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JOINT FIRE RESEARCH ORGANIZATION

THIS REPORT HAS NOT BEEN PUBLISHED AND

THE RELATIVE FLAMMABILITIES OF CARDED FIBRES

by

C. T. Webster and M. J. Gregsten

Abstract

A test is described for measuring the vertical flame speed on carded web. This test has been used to determine the relative flammability of carded webs made from a variety of fibres. Further, it is indicated that the weight per unit length affects the flammability.

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THE RELATIVE FLAMMABILITIES OF CARDED FIBRES

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At the request of the Fire Offices' Committee an investigation has been made to develop a test which would permit fibres made up into carded webs to be classified according to their fire hazard.

Flames spread most rapidly up materials which are hanging in the vertical direction and since flexible materials naturally hang vertically the vertical flame speed would seem to be the most rational method of assessing their hazards. The speeds of the flame front will also take account of the ease of ignition of the fabric since the process of flame spread is one of continuous ignition as the flame front spreads: materials which ignite easily would be expected to spread flame rapidly.

Apparatus for the vertical burning of materials

The apparatus Figure 1 used in the vertical burning tests consisted of a torsion balance, a camera and a light source. The torsion balance was constructed of a cast steel U-shape stand with a $7\frac{1}{2}$ in. long .036 diameter steel wire tensioned between the arms. At the mid point of the wire the balance arm was secured and above the fulcrum a concave mirror was fixed. A parallel beam of light was directed on the mirror from a light source. The light from the mirror was brought to a focus at the camera placed at a distance of 22 in. The camera consisted of a drum 7 in. in diameter around which photographic paper was wrapped. The drum was supported on the spindle of an electric motor which turned it at a constant rate of four revolutions per minute, the whole being enclosed in a box with a slit, 1/32 in. wide, on one side through which the beam of light from the mirror passed. As the drum revolved the movement of the beam of light, dependent on the change in angle of the mirror at the fulcrum, recorded the change in weight of the material suspended from the balance arm on the photographic paper.

Preliminary experiments showed that the maximum speed of flame travel was reached in all materials in specimens 6 ft in length, and a standard of 6 ft by 4 in. was adopted for the size of specimen.

Before each test piece was burnt, the apparatus was calibrated by hanging weights on the balance arm in the position to be occupied by the web. After calibration the specimen was hung in position and a trace obtained for the initial weight. The lower end of the specimen was ignited by a small flame and a record obtained of the rate at which it lost weight while flaming. A sample trace is shown in Figure 2. From the photographic traces curves were prepared showing the weight of specimen at various times. The curves were straight lines over most of their length, the slope of the lineal portion giving the rate of loss of weight. From these curves it is possible to derive the vertical speed of burning in the following manner. If r is the rate of loss of weight this must equal the speed of the flame front v multiplied by the loss in weight per unit length of the strip as it burns. Thus if the strip has a length l and an initial weight w_1, and the weight of the residue after burning is w_2, then

$$r = \frac{v}{l} (w_1 - w_2)$$

and the flame speed is thus given by $v = \frac{r\,l}{w_1 - w_2}$

Materials

The carded webs used in this investigation were supplied by Dr. Whewell of Leeds University. The machine used to make the carded web is known as a scribbler and is a part of the equipment of the Textile Department. Although this machine is smaller (7 ft long, as compared with say 20 ft long) than those used in general practice, it may be reasonably assumed that the sliver produced is substantially the same. Fourteen types of fibre were made into carded webs and tested, namely,

Fibro	Nylon	Vivyon
Cotton	Cellafibre	Wool Noil
Orlon	Wool tops	Clean wool
Ardil	Greasy wool	Fibrolane
	Lyhel	Merinova

Additional tests were made on carded Fibro made up into three weights of sliver namely light, medium and heavy.

Experimental results

The results of the experiments are shown in Table 1, each result being the average for three specimens. The Cellafibre could not be made to burn vertically because it melted in front of the flame. However, by heating with a bunsen burner the molten drops burnt with some persistence when they fell on a bench. Table 2 gives the individual results obtained with the three weights of carded Fibro, and the weights of the 6 ft lengths tested. Figure 3 is a curve for the average weight against flame speed.

Discussion of results

The results of the vertical spread of flame tests are given in Table 1 in order of increasing flammabilities and in pictorial form in Figure 4 The order is in substantial agreement with practical experience. It must be remembered, however, that the results given in Table 1 are tests on slivers assumed to be in a similar condition to that in which they are used in practice. From Figure 5 it may be seen that the weight, or degree of dispersion of the sliver affects the vertical flame speed to a significant extent. Some tests have been made with the webs burning at various angles to the vertical and though rate of burning may be slower the materials still fall in the same order of relative flammability. It was not possible within the range of materials so far examined to calibrate an apparatus of this kind, though this may be possible at a later date.

Conclusions

A test has been described for the measurement of vertical flame speeds on carded webs; the results are considered to give a measure of the flammability of these materials. The relative flammabilities have been determined for a variety of slivers assumed to be in a similar state to that in which they would be used in practice. The results indicate that of the samples tested Fibro and Cotton are considerably more hazardous than any other. It has been shown that the weight per unit length and therefore the degree of dispersion of the material has a significant effect on the vertical flame speed.

TABLE 1

Type of carded web	Weight per 6 foot grams	Vertical flame speed cm/sec
Dynel		No spread
Nylon		" "
Vinyon		" "
Celafibre		" "
Wool Oil	14.0	2.5
Wool top	10.4	4.3
Greasy Wool	10.0	4.6
Merinova	10.1	5.3
Clean Wool	6.12	5.8
Orlon	15.0	8.2
Ardil	18.0	9.4
Fibrolane	17.7	11.1
Cuprama	8.2	57
Cotton	12.4	96 - Burnt on the surface leaving a core of charred material
Fibro	7.9	129

Table 2

Heavy weight carded Fibro		Medium weight carded Fibro		Light weight carded Fibro	
Weight of 6 ft length gm	Vertical flame speed cm/sec	Weight of 6 ft length gm	Vertical flame speed cm/sec	Weight of 6 ft length gm	Vertical flame speed cm/sec
17.2	96.7	15.5	62.5	6.2	147
16.2	73.5	14.3	89.5	6.8	139
16.0	46.9	18.0	110	6.5	145
19.4	74.5	15.0	81.8	6.25	151
17.0	74.3			6.9	172
17.3	42.5	Mean = 15.7	Mean = 85.95	6.15	162
16.0	52.5			5.85	205
19.0	79.0	Standard deviation 1.61	Standard deviation 19.65	5.60	124
				7.15	124
Mean = 17.3	Mean = 69.98			6.3	128
				5.65	146
Standard deviation 1.3	Standard deviation 18.5	Coefficient of variation = 0.10	Coefficient of variation = 0.23	Mean = 6.3	Mean = 149.4
Coefficient of variation = 0.08	Coefficient of variation = 0.26			Standard deviation 0.5	Standard deviation 23.78
				Coefficient of variation = 0.08	Coefficient of variation = 0.16

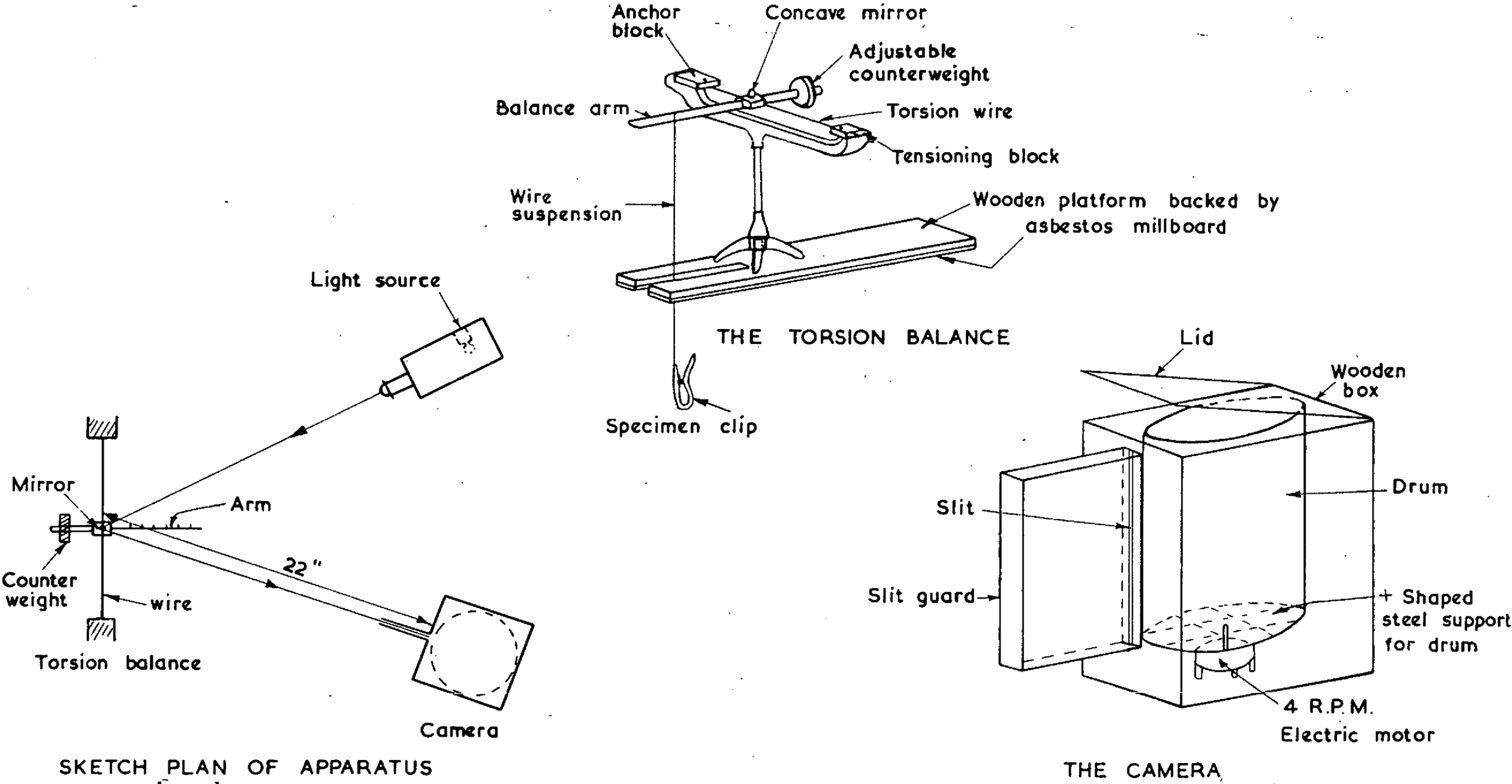

FIG.1. APPARATUS FOR DETERMINING VERTICAL FLAME SPEED

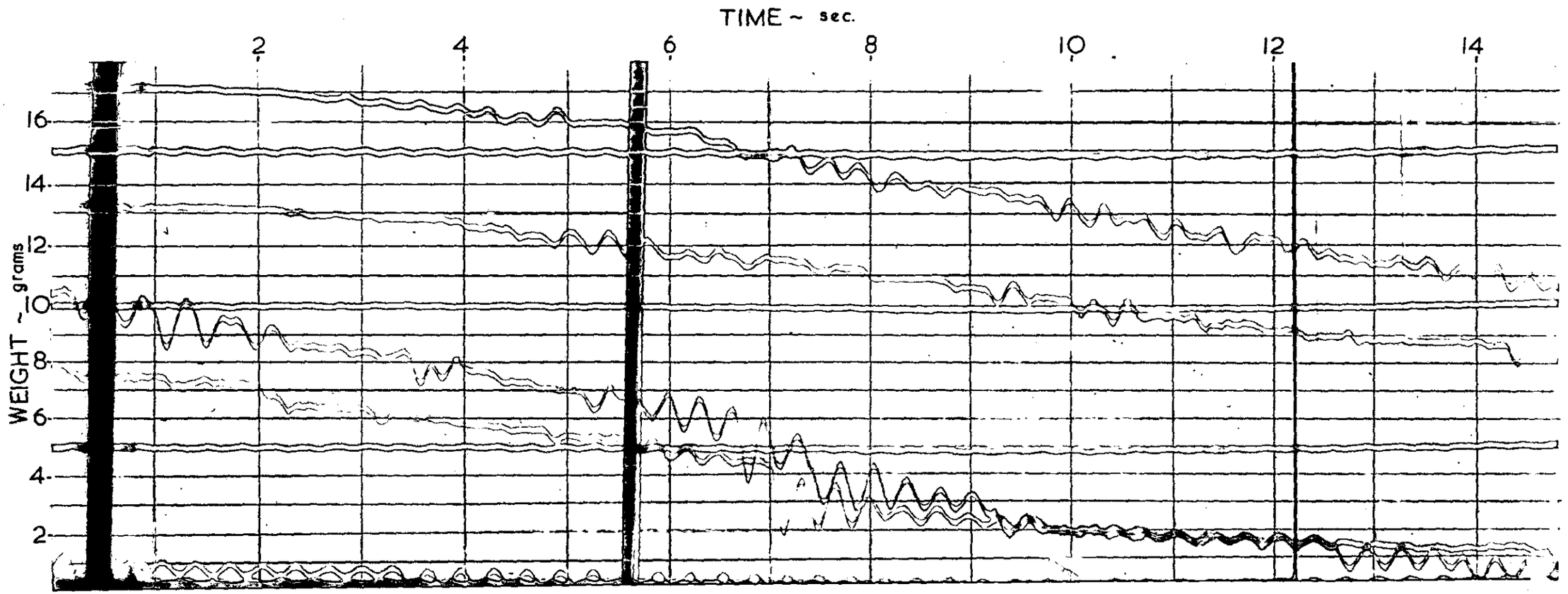

FIG. 2. TYPICAL PHOTOGRAPHIC RECORD, SHOWING TRACES OBTAINED FROM BURNING TWO SLIVERS WEIGHING 13 grams AND 17 grams

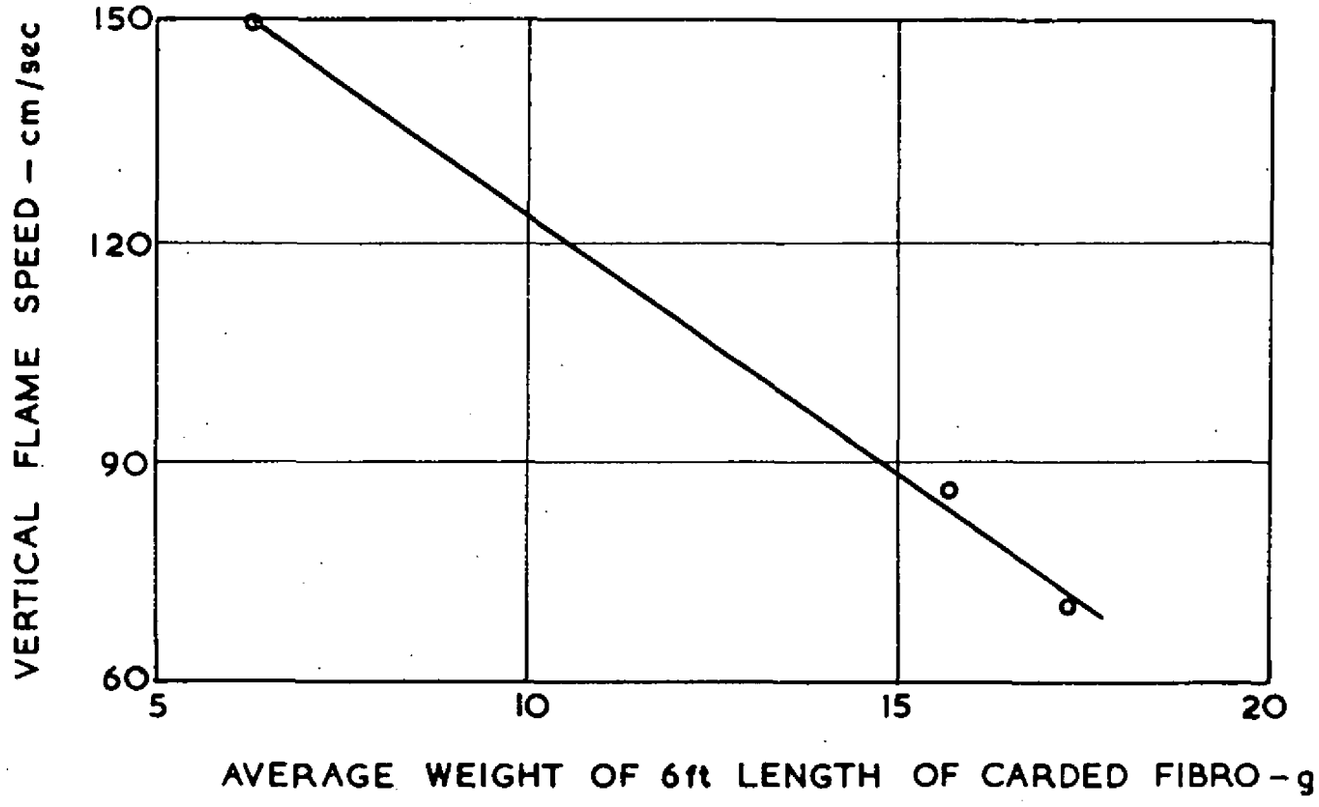
VERTICAL FLAME SPEED – cm/sec
150
120
90
60
5
10
15
20
AVERAGE WEIGHT OF 6ft LENGTH OF CARDED FIBRO – g

FIG. 3.

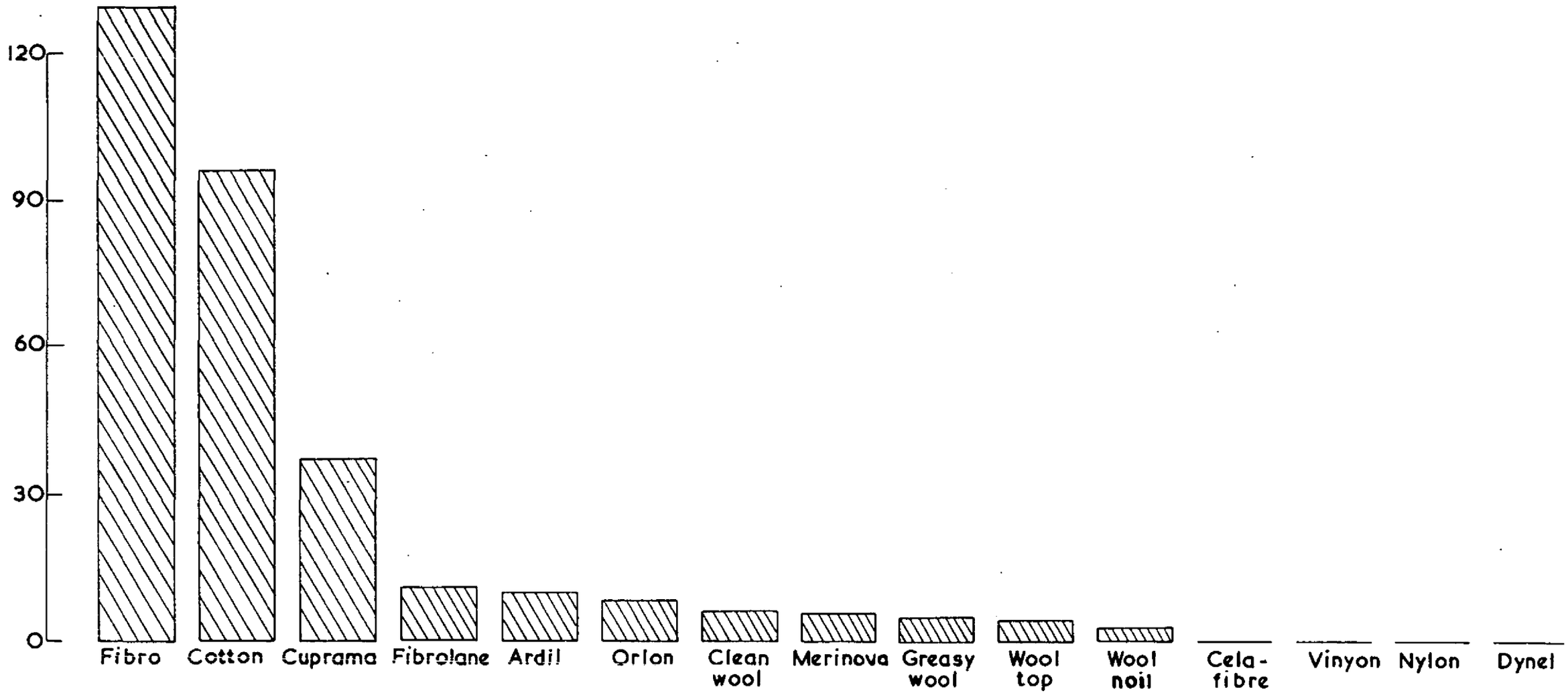

FIG.4. FLAMMABILITIES OF THE CARDED WEBB