F.R. Note No.
Research Programme
Objective C2/5

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

THE PRODUCTION OF FOAM FOR INJECTION AT THE BASE OF PETROL TANKS

by

R. J. French and P. L. Hinkley

Summary

The physical characteristics of the foam used for base injection into tanks of burning petrol must be closely controlled to obtain extinction of the fire.

It is shown in this note that while suitable foam cannot be produced by the use of self-aspirating foam generators alone, it may be made by combining such a generator with a centrifugal pump. In this way, successful use is made of normal Fire Brigade equipment, without recourse to special foam pumps or large compressed-air foam generators.

File No. 1051/1/59

September, 1956.

Fire Research Station,
Boreham Wood,
Herts.

THE PRODUCTION OF FOAM FOR INJECTION AT THE BASE OF PETROL TANKS

by

R. J. French and P. L. Hinkley

1. Introduction

It has been shown [1] that the physical characteristics of foam for injection at the base of tanks of burning petrol, must be controlled within narrow limits if extinction is to be obtained. The expansion and critical shear stress of the foam must be low to ensure that the petrol picked up by the foam reaching the surface does not exceed 10 per cent of the volume of foaming liquid. For most protein compounds, the expansion at input to the tank, must not exceed $3\frac{1}{2}$ and the critical shear stress must not exceed 240 dynes/cm^2. To ensure that the increase of foam expansion from input to the surface is not great, the 25 per cent drainage time [2] must exceed 3 minutes. Foams of these properties can be produced from at least four existing protein compounds.

The amount of energy required to produce such foams is relatively high, and involves the use of fine mesh gauze in the improver of the laboratory foam generator [3]. It should be possible to obtain similar results with a larger version of the laboratory equipment, with a foam pump using a similar improver or with specially-designed equipment such as the triple pump arrangement developed by the Naval Research Laboratory of the U.S.A. [4]. It would, however, be an advantage if suitable foam could be produced using standard fire brigade equipment. Consequently, a study has been made of the performance of a common form of self-aspirating in-line generator when delivering against a pressure, and methods have been considered of modifying its use so that foam suitable for base injection may be produced.

2. Foam compounds

Details of the foam compounds used in the experiments described below are given in Table I.

Table I

Details of foam compounds

Laboratory identification	Type	Remarks
A	Hydrolised keratin	Used unsuccessfully on 9 ft x 30 ft tank fire tests
B	Hydrolised keratin	Used successfully on 9 ft x 30 ft tank fire tests
C	Hydrolised blood	Proved suitable for base injection by laboratory tests
K	Hydrolised keratin	
M	Hydrolised keratin	

3. Description of foam generators examined

In recent years improved foam generators have been developed from the forcing type of branchpipe. These generators are capable of producing foam against moderate heads, but the back pressure has considerable influence on the properties of the foam produced. Two generators of similar design from different manufacturers have been examined, both being designed to operate at a water pressure of 150 lb/in^2. Each generator had four parallel nozzles in the water head, delivering water into the end of a parallel tube containing ports through which air was induced. At the working pressure the smaller generator (referred to as generator I) delivered 60 gal. of water per min. and the larger (generator II) 125 gal. per min.

4. Determination of the performances of self-aspirating generators used in a normal manner

The physical characteristics of the foam produced by generator I when operating against various back pressures have been determined. The foam characteristics measured were the expansion, the critical shear stress and the 25 per cent drainage time, using the method described by Tuve and Peterson (4). Great care was necessary in collecting the foam sample to prevent further aeration in the collecting vessel. The method used is shown in Fig. 1, the foam being collected in a vessel of about 1000 cm^3 capacity as it flowed off the sheet metal deflector at low velocity. The back pressure was adjusted by means of the valve at the entrance to the 4 in. pipe. Fifty feet of $2\frac{1}{2}$ in. rubber-lined hose was inserted in the line immediately after the generator; for one test 300 ft. of $2\frac{3}{4}$ in. rubber-lined hose was used.

Both compounds A and B were used in these experiments. It is generally found with protein compounds that the fire-fighting efficiency of a foam is not greatly increased by using more than 3 per cent concentration of compound. In order to keep the critical shear stress of the foam as low as possible, the compound concentration was limited to 3 per cent by putting a suitable restriction in the pick-up tube.

The relationships between the expansion of the foam produced and the back pressure on the generator obtained under these conditions is shown in Fig. 2. It is seen that the required expansion of from 3 to 4 was obtained with back pressures between about $13\frac{1}{2}$ and $15\frac{3}{4}$ lb/in^2. Fig. 3 shows the critical shear stress of the foam obtained under these conditions; over the required range of expansions the shear stress is well below the suggested maximum with compound B but is appreciably too high with compound A. The 25 per cent drainage times of the foam are similar for the two compounds; for compound B the actual values are 2·0 min. for expansion 3 and 2·7 min. for expansion 4. These are below the desired maximum of 3·0 min. at which (2) the proportion of injected liquid reaching the surface in a petrol tank decreases greatly.

It is therefore doubtful whether such a generator could be used satisfactorily for the base injection of foam into petrol tanks, even if the operating conditions could be adjusted to give the required expansion and critical shearing stress.

5. The use of two pumps to produce foam of the required characteristics

From the experiments described above it was evident that more energy would have to be put into the production of the foam in order to decrease the drainage rate.

It was considered that modification of the foam generator itself to achieve this would also further reduce the back pressure against which it could operate. It was found, however, that the foam produced by the generator could be delivered directly into the suction eye of a centrifugal pump so as to give a considerable improvement in the foam characteristics.

Experiments with this arrangement were made with generator I, operating at 150 lb/in^2 water pressure and coupled directly to the suction inlet of a light trailer pump (nominal water capacity of 120 gal/min at 100 lb/in^2). Both compounds A and B were used, the foam being delivered through 50 ft of $2\frac{1}{2}$ in. rubber-lined hose into the same 4 in. pipe previously used for the collection of foam samples. With the pump running at moderate speed and the delivery valve adjusted to give a pump output pressure of 35 - 70 lb/sq.in., stable pumping was maintained, but pressure fluctuation occurred outside these limits. Under stable conditions the back pressure on the generator was from 14 to 16 lb/in^2, giving foam expansions from 3·6 to 2·9. The probable reason why this back pressure was obtained even when delivering into the suction side of the pump was that until such a pressure was built up, the foam was not sufficiently dense to be pumped by this type of appliance; foam of expansion 3·5 at a pressure of 15 lb/in^2 has a relative density of about 0·45.

The effect of the use of this second pump was to increase the 25 per cent drainage time of the foam made from compound B to values between 3·5 and 6·5 min. and at the same time to give a critical shear stress of 50 to 90 dyne/cm^2, a slightly lower value than had been obtained with the generator alone. The fact that with compound B, there was virtually no increase in critical shear stress, despite the great increase in energy used to produce the foam of necessary stability, had also been observed using the laboratory foam generator; it was this feature of compound B that first enabled foam suitable for base injection into petrol storage tanks to be produced. With compound A, the second pump increased the critical shear stress of the foam to a value well above the desired maximum.

Compounds C, K and M, which on the basis of other work (2) were considered likely to be suitable for base injection, were also tried in this equipment and were found to give results very similar to those obtained with compound B. The results of all these experiments are shown in Figs. 5, 6 and 7.

Two other combinations of in-line foam generator and centrifugal pump were tried for comparison; in one of these generator I delivered into a much larger pump (nominal water capacity 700 gal/min at 100 lb/in^2). The other arrangement tried was generator II delivering into this same larger pump. With either of these two arrangements it was difficult to obtain the back pressure on the generator necessary to give the required expansion. Suitable foam could be produced with either of these combinations under carefully adjusted operating conditions but, in practice, to be certain of obtaining the required expansion, a pressure gauge would be required between the generator and the pump.

Both these pumps had indirect cooling systems and it was found that, with foam flowing through the cooling coils, they could be operated without over heating, but no experiments were carried out in which the pump was run for more than about fifteen minutes.

6. Conclusions

Normal self-aspirating foam generators cannot generally produce foam suitable for the extinction of petrol fires by base injection.

By passing the foam output from one of these generators through a suitable centrifugal pump, foam of the required properties can be produced: in addition, the outlet pressure from the pump should be adequate to overcome the product head and the pipe line losses in actual installati ns.

This method of producing foam has the advantage that it makes use of existing fire brigade equipment. It is probable that the system would work satisfactorily on a much larger scale using suitable generator and pump combinations. It is thought however that more work should be carried out with larger equipment before the method is put forward for use on large petrol tanks.

Acknowledgment

Acknowledgment is due to C. W. Claridge for his assistance in the work described above.

References

1. French, R. J. and Hinkley, P. L. The extinction of fires in petrol storage tanks by the base injection of air-foam. Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization F.R. Note No. 100/1954, July, 1954.

2. French, R. J. and Hinkley, P. L. The development of laboratory tests to determine the suitability of a foam for base injection into petrol storage tanks. Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization F.R. Note No. 272/1956, October, 1956.

3. Fry, J. F. and French, R. J. A mechanical foam generator for use in laboratories. Journal of Applied Chemistry, 1951, 1, 425-429.

4. Tuve, R. C. and Peterson, H. B. A study of some mechanical foams and their use for extinguishing tank fires. U.S. Naval Research Laboratory Report No. 3725. August, 1950.

ERH

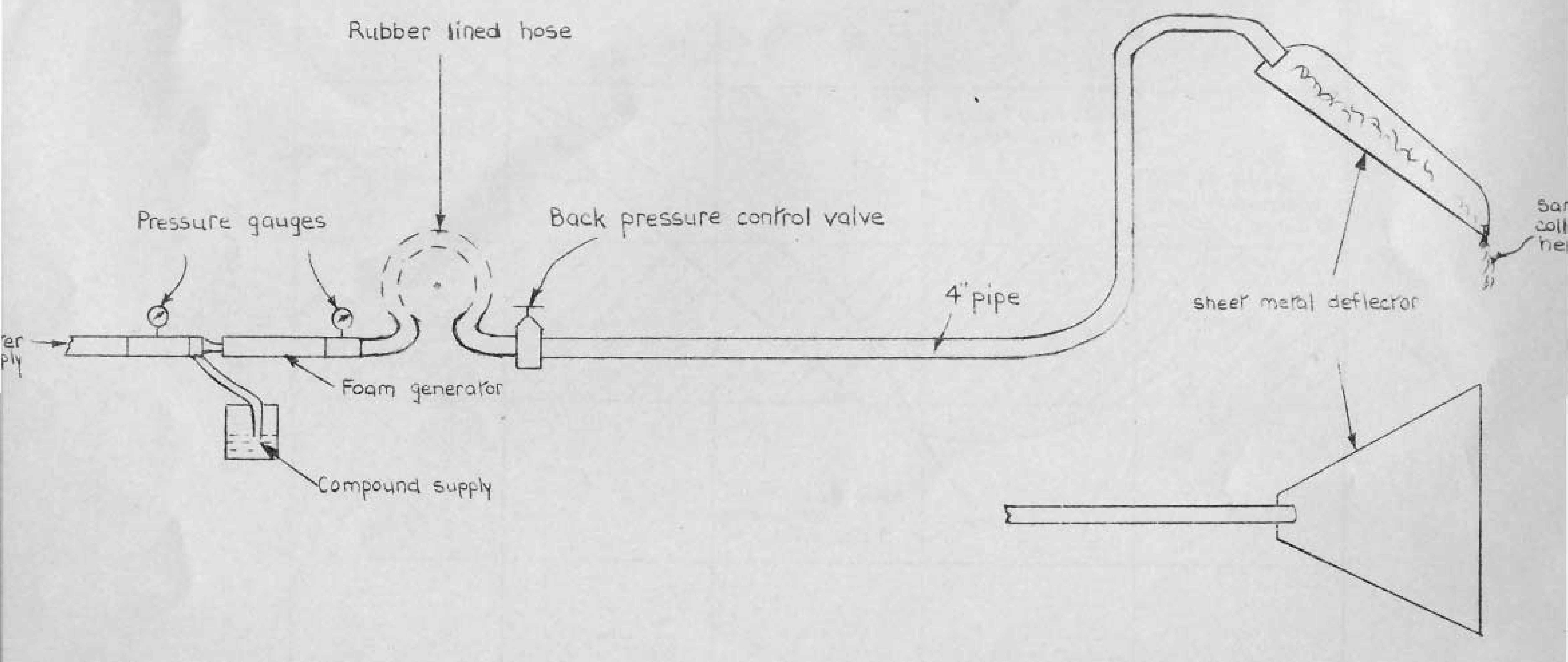
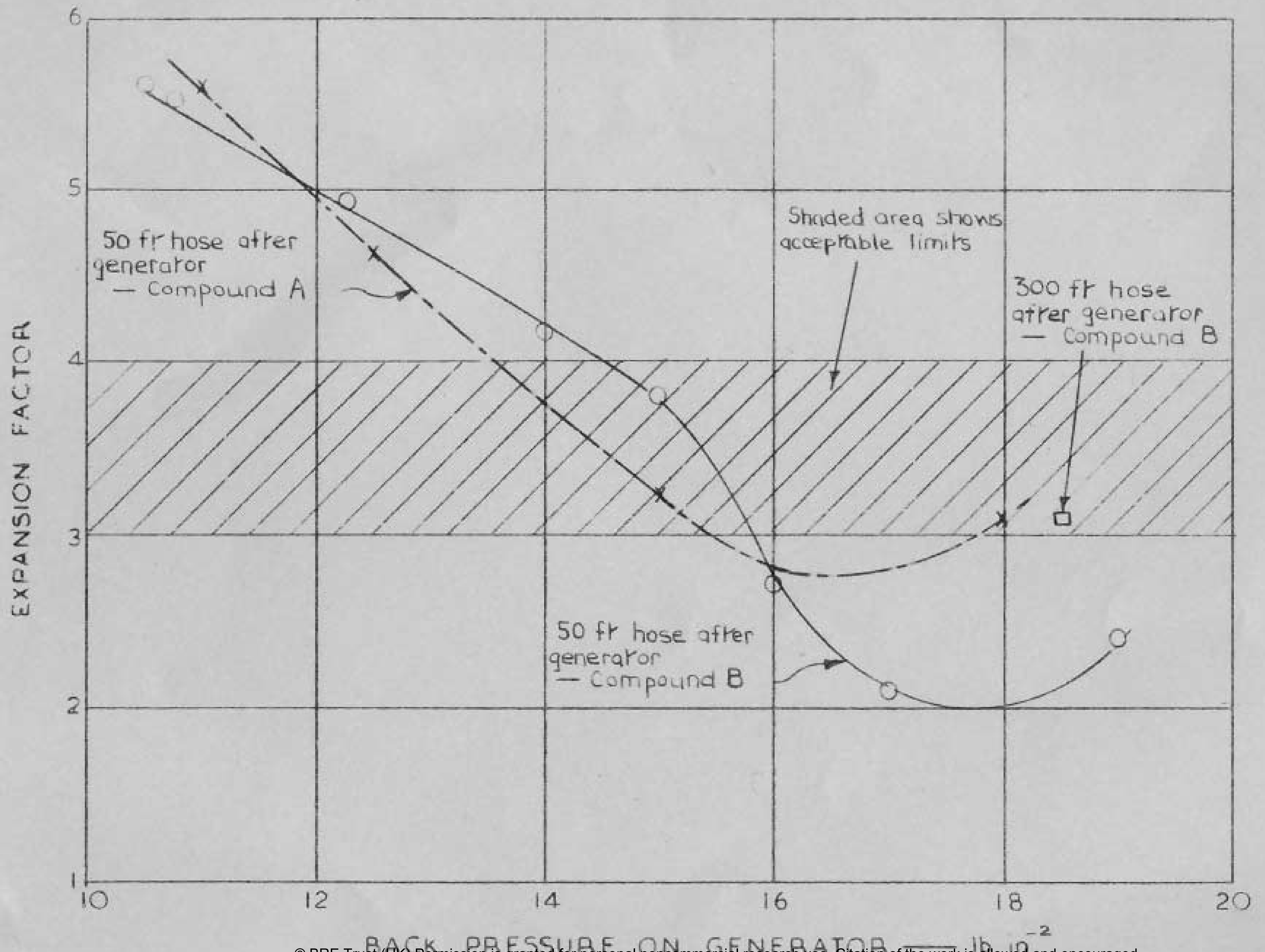


FIG.1. DIAGRAMMATIC ARRANGEMENT OF APPARATUS



.2. RELATIONSHIP BETWEEN EXPANSION AND BACK PRESSURE FOR GENERATOR I

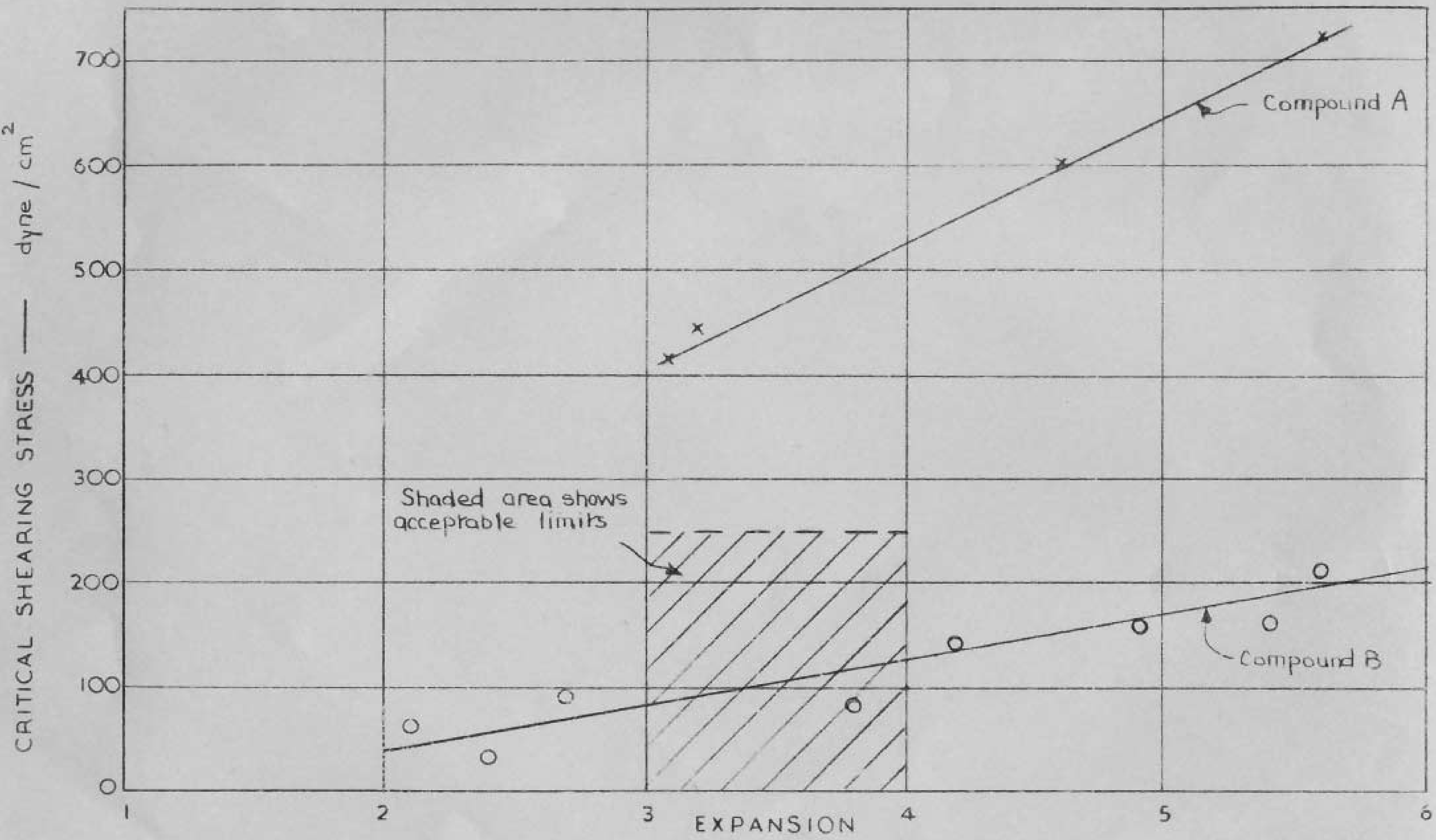


FIG 3. RELATIONSHIP BETWEEN EXPANSION AND CRITICAL SHEARIN
STRESS OF FOAM PRODUCED BY GENERATOR I FOR COMPC
A & B

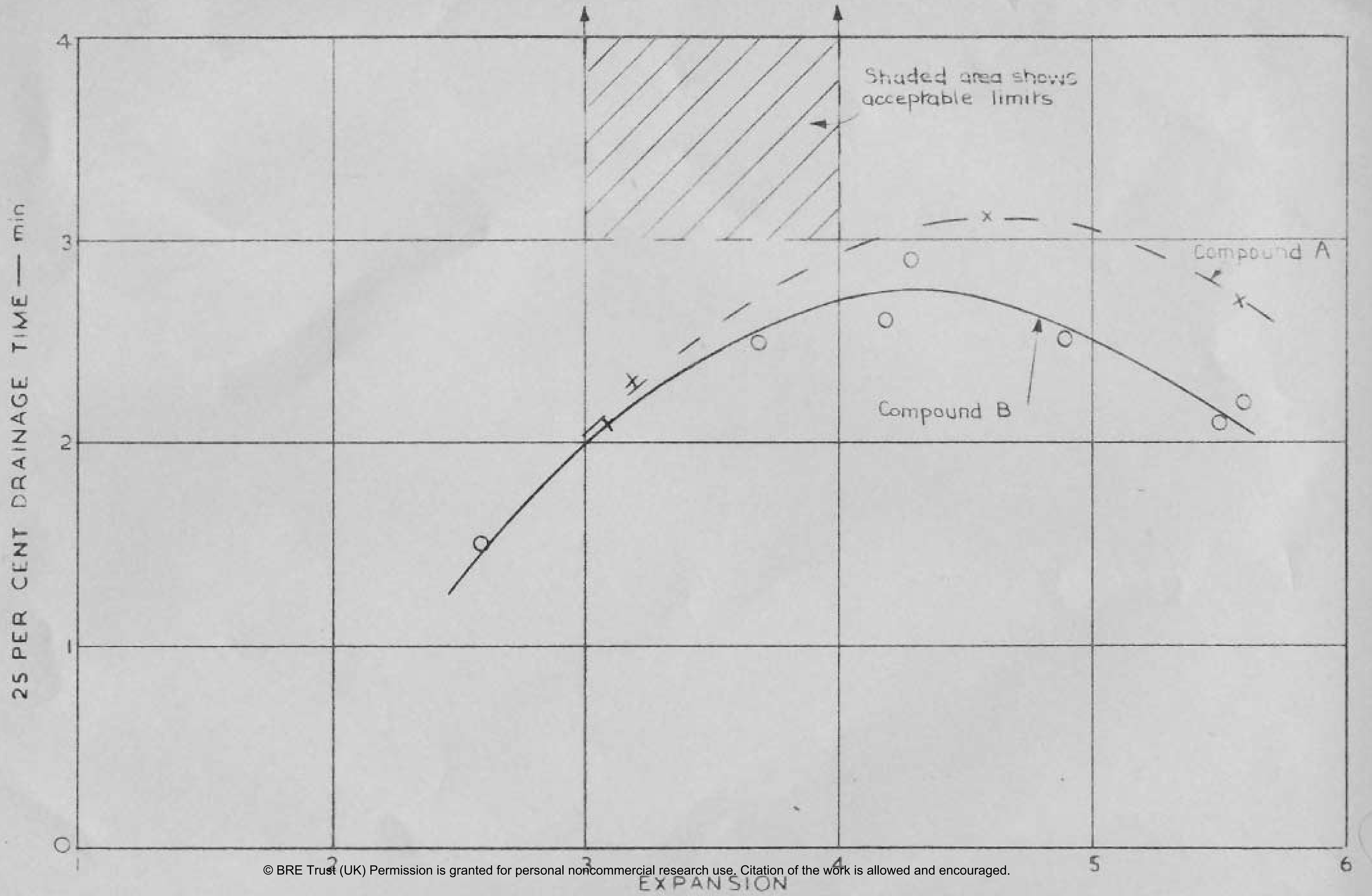
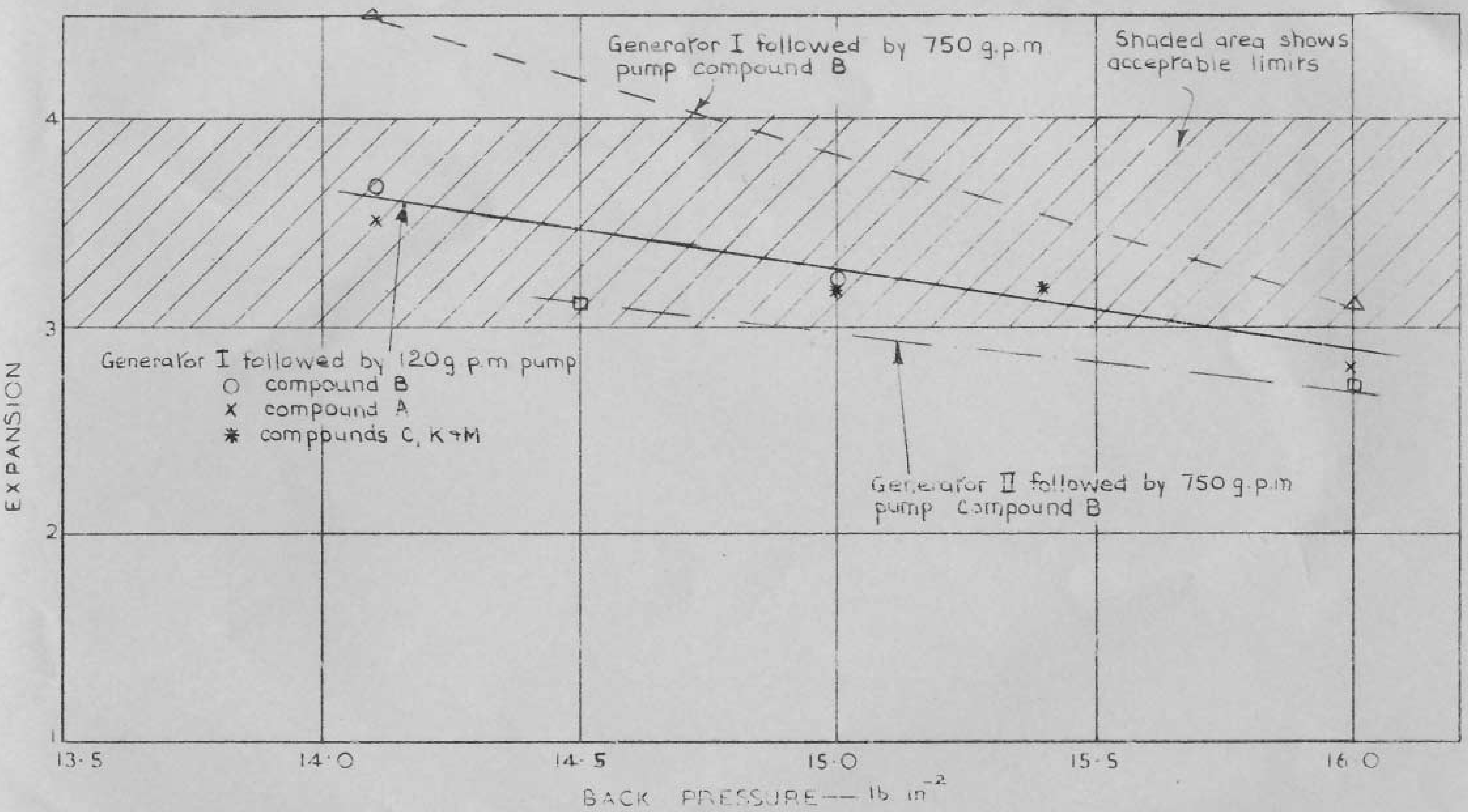


FIG.4 RELATIONSHIP BETWEEN EXPANSION AND 25 PER CENT DRAINAG
TIME OF FOAM PRODUCED BY GENERATOR I FOR COMPOUNDS



G.5. RELATIONSHIP BETWEEN BACK PRESSURE AND FOAM EXPANSION FOR GENERATORS I & II WHEN FOLLOWED BY A CENTRIFUGAL PUMP

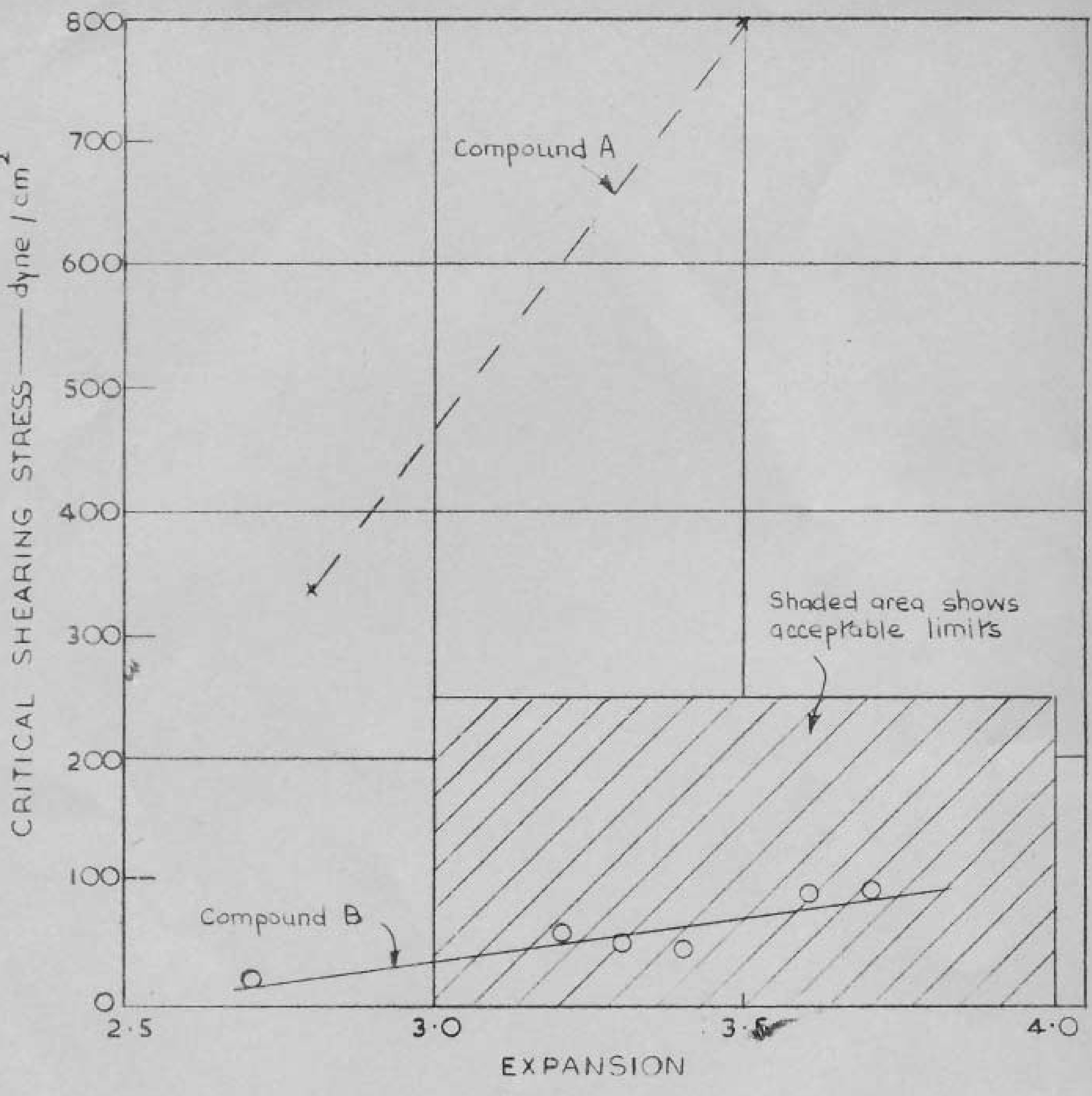


FIG. 6. RELATIONSHIP BETWEEN FOAM EXPANSION AND CRITICAL SHEARING STRESS FOR GENERATOR I FOLLOWED BY 120 G.P.M. CENTRIFUGAL PUMP

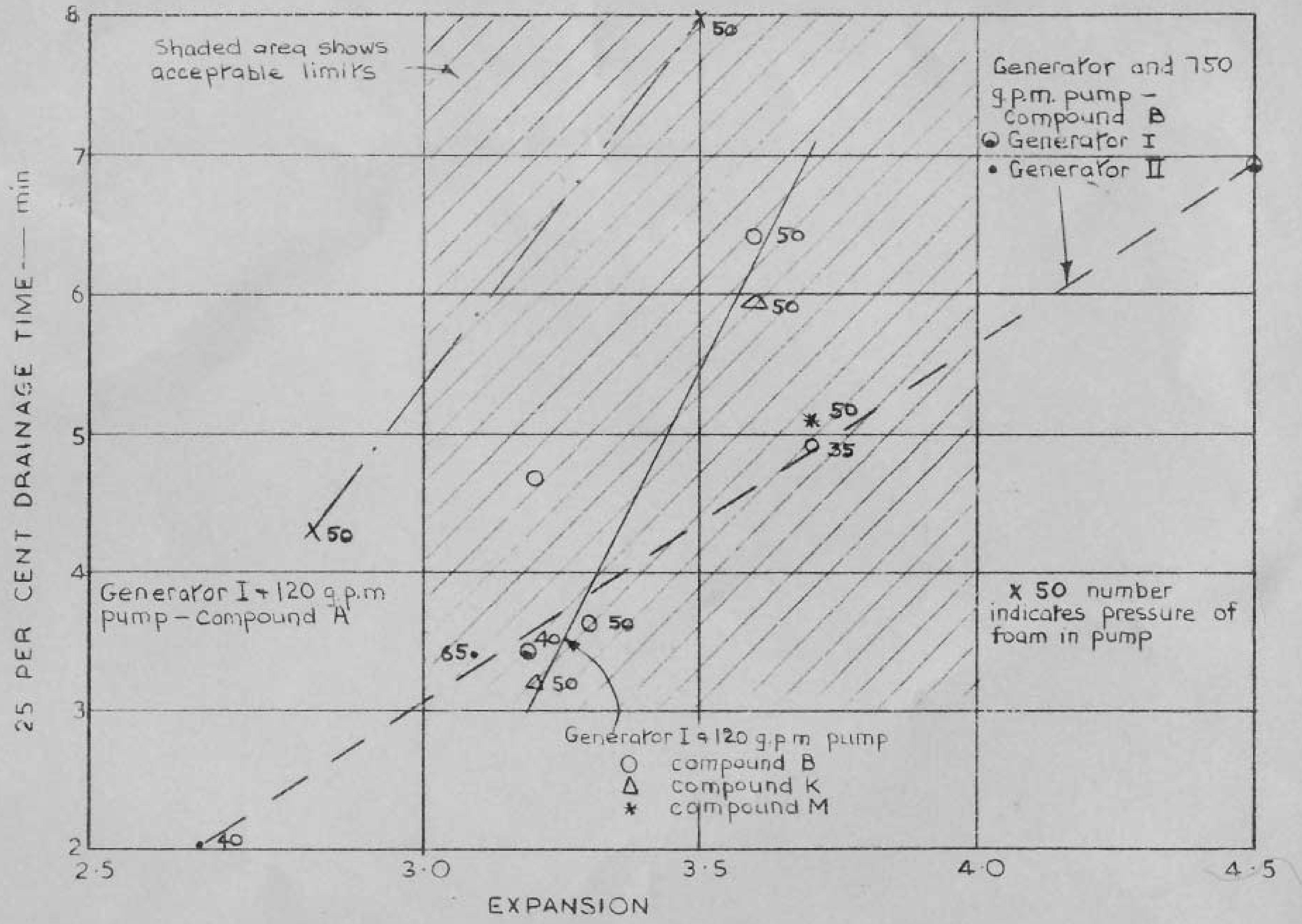


FIG. 7 RELATIONSHIP BETWEEN FOAM EXPANSION AND 25 PER CENT DRAINAGE TIME FOR GENERATORS I & II FOLLOWED BY A CENTRIFUGAL PUMP