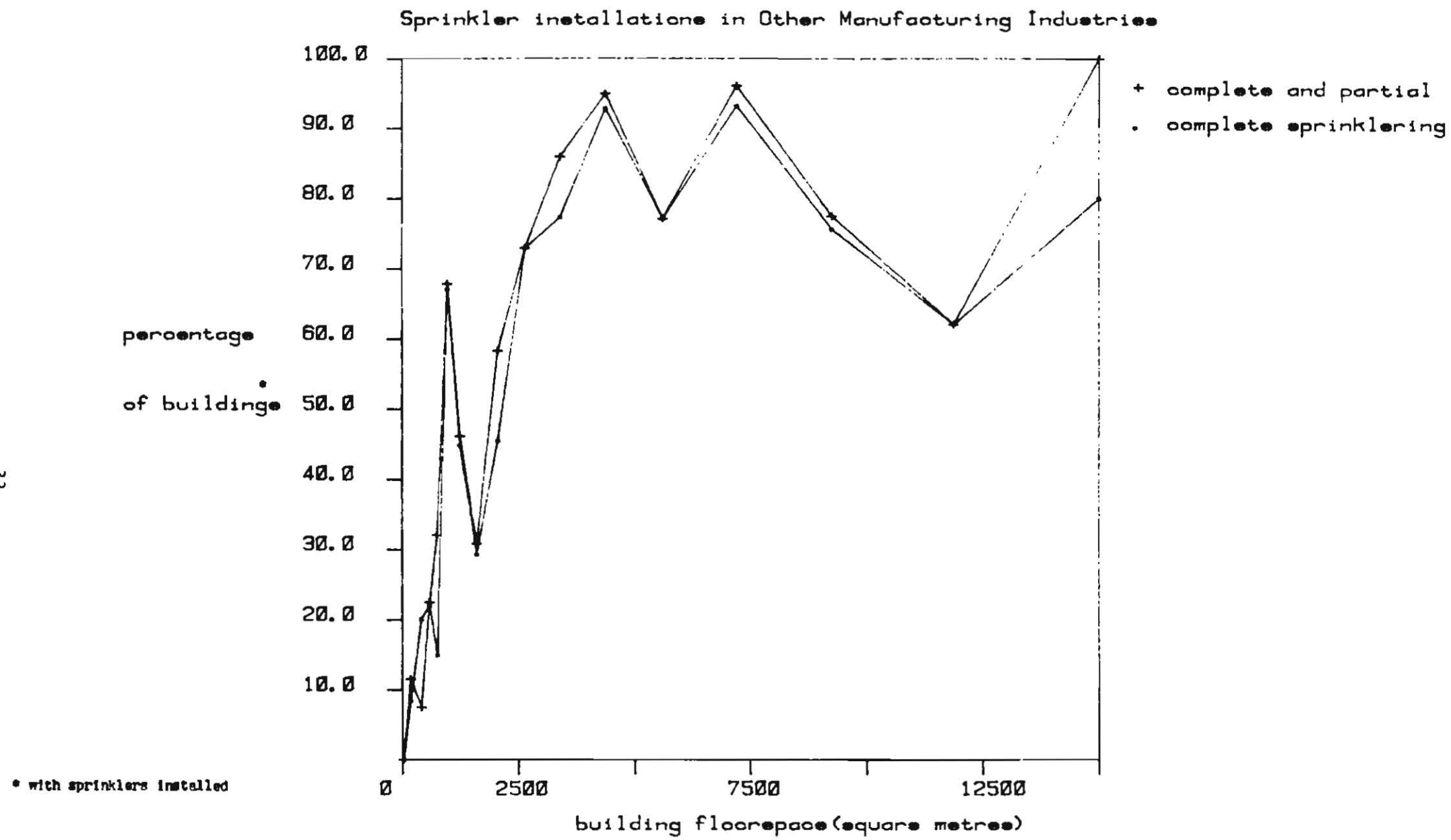


Figure 11: Sprinkler installations in Other Manufacturing Industries

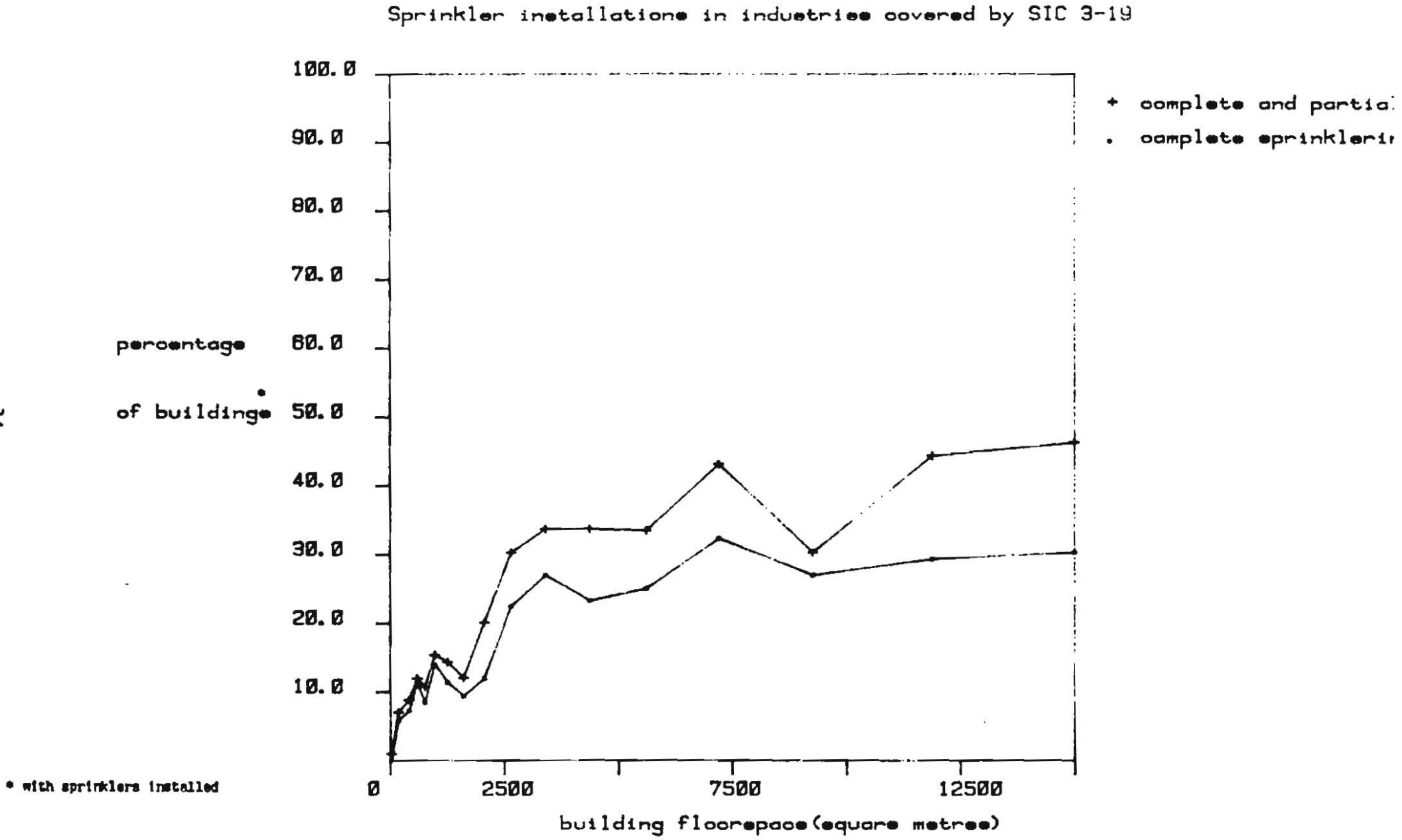
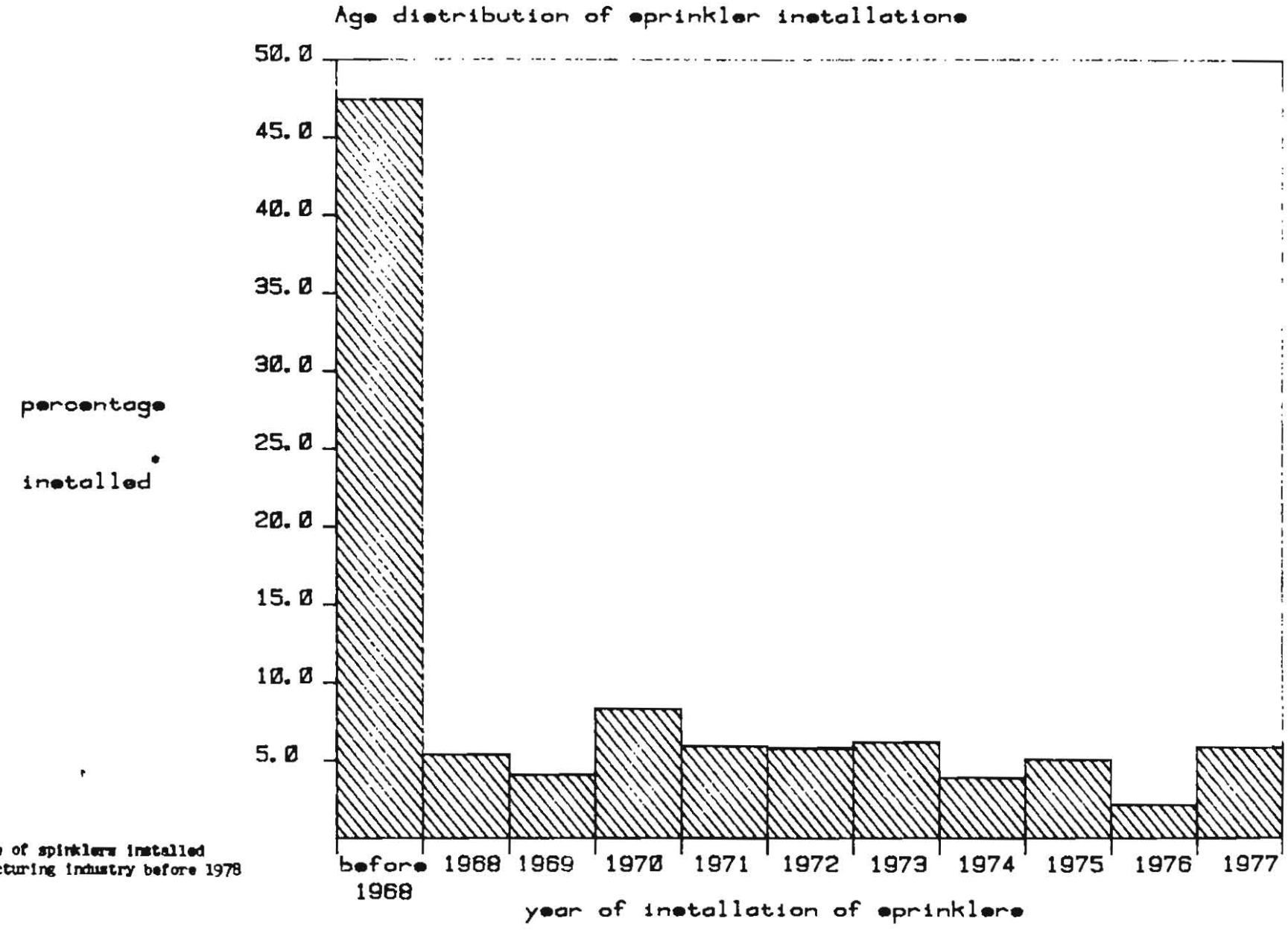


Figure 12: Sprinkler installations in industries covered by SIC III - XIX



* percentage of spinklers installed in manufacturing industry before 1978

Figure 13: Age distribution of sprinkler installations

APPENDIX A

THE SURVEY QUESTIONNAIRE, COVERING LETTER AND REMINDER LETTER

FIRE AND FIRE PROTECTION - A SURVEY OF MANUFACTURING INDUSTRY

Name of Firm

Address

Number of persons employed at this site:
(include full time equivalent for part time employees)

Number of shifts operated:

Q1. DESCRIPTION OF BUILDINGS

i. Only main buildings should be listed. Minor buildings such as small huts, sheds, gatehouses, temporary buildings etc may be omitted.
ii. The floor area required is the total floor area and will be the sum of the floor areas in a multi storey building.

	Main Building	Other Buildings			
	1	2	3	4	5
Total Floor Area (state m^2 or $feet^2$)					
No. of storeys					
Use of the Building % used for production - % used for storage - % used for other purposes - (please specify)					
Is the building sprinklered? State % sprinklered if only partly sprinklered					
If there are sprinklers - when were they installed?					
Are automatic fire detectors installed? State % of building covered by detectors					
If there are detectors - when were they installed?					

PLEASE TURN OVER FOR QUESTION 2

Q2. RECORD OF FIRES

Please list the fires which occurred in 1975 and 1976. Minor fires and fires which did not affect buildings can be omitted.

The fires which should be noted are:

(a) fires to which the fire brigade were called
(b) other fires in which sprinklers or automatic detectors operated; or fires where there was a significant emount of damage.

If you do not have all the details of the fire, please provide as much information as you have, rather than not answer the question at all.

	Fire 1	2	3	4	5
Building Number (as used in Q.1)					
Year of fire 1975 or 1976					
Did sprinklers opurate?					
If sprinklers operated, how many heads operated?					
Was the fire discovered by automatic fire detectors?					
Were the brigade called?					
How was the fire extinguished?					
Brief description of damage (including area of fire damage)					

HOME OFFICE
Horseferry House, Dean Ryle Street, LONDON S.W.1P 2AW
Telex: 24986
Telephone: 01-

Our reference: SAP 11/13/1
Your reference:

October 1977

FIRE AND FIRE PROTECTION - A SURVEY OF MANUFACTURING INDUSTRY

Dear Sir

The Scientific Advisory Branch is undertaking a study of fire and fire protection measures on behalf of the Home Office. Much of the data needed for this study is already available from fire brigades and other sources, but there remains some essential information which is still missing. We are therefore writing to you, as one of a sample of firms in manufacturing industry, to ask whether you would be able to help us with this study by providing the information specified in the attached questionnaire.

The questionnaire covers two areas of information which are required for this study. The first question covers the description of the buildings. This will provide information on the buildings which are at risk, and the fire brigade statistics can then be examined against the background.

The second question is designed to elicit information about the total number of fires which occur in industry, and particularly those fires which were extinguished by sprinklers or discovered by automatic detectors in the early stages and to which the brigade did not therefore need to be called. At present we only know of those fires to which the brigade are called.

Your replies will be treated in confidence and the information will only be used in the research units of the Home Office Scientific Advisory Branch and the Fire Research Station.

If you require any further information about this survey please contact Mr R Rutstein of the Scientific Advisory Branch, telephone 01-211 5690 or 01-211 6757.

A reply-paid, addressed envelope is enclosed for your reply.

Thanking you for your co-operation.

Yours faithfully

R Rutstein

R. RUTSTEIN

HOME OFFICE
Horseferry House Dean Ryle Street London SW1P 2AW

Direct line 01-211
Switchboard 01-211 3000

Your reference

Our reference
SAF/11/13/1
Date

November 1977

FIRE AND FIRE PROTECTION - A SURVEY OF MANUFACTURING INDUSTRY

Dear Sir

About a month ago I sent you a questionnaire about fire and fire protection. It is important to have as many replies as possible to this questionnaire in order to obtain an accurate and reliable picture of fire and fire protection in industry. As we have not yet received a reply from you I am writing again, and enclosing a further copy of the questionnaire. I would be most grateful for your help and co-operation in this study.

If you have already returned your questionnaire please disregard this letter.

THE NEED FOR THE STUDY

The Scientific Advisory Branch is undertaking a study, on behalf of the Home Office Fire Department, of fire and fire protection in industry. Much of the information needed for this study is already available, but some of the essential information is still missing. It is therefore necessary to set up this survey and to ask you for this further information.

THE COMPLETION OF THIS QUESTIONNAIRE

You may feel that your reply would not be of interest because you have had no fires and there is a very low risk of fire in your premises. However it is essential to cover these cases in the survey if we are to obtain a fair and balanced picture of the risk of fire in industry.

Your company has been included in the survey as part of a randomly chosen sample. The questionnaire is intended to apply only to the site to which it is addressed, and not to any other part of the company which may operate at a different location.

The first question covers a description of buildings. If you have more than 5 buildings, and the detailed information is readily available, would you please note the details of the additional buildings on a continuation sheet. If you have a very large number of buildings a summary of these buildings would be sufficient. The summary may take the form for example, "Total floorspace of approximately 150,000 sq ft in 10 buildings. One building of 10,000 sq ft, used for production, is sprinklered".

The second question covers a description of fires which occurred in buildings. The fires of particular interest are those fires in which sprinklers or detectors operated, those fires to which the brigade were called, and any other fires which

caused a significant amount of damage. If there have been a large number of fires then a short summary of these fires would provide the information we require.

Your replies will be treated in confidence and the information will only be used in the research units of the Home Office Scientific Advisory Branch and the Fire Research Station.

If you require any further information about this survey please contact Mr R Rutstein of the Scientific Advisory Branch, telephone 01-211 5690 or 01-211 6757.

A reply-paid addressed envelope is enclosed for your reply.

Thanking you for your co-operation.

Yours faithfully

R. Rutstein

R RUTSTEIN
Principal Scientific Officer
Scientific Advisory Branch

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APPENDIX B

Building size distribution histograms

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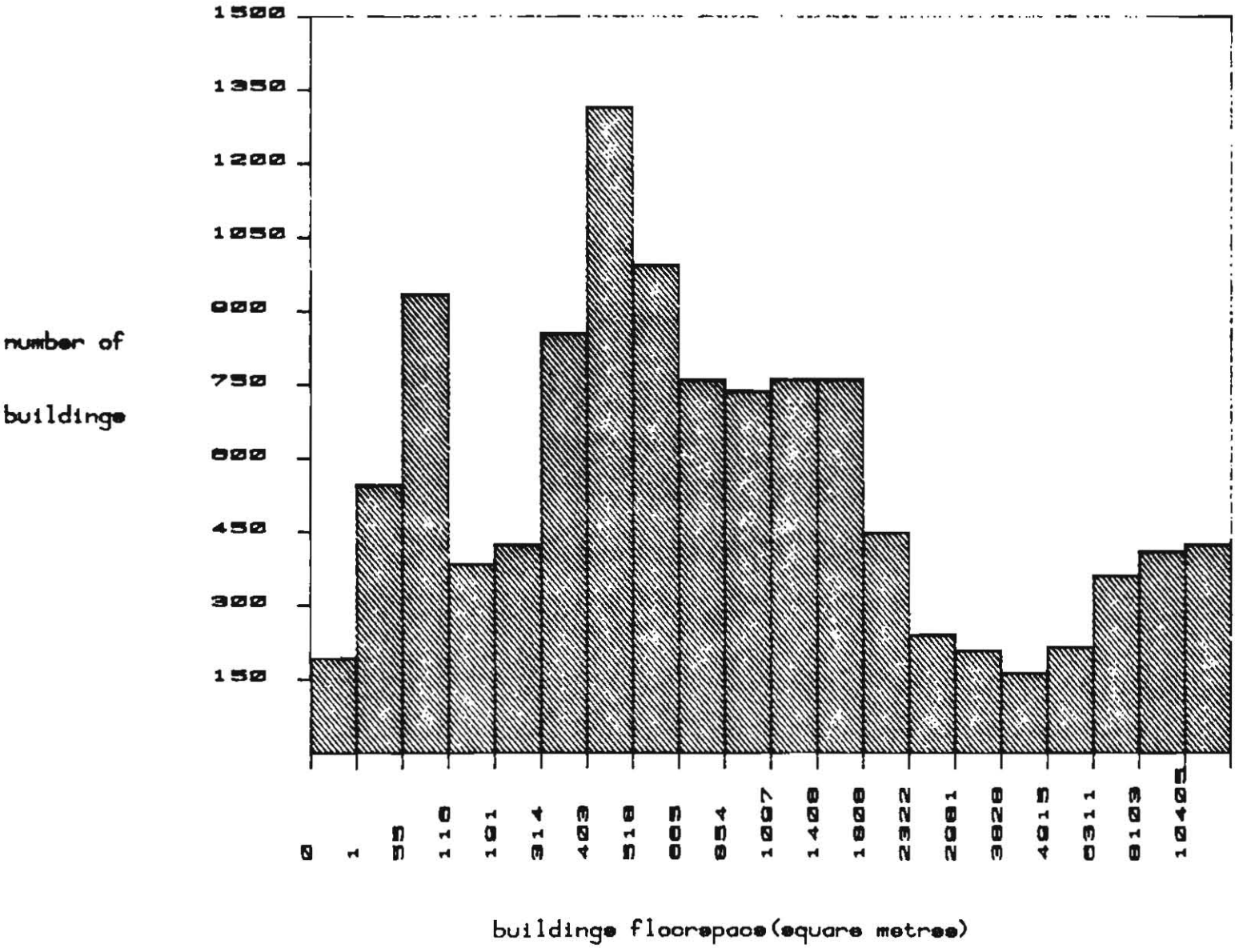

Figure B1: Food, Drink and Tobacco: Number of buildings by size

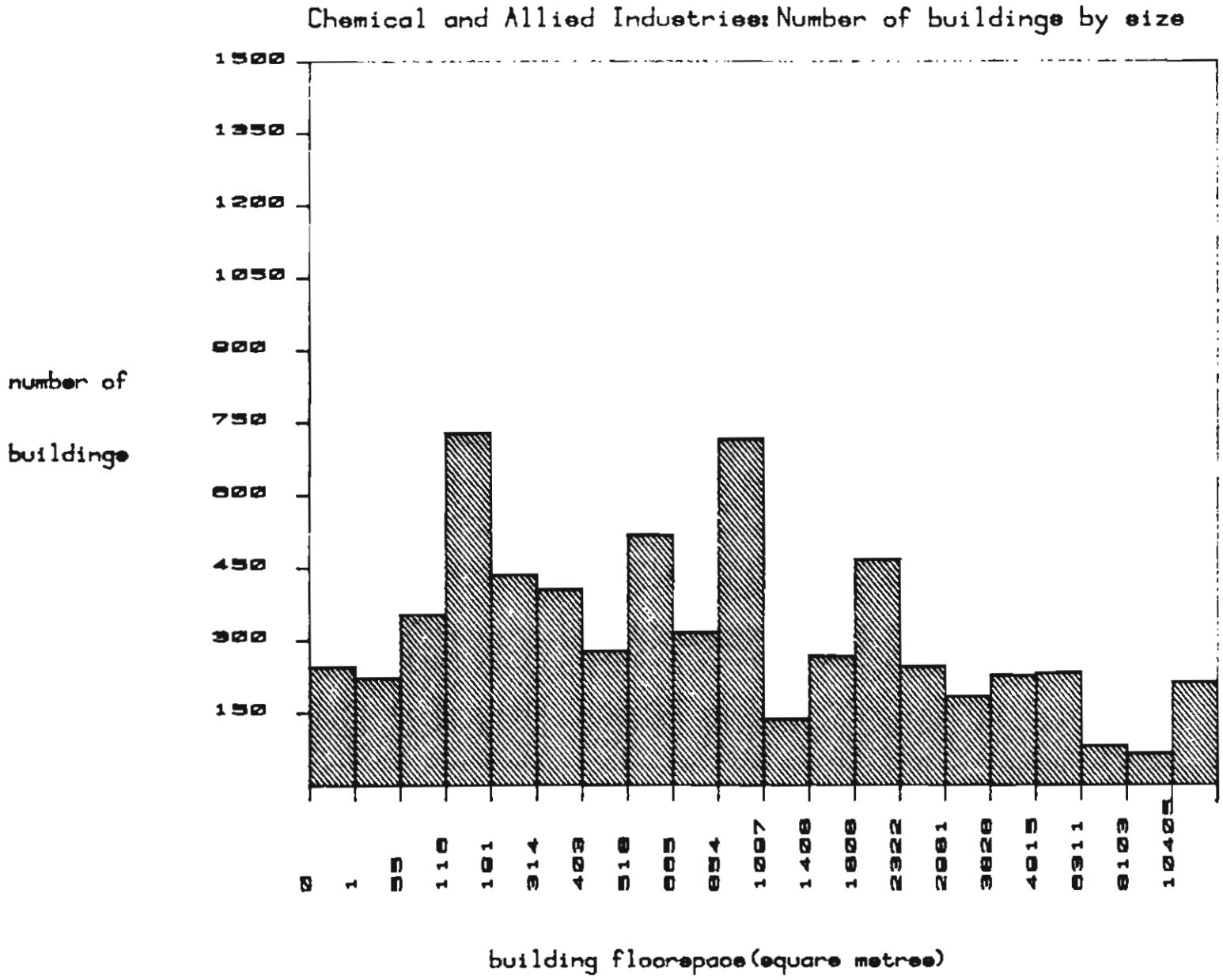

Figure B2: Chemical and Allied Industries: Number of buildings by size

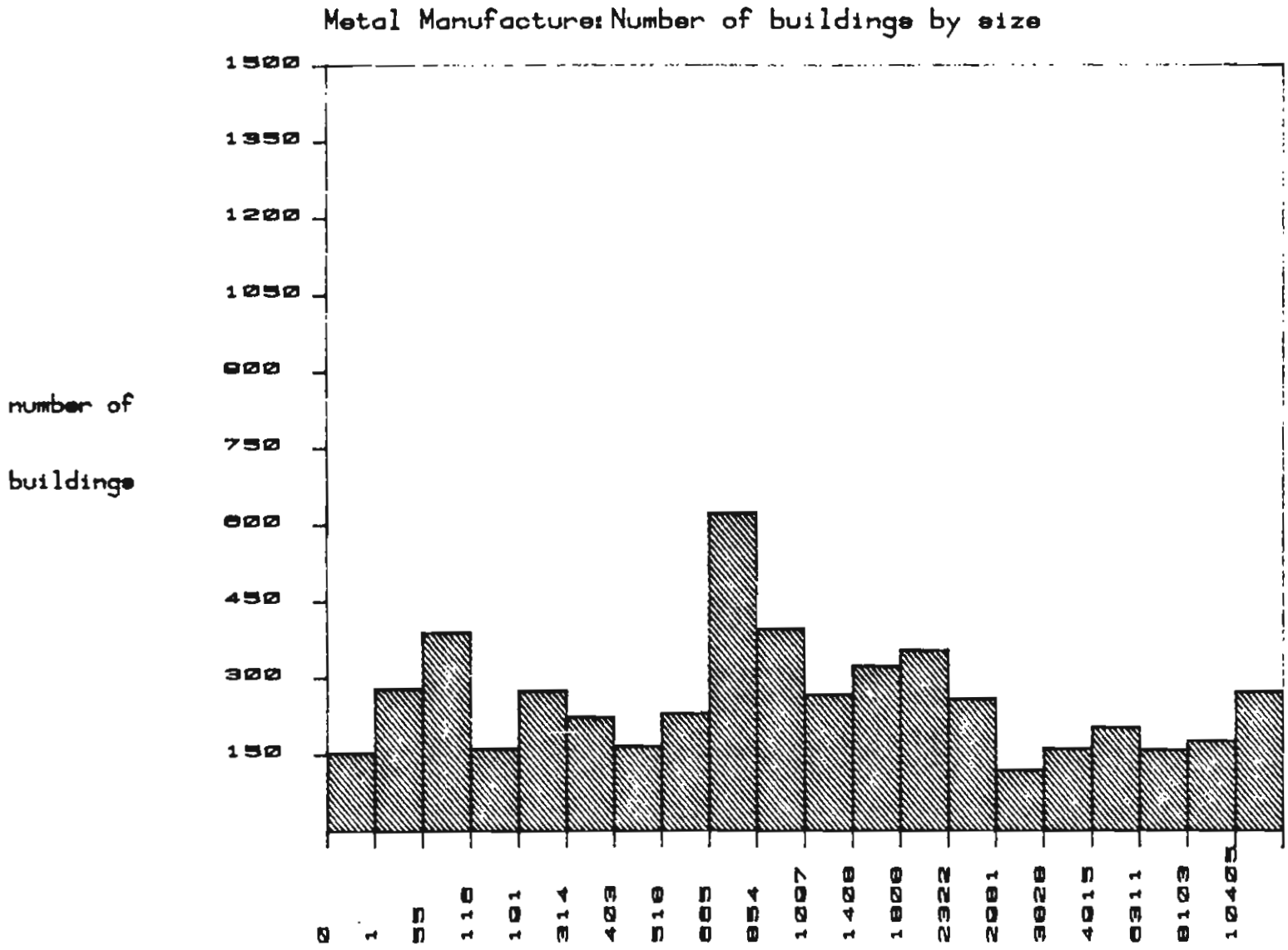

Figure B3: Metal Manufacture: Number of buildings by size

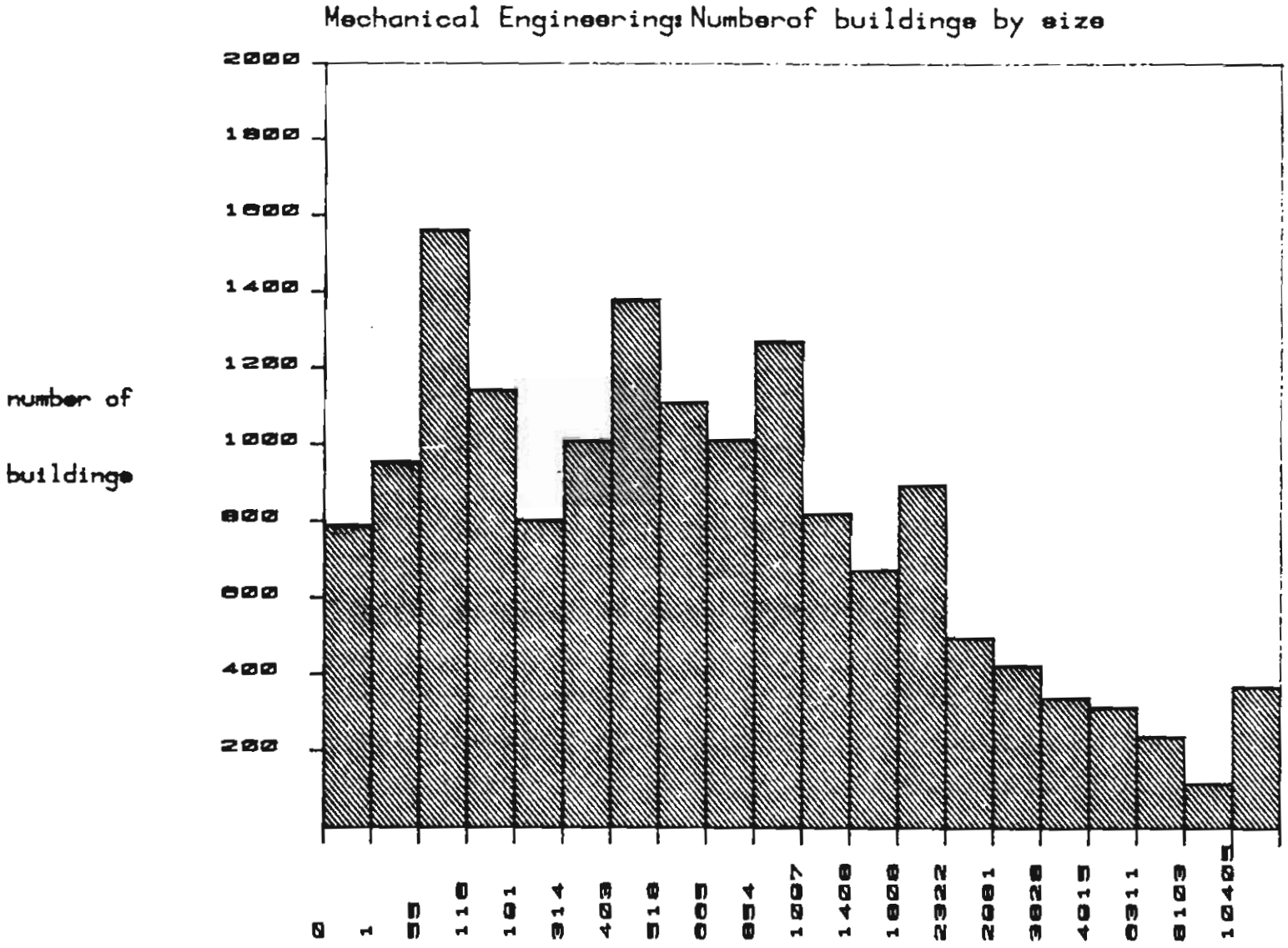

Figure B4: Mechanical Engineering: Number of buildings by size

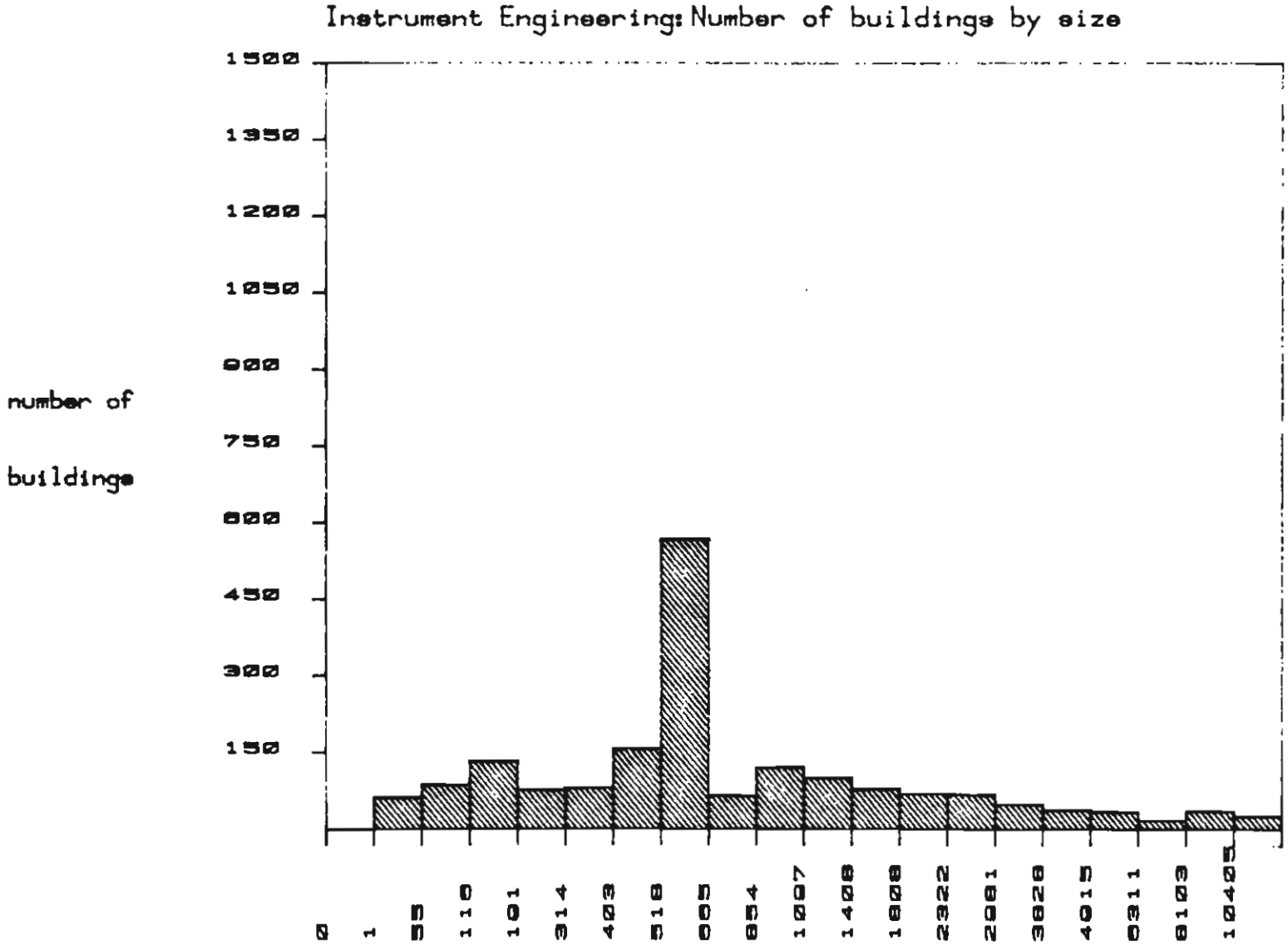

Figure B5: Instrument Engineering: Number of buildings by size

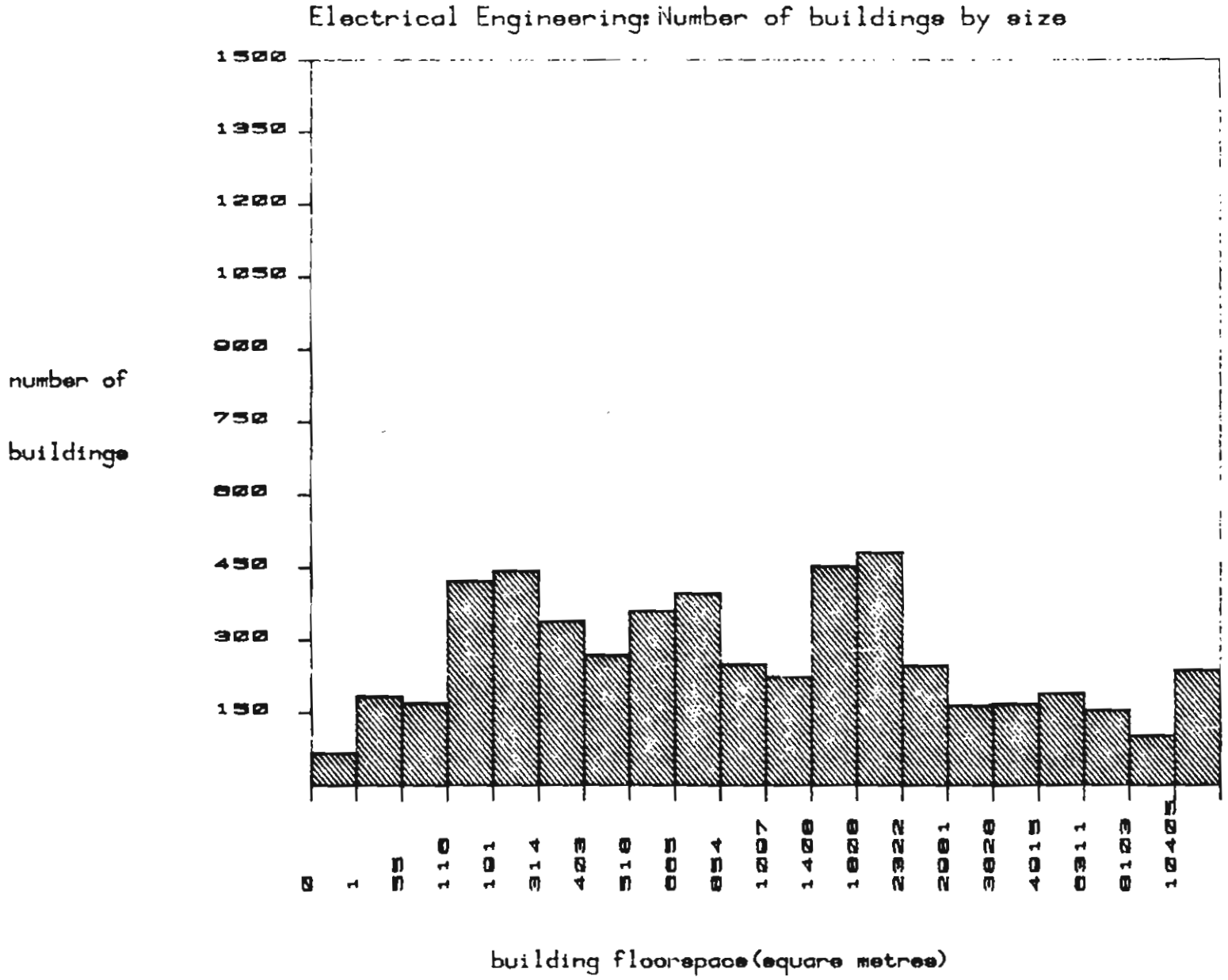

Figure B6: Electrical Engineering: Number of buildings by size

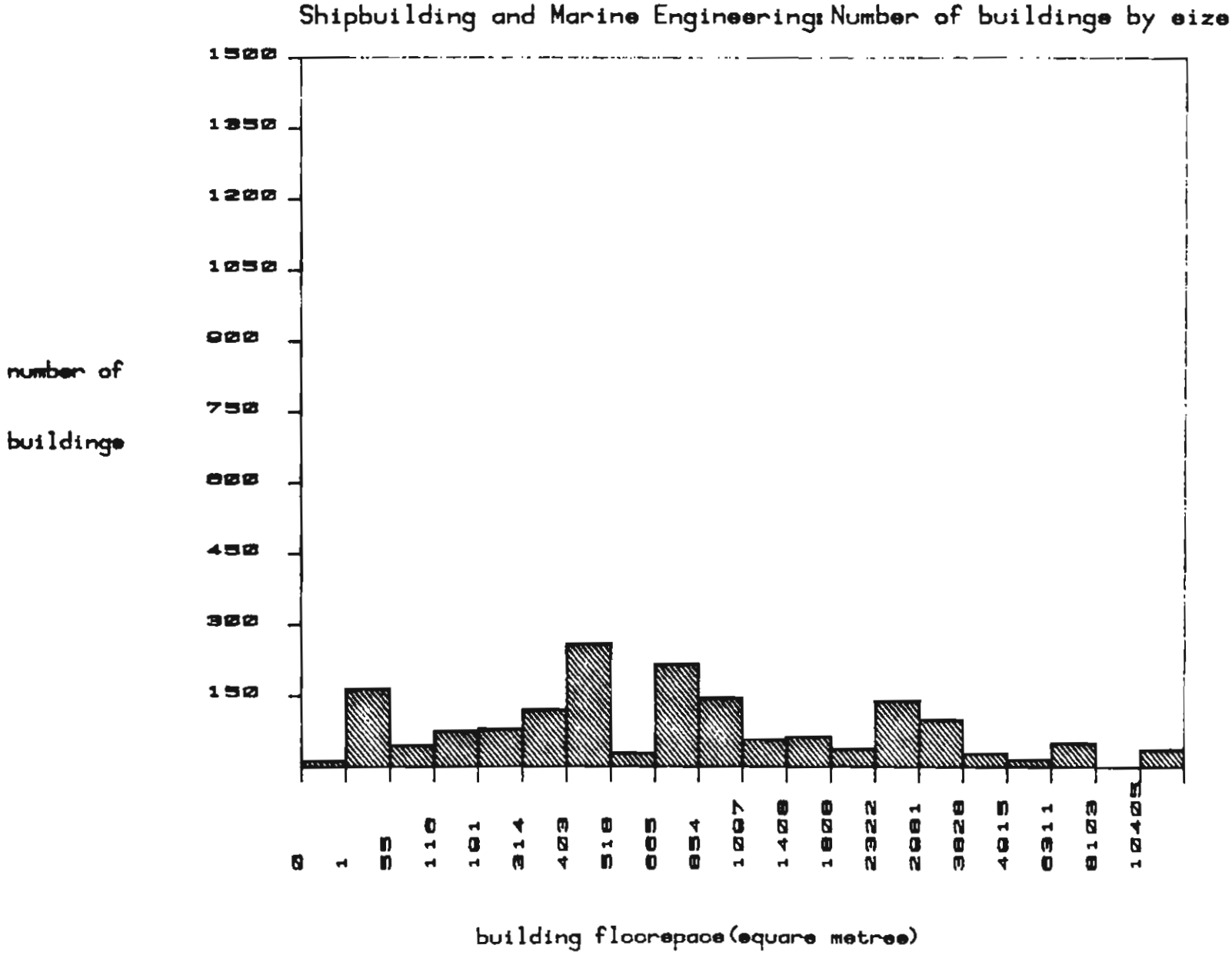

Figure B7: Shipbuilding and Marine Engineering: Number of buildings by size

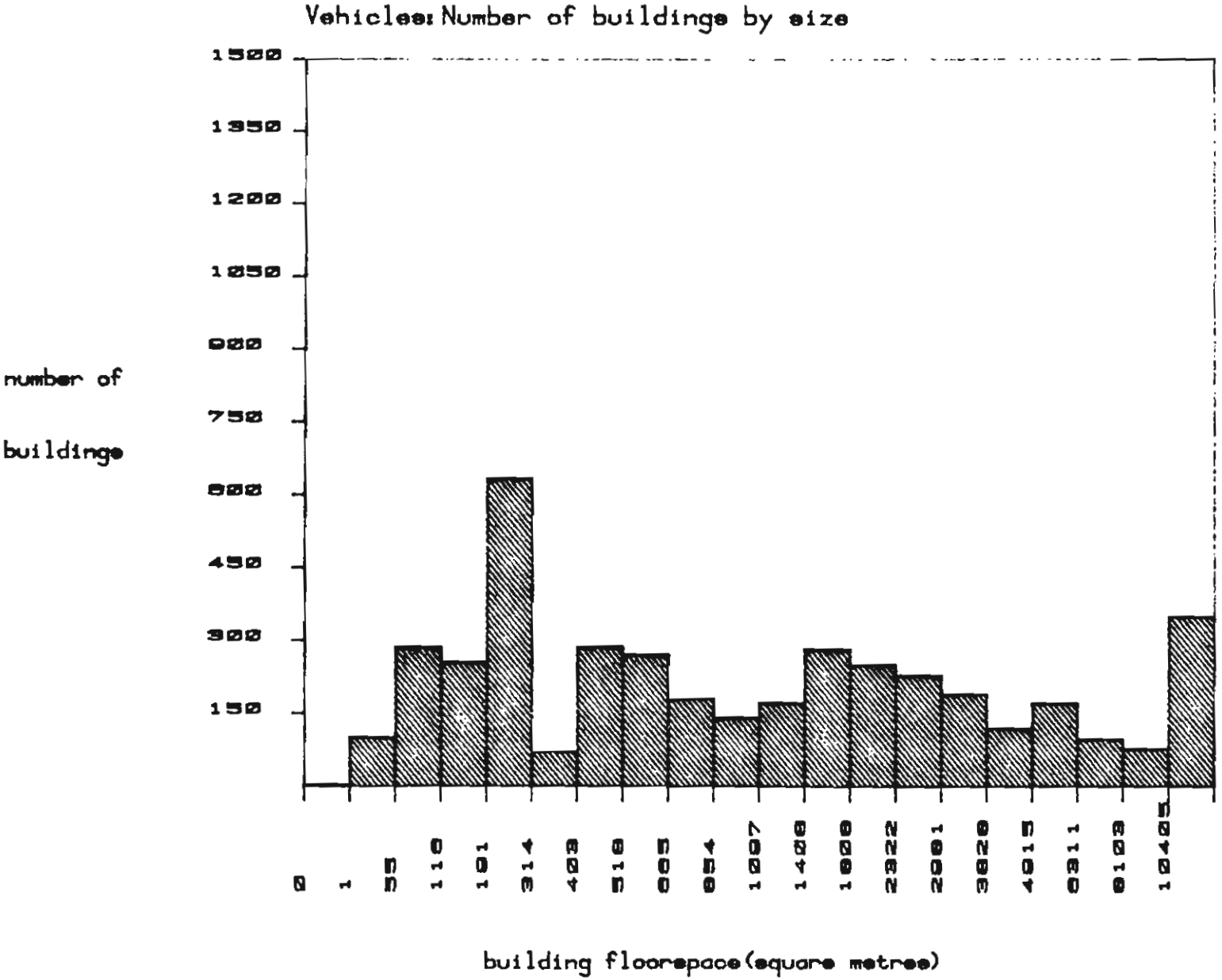

Figure B8: Vehicles: Number of buildings by size

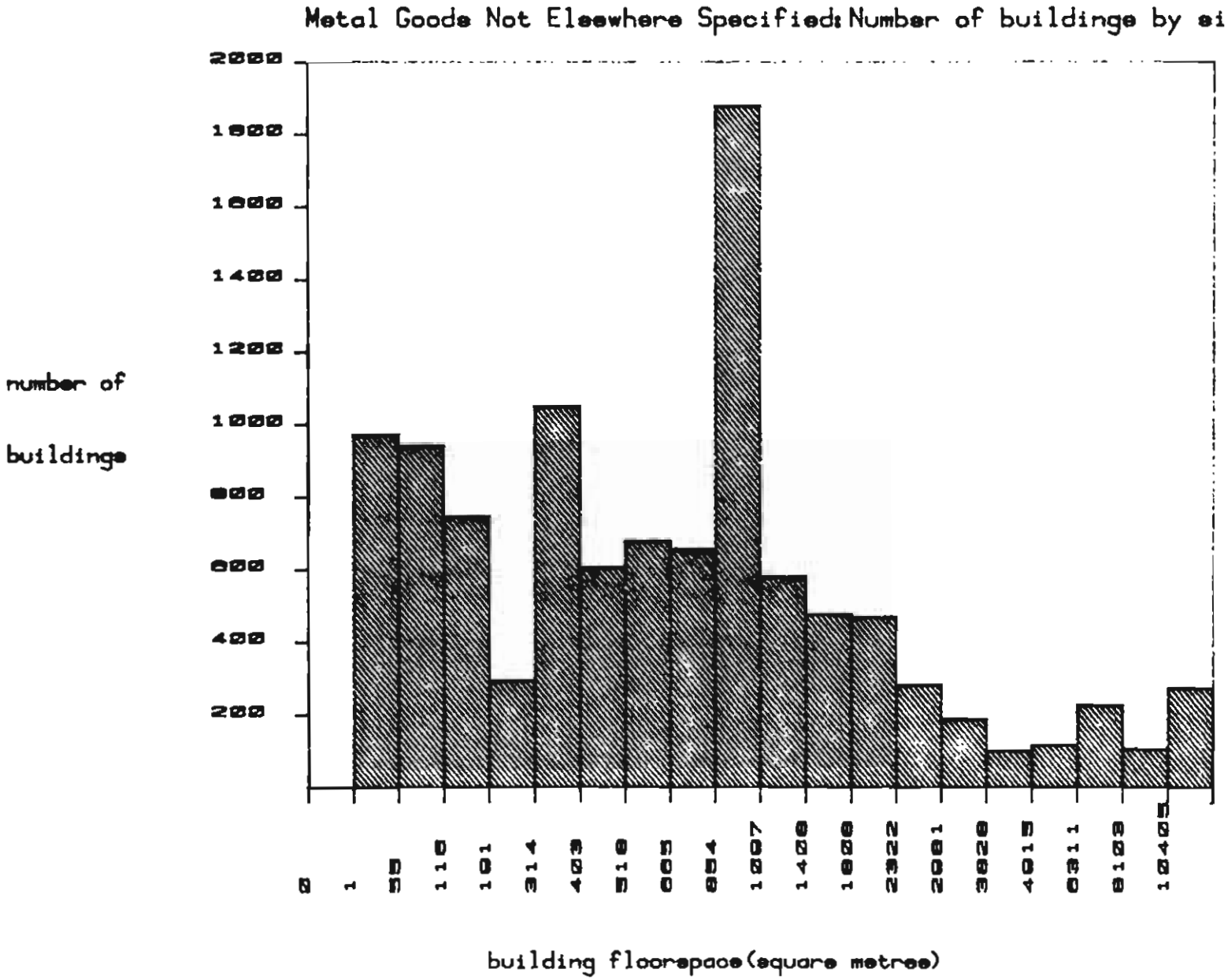

Figure B9: Metal Goods Not Elsewhere Specified: Number of buildings by size

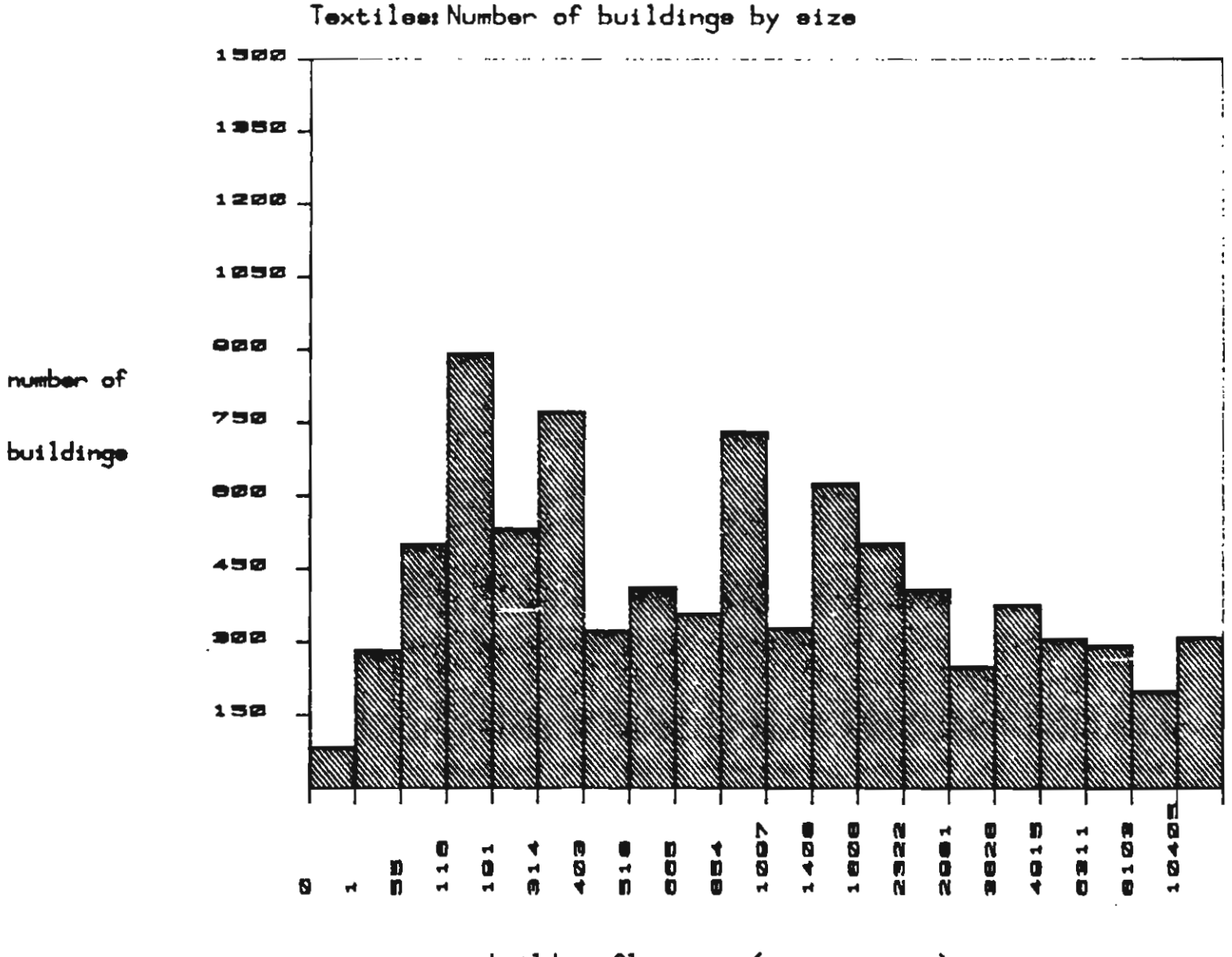

Figure B10: Textiles: Number of buildings by size

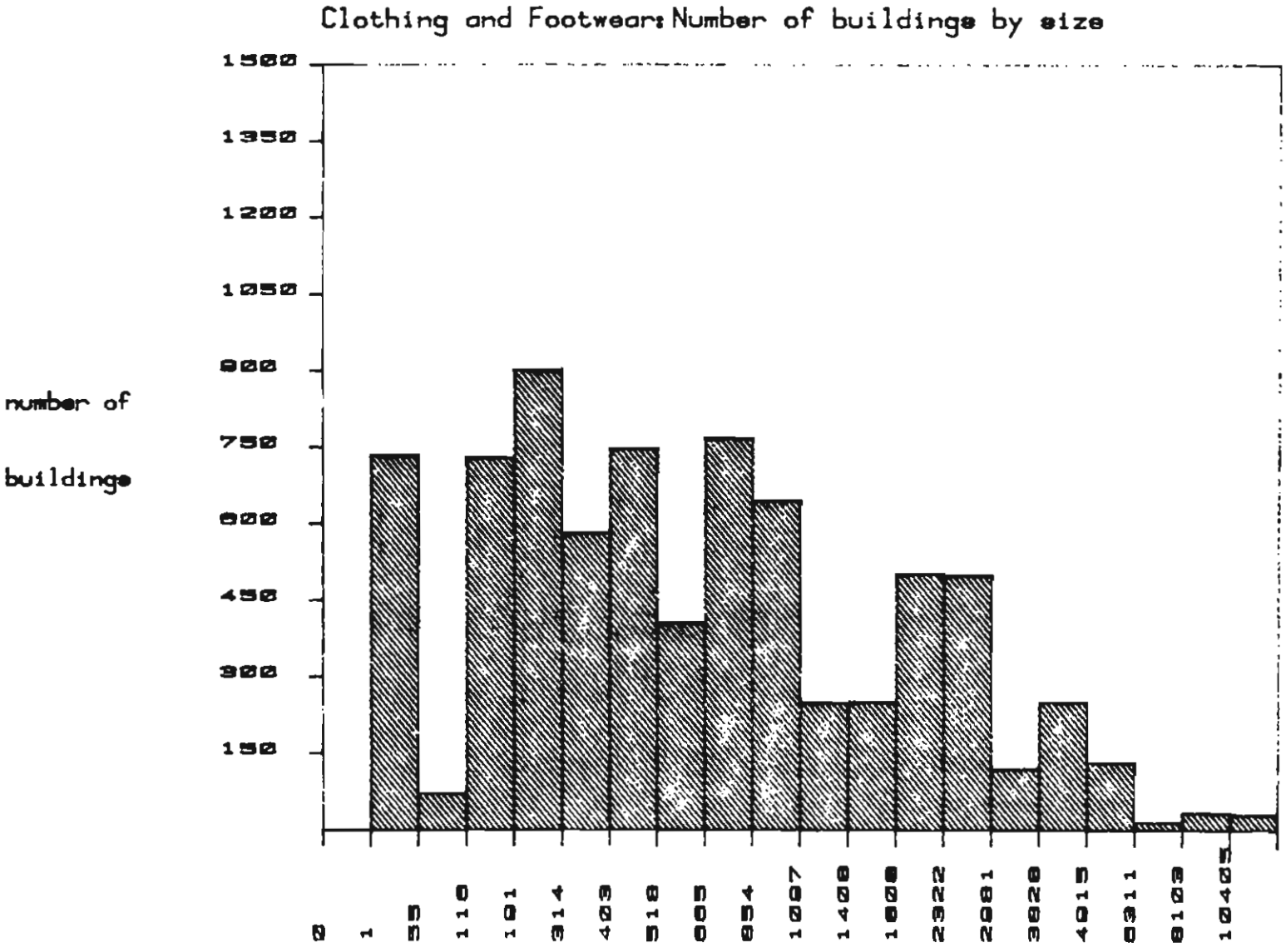

Figure B11: Clothing and Footwear: Number of buildings by size

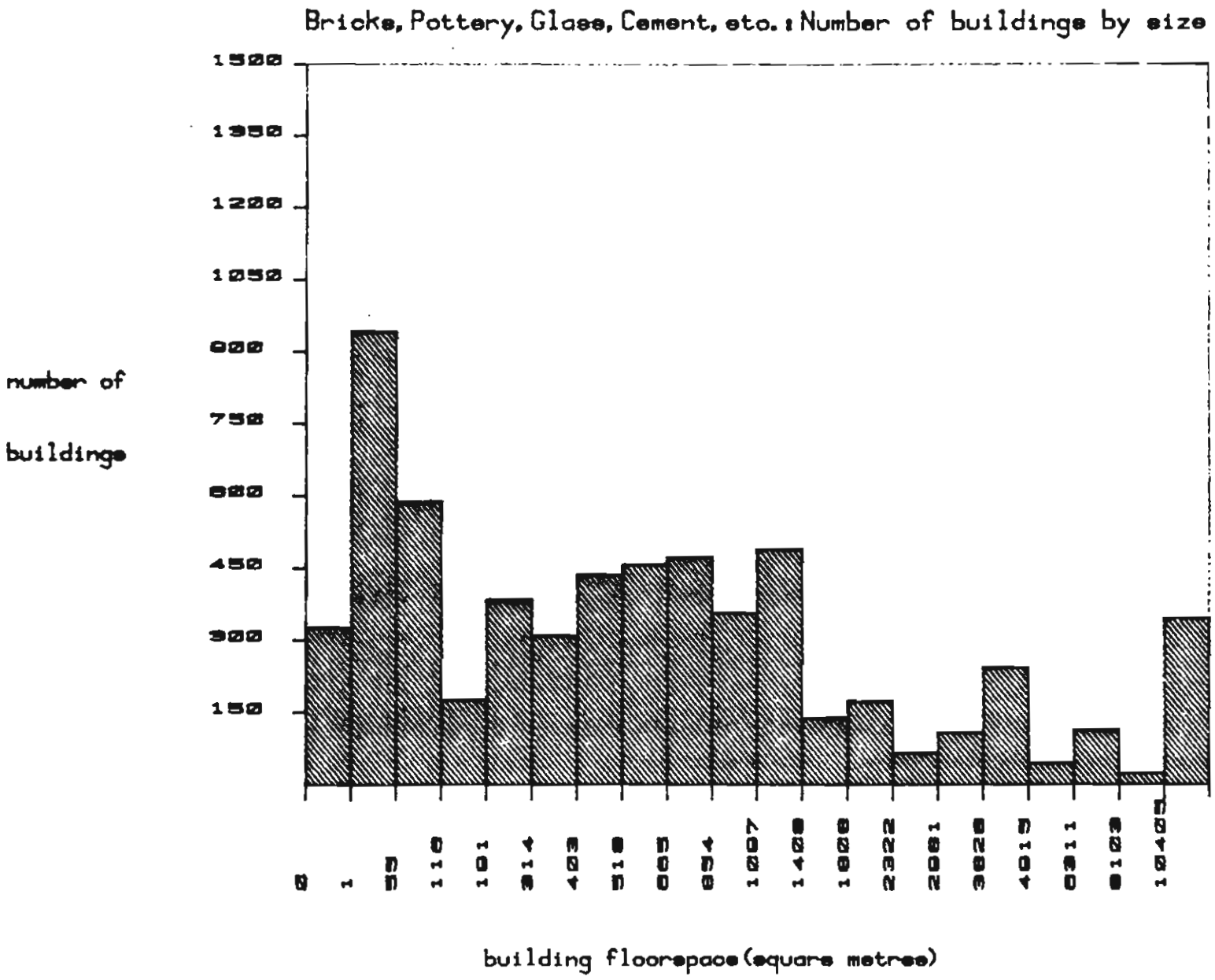

Figure B12: Bricks, Pottery, Glass, Cement, etc. Number of buildings by size

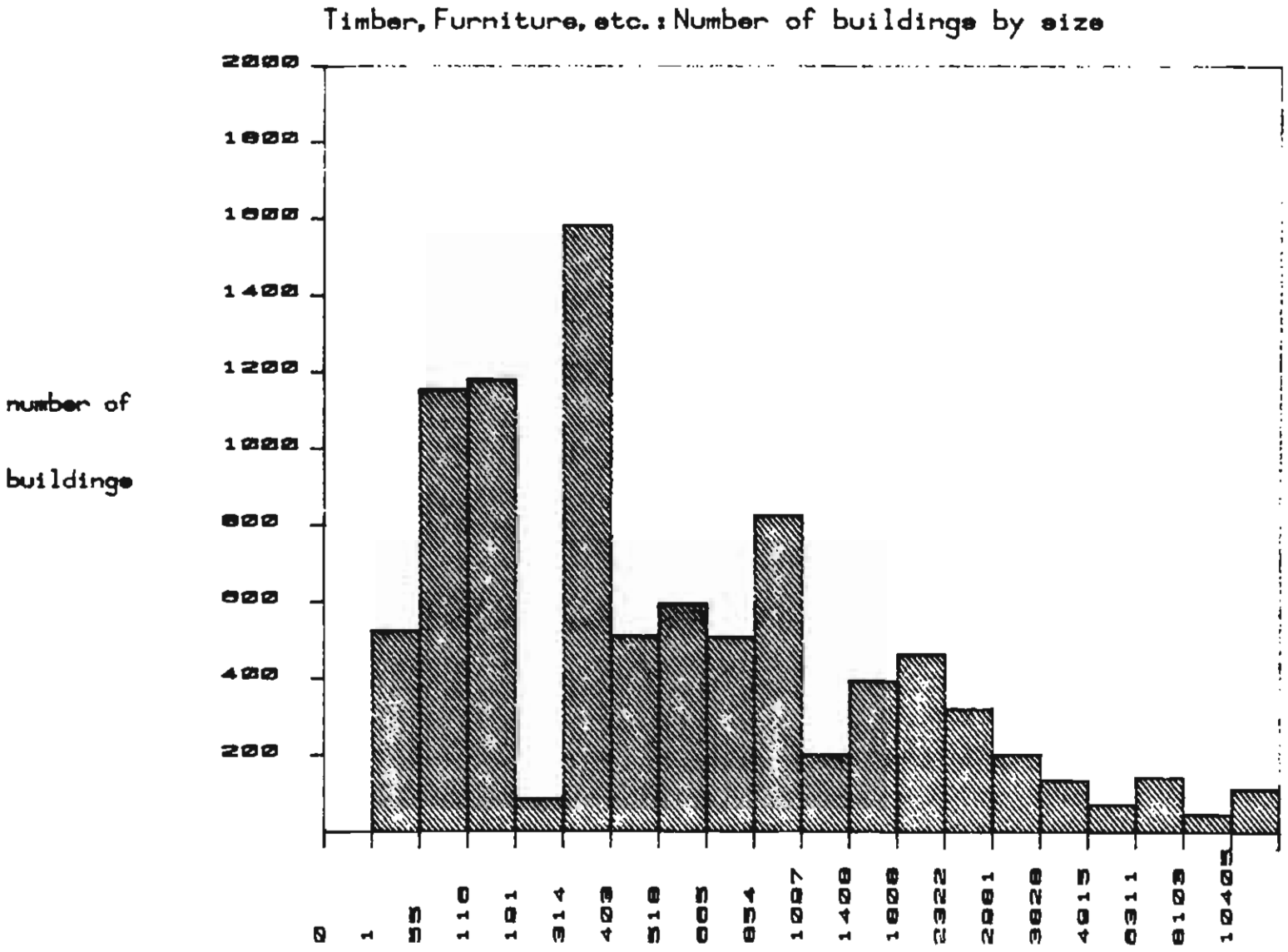

Figure B13: Timber, Furniture, etc.: Number of buildings by size

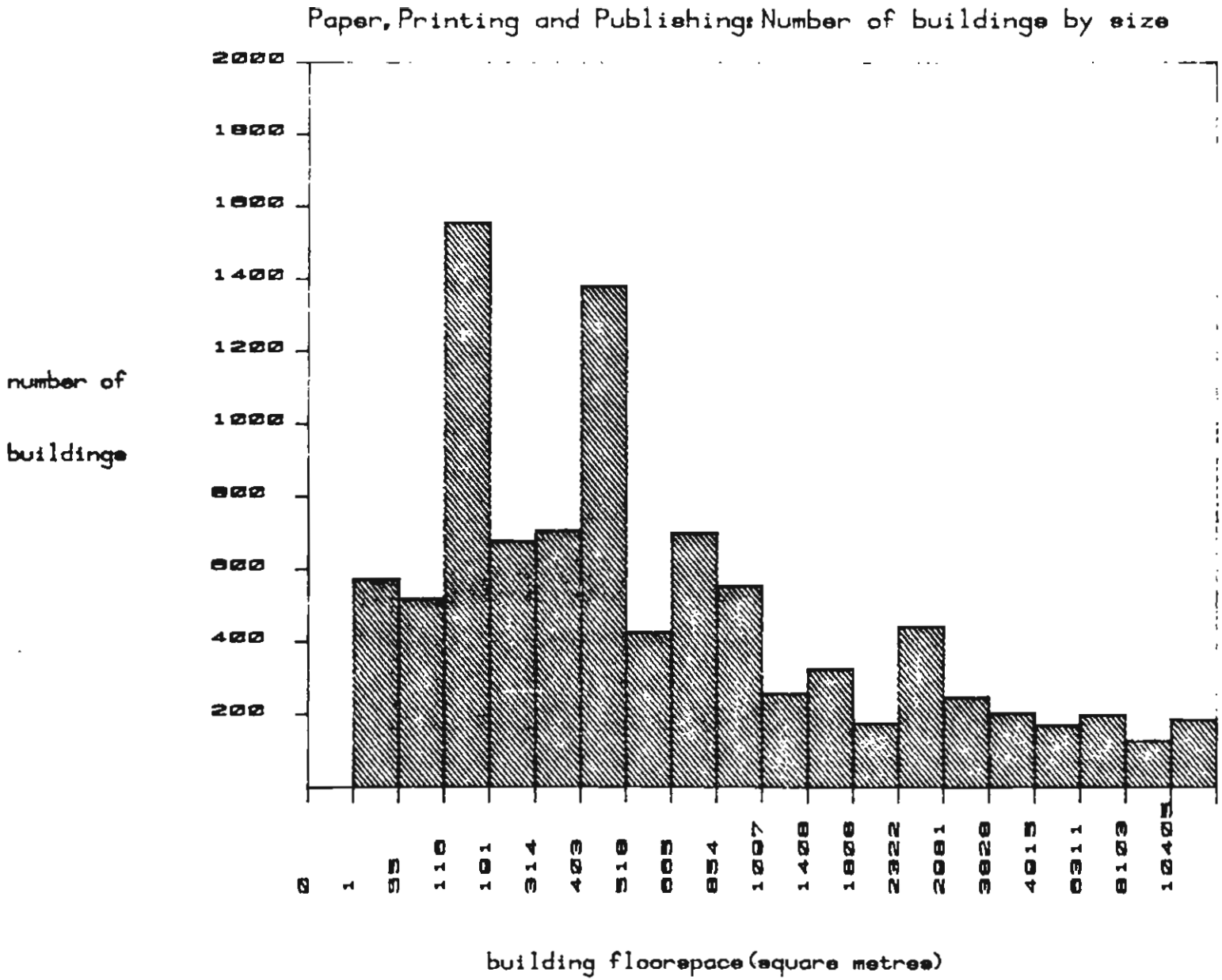

Figure B14: Paper, Printing and Publishing: Number of buildings by size

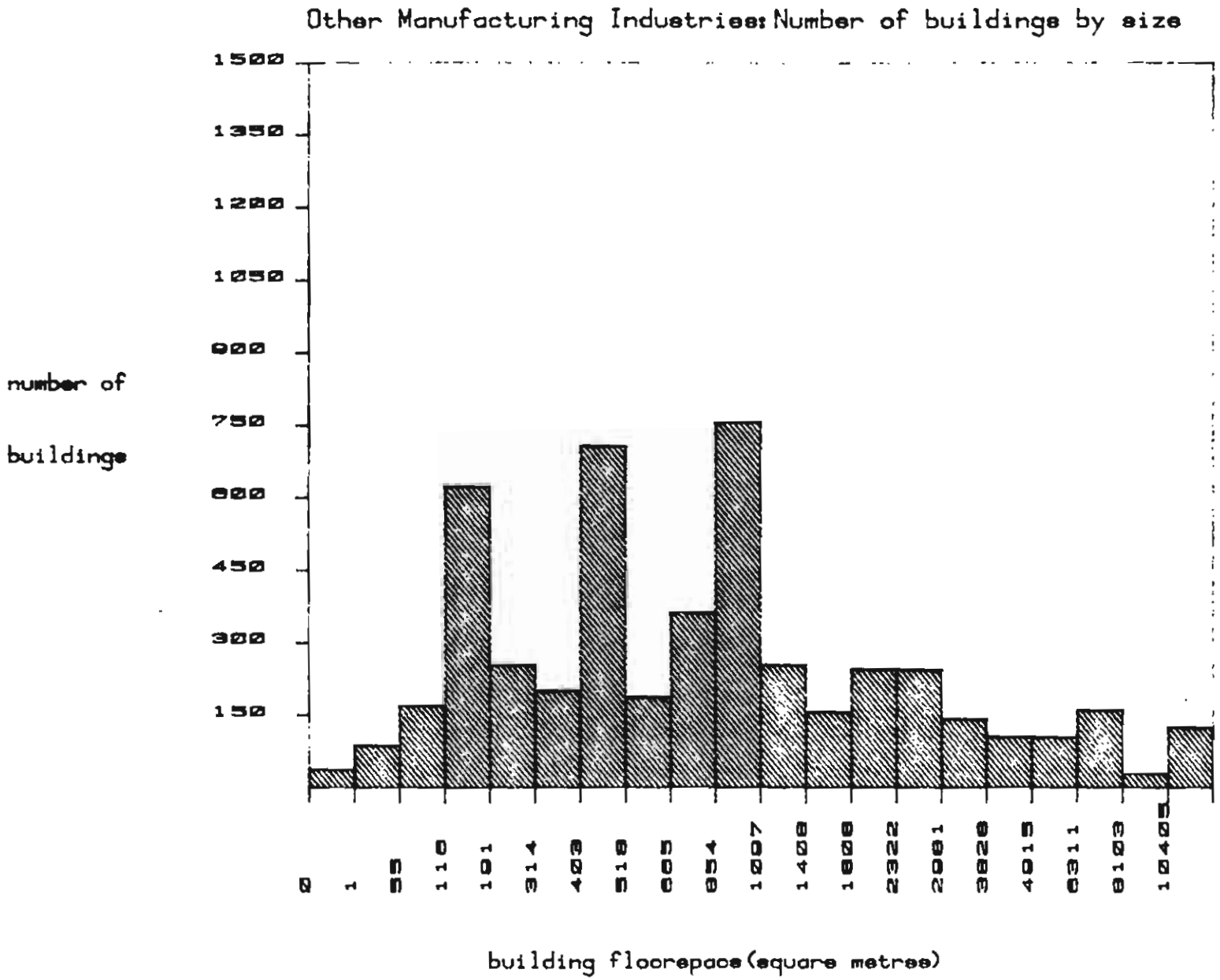

Figure B15: Other Manufacturing Industries: Number of buildings by size

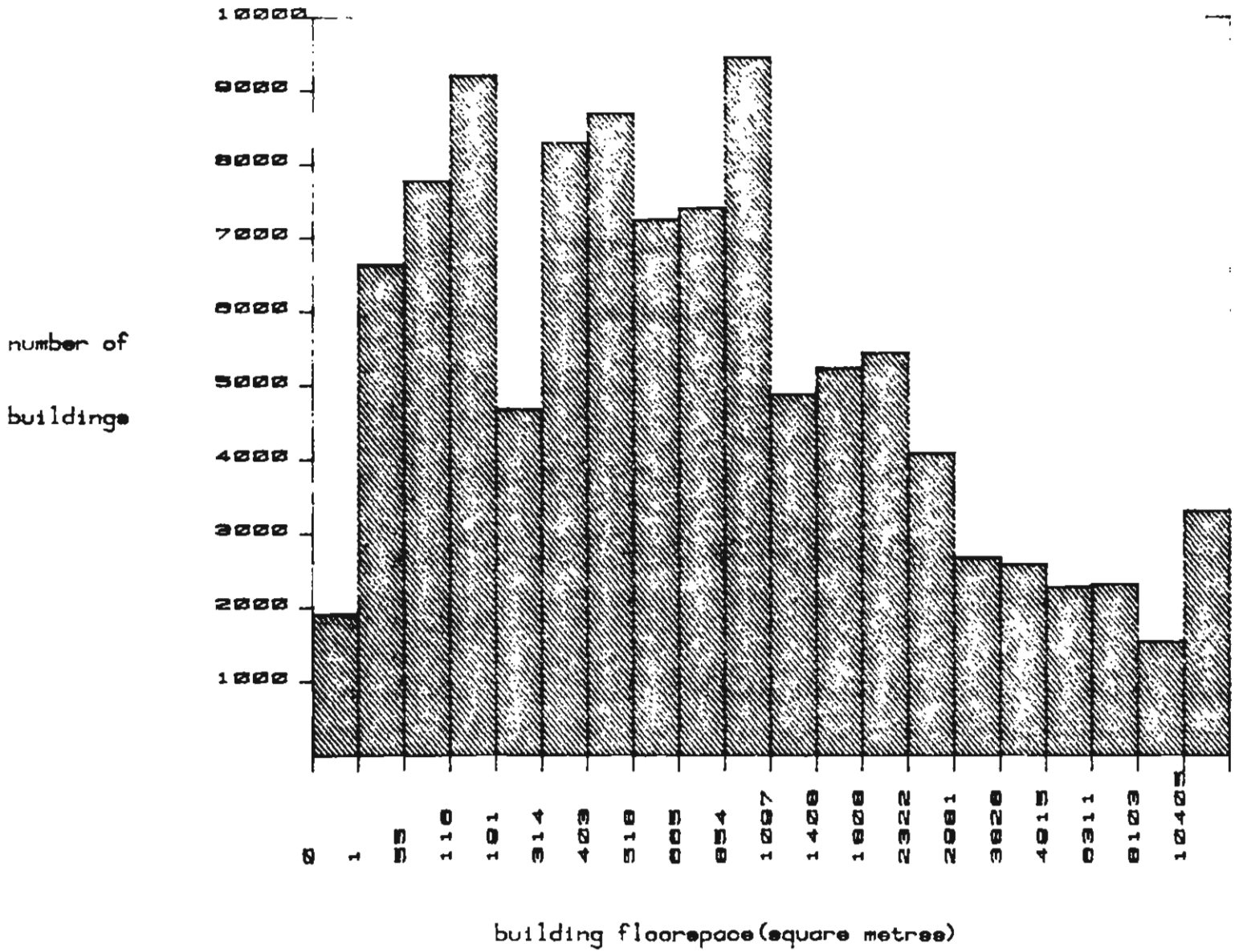

Figure B16: Manufacturing Industry: Number of buildings by size