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THE RESISTANCE OF FIRE-FIGHTING FOAMS TO DESTRUCTION BY PETROL

by

R. J. French and P. L. Hinkley

SUMMARY

The breakdown and subsequent drainage of a foam layer on the surface of petrol has been measured for a range of petrol temperatures, using different types of foam compound. In the experiments described, the liquid resulting from the breakdown of the foam was collected after it had drained, and a "petrol resistance index", defined as the time in which 25 per cent of the liquid content of the foam could be collected, was calculated. This index was found to vary greatly with the temperature of the petrol and this type of foaming agent employed.

June, 1953.

Fire Research Station,
Boreham Wood,
Herts.

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Introduction

Not only should a foam used in fighting fires involving liquids having low flash points form a blanket on the surface of the hot liquid but it should persist after the extinction of the fire in order to prevent re-ignition when application has ceased. The purpose of the experiments described in this note was to obtain a measure of the time that foams made from various types of foaming agents can exist as a blanket on both hot and cold petrol.

The petrol resistance index

Preliminary experiments showed that certain foams can exist for several hours on the surface of cold petrol and, in order to shorten the time taken by each experiment, it was decided to collect the liquid draining from the foam after its breakdown by the petrol and to define the "petrol resistance index" as the time taken to collect 25 per cent of the liquid content of the foam. It is found that if foams differ only in their expansion factors the minimum rate of application necessary to achieve control of a fire and the time needed to control a fire at a given rate of application are the same if these rates are expressed in terms of the liquid content of the foam (1). It was therefore decided to make the depth of the foam layer in these experiments proportional to the expansion factor so that the liquid content of the foam was always the same. The volume of foam applied in each experiment was the equivalent of a layer 1 in. deep of a foam having an expansion ratio of 10.

Description of apparatus

The apparatus, which is shown in Fig. 1, consisted essentially of a copper vessel containing petrol which could be heated to any desired temperature by means of a steam coil. The steam for the coil was supplied from a boiler heated by a controllable immersion heater, and could be cut off entirely if necessary.

Foam was applied to the surface of the petrol from the applicator A, which consisted of a copper cylinder of the same diameter as the petrol vessel aligned with the latter by means of two pins. A disc B, having a diameter slightly less than that of the cylinder was mounted on a plunger C, so that it could be slid up and down in the cylinder. The lower limit of travel of the disc coincided accurately with the bottom of the cylinder while the upper limit could be varied by means of an adjustable collar on the plunger rod so that the distance of travel of the disc could be made proportional to the expansion factor of the foam. Calibration of the applicator showed that the initial liquid content of the foam layer could be maintained constant within $\pm$ 1·5 per cent. The liquid draining from the foam could be collected in a graduated glass tube for measurement.

Experimental procedure

The petrol was raised to the required temperature and the level was adjusted so that the ullage was equal to the required depth of the foam layer. The applicator was inverted with the plunger raised and was filled with foam, any excess being removed. A flat plate was placed over the base and the assembly was placed in position on top of the petrol vessel. Thirty seconds after the collection of the foam the plate was withdrawn, the plunger depressed, and the applicator carefully slid off leaving a layer of foam of the correct depth on the petrol. The time for the collection of 25 per cent of the liquid content of the foam was measured.

The foam was produced in a compressed air generator [1] and had the same critical shearing stress and expansion ratio as foam produced with a No. 2 branchpipe. The physical properties of the four types of foam tested are stated in Table 1.

TABLE 1

Expansion ratio and shearing strength of foam tested

Laboratory reference	Foaming agent	Critical shearing stress	Expension factor
		dyne/cm^2	
A	Hydrolysed keratin	680	7·5
D	Soap solution	90	11
E	Wetting agent	65	11
G	Hydrolysed protein	500	7·0

Experimental results

In Fig. 2 the petrol resistance index of each of the four foaming agents used is plotted on a logarithmic scale against temperature.

A number of measurements were made of the petrol resistance index of compound D at 19·4°C. This was found to be 2·7 minutes with a standard deviation of 0·5 minutes. This deviation is, however, small compared with differences between values of the petrol resistance index of different foams and between values of the index of the same foam at different temperatures.

Owing to the time taken for the drops to fall into the graduated tube and form a homogeneous body of liquid, values of petrol resistance index below about 30 seconds are unreliable.

The foam formed from compound A degenerated to a gelatinous mass which, before 50 per cent of its liquid had drained, did not cover adequately the surface of the petrol, and could not be regarded as forming a satisfactory blanket after 25 per cent of the liquid had drained.

Comparison of petrol resistance index and normal drainage of foam

Whatever surface a foam rests upon, the liquid in the foam is continuously draining through the foam layer and any breakdown or possible support of the foam in contact with the surface is in addition to this drainage. In order to make an estimate of the relative magnitude of these two effects for a foam layer on cold petrol, measurements were also made of the 25 per cent drainage times for foam layers resting on a solid surface. These were obtained by a method based on that of Tuve and Peterson [2]. The applicator was inverted and filled with foam, any excess being removed; it was then placed in the top of a funnel so that it had a 10° slope and the liquid draining from the foam was collected in a measuring cylinder.

In Table 2, the 25 per cent drainage times on a solid surface at room temperature (15°C) are compared with the petrol resistance indices at the same temperature.

TABLE 2

Petrol resistance index and 25 per cent drainage time on a solid surface

Foaming agent	Petrol resistance index	25% drainage time
	minutes	minutes
A Hydrolysed keratin	(several hours)	8
D Soap	4	7·6
E Wetting agent	0·8	1·2
G Hydrolysed protein	14	14

It will be seen that the petrol resistance index is at least as great as the 25 per cent drainage time for the protein compounds A and G. It is thus unlikely that there is much breakdown of these foams by petrol at this temperature; the liquid draining from the foam A appeared to remain suspended beneath the foam layer.

Discussion of results

It is clear that compound A, which is a typical good quality protein compound, was very much superior to the other foaming agents tested and both protein compounds were superior to the soap and wetting agent compounds.

Observation showed that the time for which an effective foam layer would persist was probably of the order of four times the petrol resistance index except in the case of compound A when it was of the same order as the petrol resistance index. If it is assumed that the rate of destruction of any given foam is independent of the depth of the layer, it is possible to estimate the rate at which foam must be applied to maintain a blanket of foam on hot petrol after the fire has been extinguished. This is given in Table 3 for a temperature of 70°C both in gal./sq.ft./min. of liquid and as a percentage of the critical rate (3).

TABLE 3

Rate at which foam must be applied to maintain a blanket on petrol at 70°C

Foaming agent	Rate of application to maintain blanket	Critical rate	Rate of application to maintain a blanket as a percentage of the critical rate
	gal./sq.ft./min.	gal./sq.ft./min.	%
A Hydrolysed keratin	0·0028	0·028	10
D Soap	0·04	0·055	75
E Wetting agent	0·04	0·055	75
G Hydrolysed protein	0·01	0·055	20

From these results it would appear that the drainage and breakdown on a petrol surface of a foam produced for fire-fighting may be a major factor in determining the critical rate of application of foams produced from soap and wetting agents, though it does not seem to be so for foams produced from protein compounds.

References

(1) FRY, J. F. and FRENCH, R. J. A mechanical foam generator for use in laboratories. Journal of Applied Chemistry, 1951, I, 425-429.

(2) TUVE, R. L. and PETERSON, H. B. A study of some mechanical foams and their use for extinguishing tank fires. U.S. Naval Research Laboratory Report 3725. August, 23rd, 1950.

(3) FRENCH, R. J., HINKLEY, P. L. and FRY, J. F. The surface application of foam to petrol fires. Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization. F.R. Note No. 21/1952.

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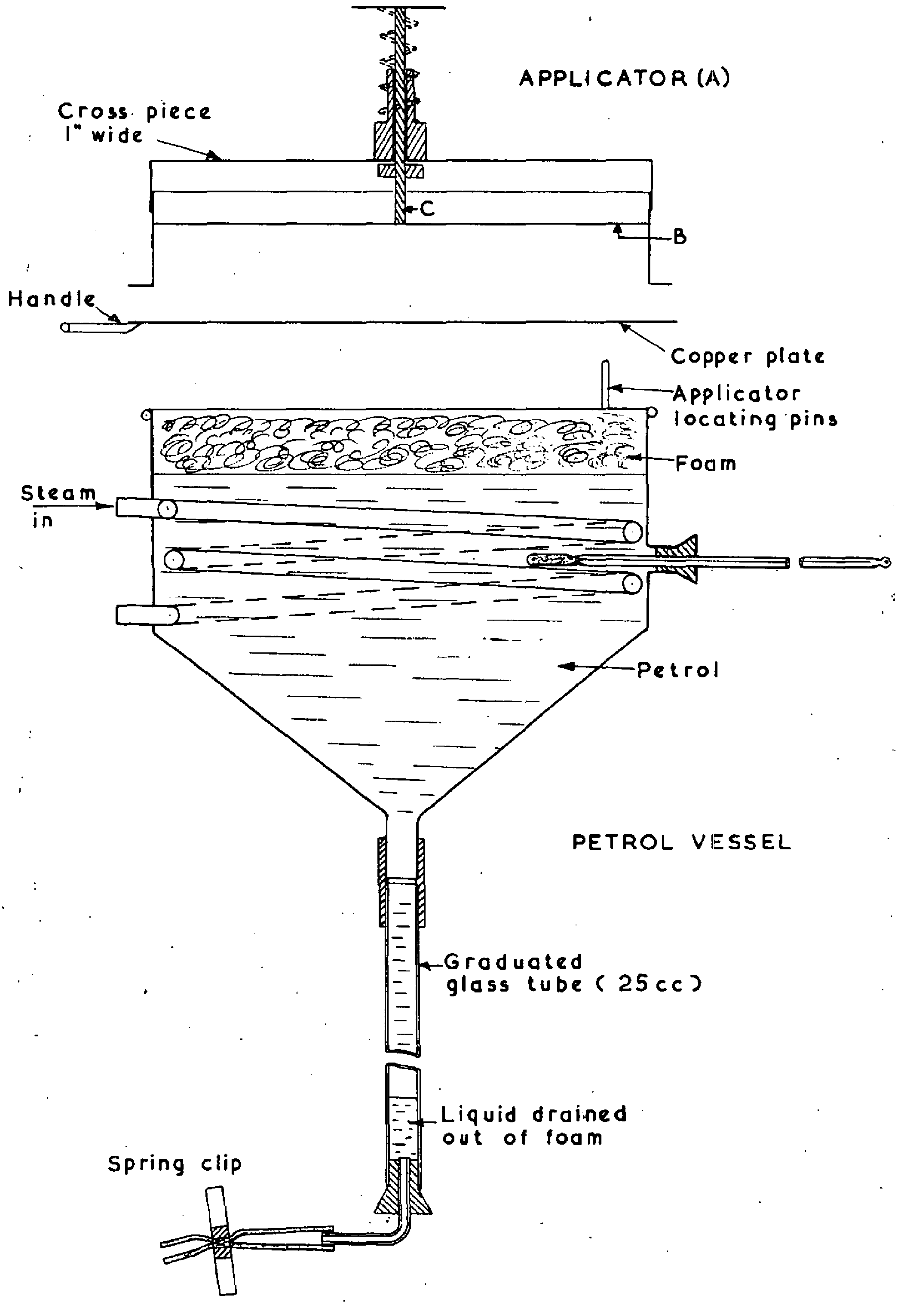

FIG. 1. APPARATUS TO MEASURE RATE OF DRAINAGE OF FOAM ON HOT PETROL

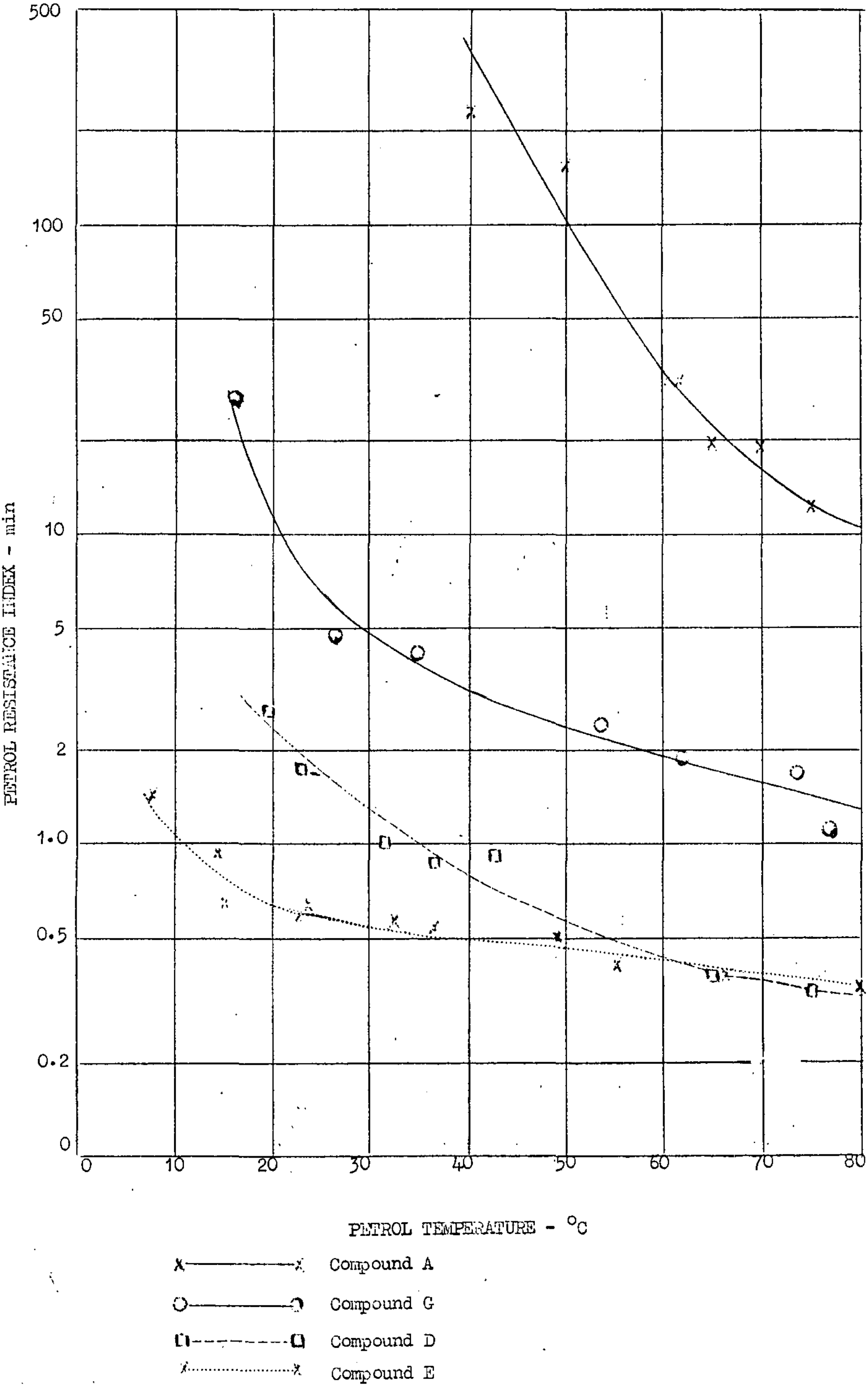

FIG.3. THE EFFECT OF PETROL TEMPERATURE ON THE PETROL RESISTANCE INDEX FOR FOUR FOAM COMPOUND