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A NOTE ON THE EXTINCTION OF VERY LARGE FIRES

by

P. H. Thomas

Summary

Improving either or both fire protection and fire extinction methods might be expected to reduce the fire loss, and it is necessary to discuss the balance of effort into improving one or the other. This paper only discusses extinction and a comparison of typical laboratory results with actual fires suggests that the greater part of the time taken to control a large fire is consumed in increasing the fire-fighting effort up to the minimum value, below which no extinction at all is possible. An analysis of data of actual fires gives some interesting relationships and their significance is discussed.

July, 1957.

Fire Research Station,
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Introduction

It is known that comparatively few fires are responsible for the major part of the financial loss due to fire. For instance less than 0.3 per cent of the fires in Britain each assessed at causing over £10,000 loss are responsible for approximately one half(1) of the assessed fire loss. It is not immediately clear what is the best way to reduce this loss; an improvement in fire protection methods and regulations would be expected to reduce the incidence of both large and small fires, while an improvement in extinction methods might also be expected to reduce the number of small fires becoming large fires, but there is as yet insufficient information available to indicate what is the proper balance between these two lines of approach.

This paper is concerned only to refer to one aspect of this problem, namely the relation between the size of a large fire and the effort used to fight it. Two measures of this effort would be the total manpower, and the rate of delivery of water. One would in general expect these to be proportional to each other, but the requisite information is not listed in fire reports. Unfortunately the quantities of water used at any fire cannot be found because the size of jet and the applied water pressures are not specified. Nevertheless, over the large range of sizes of fires examined there will be a greater variation in the number of jets than in their size or the applied water pressures. Information of the number of jets used is given in the reports of fires and was therefore used as a first measure of fire-fighting effort.

Analysis of results

A statistical analysis of 48 fires ranging from 300 to 600,000 sq.ft in area(2) has indicated that despite considerable variation from fire to fire there was a definite trend over a large range of size of fire between the number of jets and the area (see Figure 1). The equation of the line in Figure 1 is

$$J = 0.1_2\sqrt{A} \qquad (1)$$

where J is number of jets used to control the fire.
A is ground area of fire in sq. ft.

It was also found that there was a similar relation between the reported time of control 'T' in minutes and the area 'A' as shown in Figure 2. The equation of the line in Figure 2 is

$$T = 1._c\sqrt{A} \qquad (2)$$

An attempt was also made to assess the proportion and size of fires which were controlled and extinguished before being effectively burnt out but the data were insufficient to draw useful conclusions. More detailed analysis showed that the fire loading per unit area influenced the number of jets but this is not as important a factor as the size of the fire area.

Discussion

There are at least two possible explanations of the relation expressed in equations 1 and 2.

The first is that the jet extinguishes an area of fire per unit time, and that there is a rate of build-up of jets largely independent of area.

If 'a' is the area of the fire at any time and 'r' the rate of build-up of jets, it follows from the above assumptions that

$$\frac{da}{dt} \propto r.t$$

i.e. $$A \propto rT^2$$

i.e. $$T \propto J \propto \sqrt{A}$$

From the numerical data a jet would on this model extinguish 17 sq.ft/min.

Although one minute is considerably higher than the time necessary to extinguish a fire in a room of 17 sq. ft[3], allowance must be made for the necessity of preventing re-ignition of the fire once extinguished. This explanation presupposes that the fire is fought inside the building.

Fought outside the building, the fire must be controlled by jets at a certain spacing around the perimeter. This in itself is a second explanation of equation 1, while the assumption of a steady build-up of jets would then lead to equation 2. The numerical data give a figure of about 30 ft. for the spacing. No doubt some fires are fought solely from outside until a relatively late stage in the control of the fire. On the other hand, others are fought from inside from an early stage.

The reported times of control (or 'stop' times) ranged from 30 minutes to several hours, and it is interesting to compare these with the few seconds or at most two or three minutes to extinguish fires under controlled conditions. Such short times are characteristic of all the common extinguishing agents, water,[3][4][5] foam,[6] dry powder,[7] vaporising liquids[8] when applied at a rate in excess of a certain critical rate below which no extinction or control is possible. These times are of the order 100-1000 times less than needed for large building fires and this is consistent with the view that the rate of delivery of water is for a long period below the critical rate appropriate to these fires, and that the fire-fighting effort is increased continually until this is achieved.

The amount of water

The amount of water used is proportional to the product 'J' and 'T' that is, approximately to the total area. If it is assumed that each jet is in operation for an average of half the total time, and that a typical jet is $\frac{3}{4}$ in. or 1 in. diameter operating at 60 lb sq. in. gauge, the mean amount of water is approximately 8 gal./sq. ft for the $\frac{3}{4}$ in. jet, or about twice this for the larger jet. Because this result is based on a sample which was deliberately chosen as representative of the large fire, this amount of water cannot be taken as representative for a small fire. In fact a room fire of 100 sq. ft would not be expected to take as much as one-tenth of this.

The rate of build-up of jets

As one might expect from equations 1 and 2, there is no correlation between the ratio of J/T and A. This is consistent with the view that there exists a parameter - the rate of build-up of jets - which is largely independent of the size of a fire and which may well be a limiting factor in extinguishing fires. If, in fact, the number of jets were increased at a steady rate, then indeed the number of jets and the time of control would be proportional to one another, and perfectly correlated. It would be interesting to know how variations in this rate of build-up of jets affects the number of jets and the time to control a fire of given area. One would expect that an increased rate of build-up produced earlier extinction with fewer jets, but this analysis cannot be undertaken with the data available at present. If this is so, it raises a number of organizational problems for fire brigades in assessing the appropriate amount and rate of build-up of resources at a fire.

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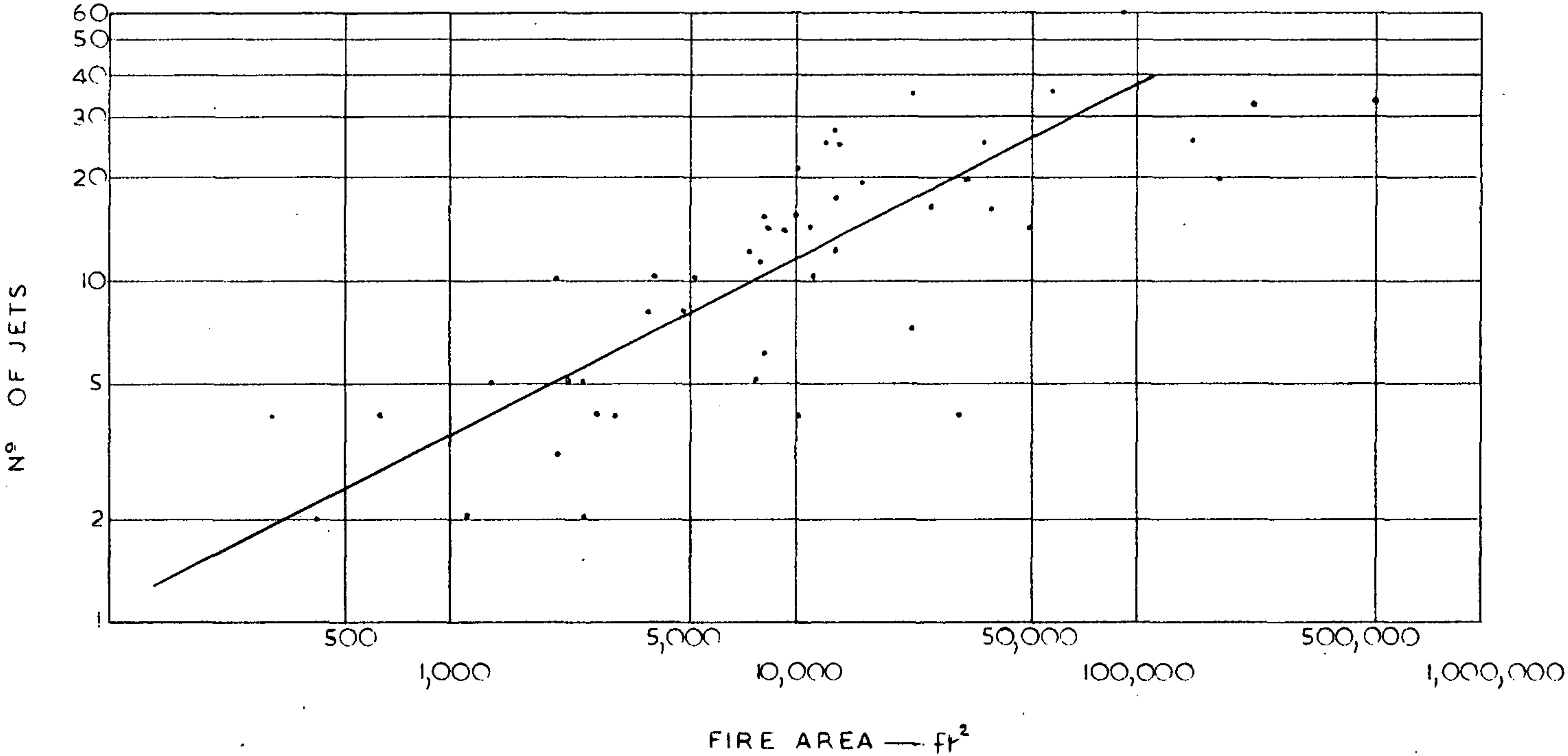

FIG. I. NUMBER OF JETS IN OPERATION AT THE CONTROL TIME AS A FUNCTION OF THE FIRE AREA

F.R. 246 1/2743.

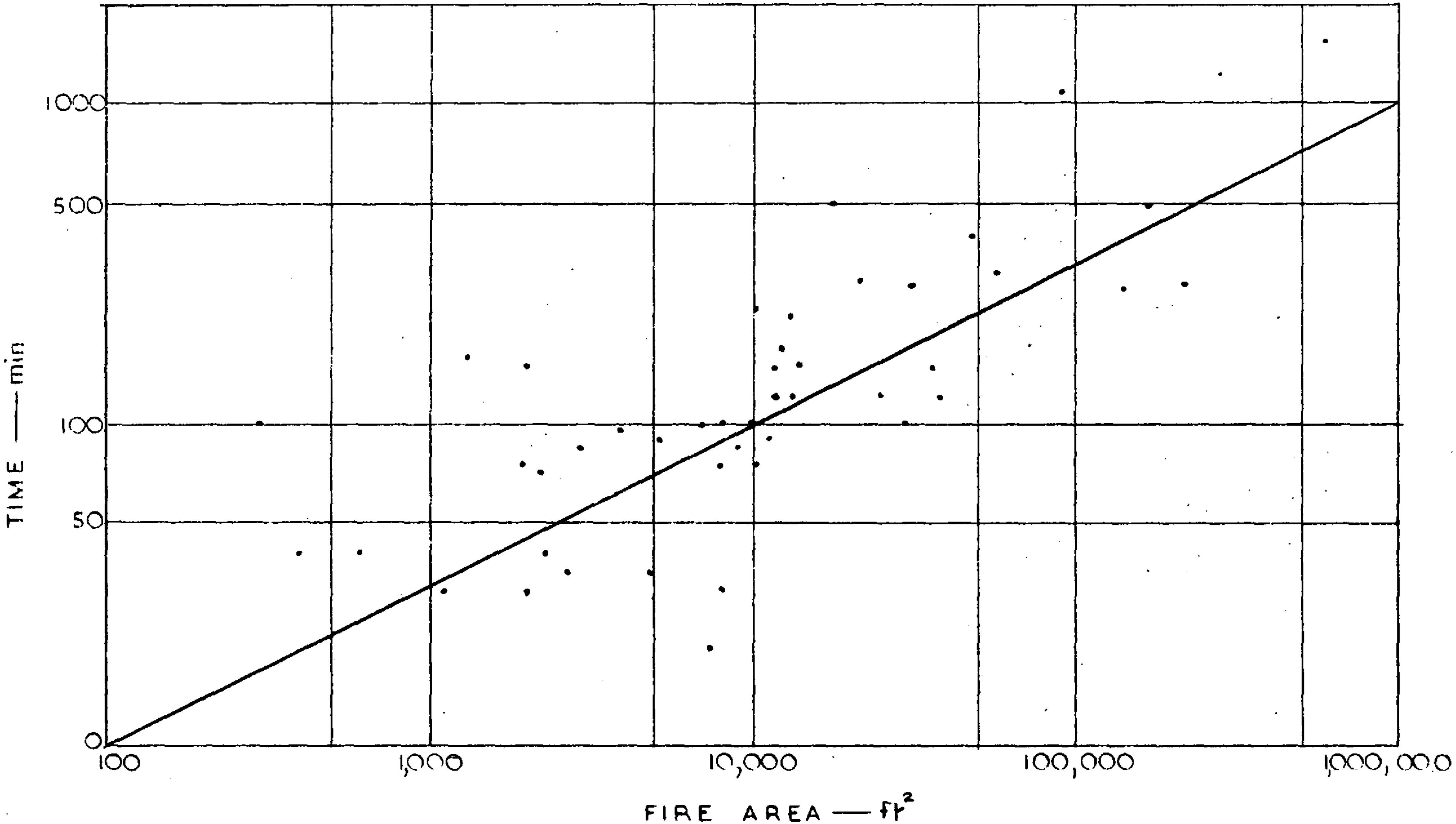

FIG. 2. TIME OF CONTROL AS A FUNCTION OF THE FIRE AREA