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THE CONSTRUCTION AND USE OF AN APPARATUS FOR DETERMINING THE DRAINAGE CHARACTERISTICS OF HIGH EXPANSION FOAM

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SUMMARY

This note describes the construction and use of an apparatus for measuring the drainage characteristics of high expansion foam. It is intended as a possible method for use with a specification for high expansion foam liquids.

Results of drainage measurements on different liquids are given.

KEY WORDS: Foam, high-expansion, drainage.

MINISTRY OF TECHNOLOGY AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

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Introduction

High expansion foams are becoming widely used for extinguishing fires in buildings and other enclosures. Because these foams are so expanded (e.g. 1000:1 is commonly used), their water content per unit volume is low. It is essential for the foam to retain a reasonable proportion of the contained water, in order that it may be available to cool the burning surfaces. For this reason, a test for measuring the drainage characteristics is necessary, and this note describes a method suggested for this purpose, and used experimentally at the Fire Research Station. The drainage is expressed in terms of the time in minutes to drain half the contained liquid under cold (i.e. non-fire) conditions.

Foam has often to travel some distance to the seat of the fire and a long "cold drainage" time is valuable under these conditions as it controls the quantity of water reaching the fire. Some typical drainage measurements are given (Fig. 6).

Experimental Apparatus

The apparatus consists essentially of two parts, a foam generator and a foam collection and weighing system. The components are supported on a light steel framework, the arrangement being shown in Fig. 1. The foam container and balance is shielded from draughts by polythene sheeting over the top, back and sides.

Foam Generator

The generator (Fig. 2) is mounted on a trolley running on rails so that it may be moved conveniently. It is mounted at an angle of 10 degrees to the horizontal so that any liquid not made into foam runs to the back of the generator and is discharged through a drain-hole, thus avoiding an error which has occurred with other methods. The 3.5 in I.D. x $\frac{1}{4}$ in thick circular section perspex tube which forms the main body of the generator is in two parts in order to give access to the spray nozzle; the joint is readily made air-tight with adhesive tape. The foam-making net is a commercial woven nylon filter* having holes of approximately 0.05 inch (1.3 mm) diameter, occupying approximately 40 per cent of the area. It is convienttly secured to the tube by an elastic band. It has been found that the size of the holes in the net has an effect on the bubble size but this is not critical.

The nozzle used is a brass Lechler SZ006**. It is set to face upwards at about 3° to the axis of the generator, in order to ensure even distribution over the area of the net by compensating for liquid running down the net. The distance between the spray nozzle and the net is critical and must be determined by trial to give as even a distribution as possible. Uneven distribution will show up as larger bubbles in these areas receiving less liquid. From the diagram of the spray pattern, Fig. 3, it can be seen that in order to achieve a good distribution over the net only part of the spray cone is utilised, the outer portion striking the generator tube wall and subsequently discharging through the drain-hole.

Facilities are provided for controlling the temperature of both air and liquid since it has been found that temperature variation can have a large effect on drainage. All the results shown in this note are at air and liquid temperatures of 20°C.

Diluted foam solution is forced out of the reservoir by air pressure and supplied to the nozzle by means of rubber tubing. A 53 μm mesh brass filter is incorporated in this line and all fittings downstream of the filter are made of brass or copper to avoid corrosion particles blocking the nozzle. A heat exchanger is incorporated in the liquid feed time. It consists of a water jacket containing a spiral constructed from 3 feet of $\frac{1}{8}$ in I.D. thin-walled copper tubing. The temperature of the water flowing through the water jacket is adjusted until the flow of foaming solution is at the desired temperature. The temperature of the liquid in the reservoir should be approximately identical at each test to avoid the need for compensatory adjustments to the water jacket temperature.

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* Obtainable from

Fryman and Fletcher Ltd., Fryman House, Denison Street, Nottingham.

** Obtainable from

Kershaw Highes & Partners Ltd., Falcon Works, 160 Matilda Street, Sheffield 1.

Air is supplied to the generator after passing through a second heat exchanger. This is readily constructed from the heat exchanger component of a small car heater. It is placed in a water bath and air is passed through what was originally the water passage. This arrangement works very efficiently. Both the air line and the liquid reservoir are fitted with pressure gauges so that known conditions may be readily reproduced. Normally the expansion ratio is varied by altering the air pressure, leaving the liquid pressure at the optimum setting (for this apparatus : 83 kN/m^2 (12 lb/in^2) in the reservoir, which corresponds to about 70 kN/m^2 (10 lb/in^2) at the nozzle). It is convenient to have some restriction in the air line after the gauge, so that variations in the air flow give measureable pressure changes at the gauge. The air pressure in the generator is very low and difficult to measure directly.

Collection and Weighing System

The container is constructed from 26 SWG (0.457 mm) aluminium as in Fig. 4. The joint between the bottom and sides has a fillet on the inside and all seams are filled to give a smooth internal surface. A flexible sealing compound is advisable for this purpose. The container has 4 suspension wires and is left unpainted

The balance (Fig. 5) is constructed of brass, with the exception of the hardened steel knife-edges. Three beams are used, these being joined by rods as shown. The centre beam is longer than the other two and has the container suspended from one end and a basket counterpoise weight at the other. It carries a rider and a scale graduated 0-400 gms in 20 gram divisions. The second beam is a screwed rod carrying a large brass nut which is used to supplement the basket counterpoise weight. The third beam is graduated 0-20 gms in 1 gram divisions. Each division on the graduated beams has a small niche to ensure exact location of the weight. The riders are made as shown in the diagram, and will swing freely on the beam. When calibrating the balance, the weight of each rider is adjusted until the balance is calibrated.

As mentioned previously, it is necessary to shield the container as even slight draughts can cause errors. A plastic bucket or similar receptacle is placed under the container to catch liquid draining during filling and balancing operations. The volume of liquid collected rarely amounts to more than a few millilitres but the bucket must have a wide top to ensure collection of all liquid even if the basket tends to swing. A stop clock is used for measuring the drainage time.

Procedure

The high expansion foam concentrate is made up to a solution of the required strength and this solution is placed in the reservoir. The temperature of the solution should be as close as practicable to the required liquid temperature. It is important to use the solution as soon as possible after mixing as some solutions deteriorate on standing. Fresh solution must be used for each determination. The temperatures of liquid and air issuing from the heat exchangers are adjusted to give the required values. The foam container is washed and dried to a constant weight, and is then suspended from the balance and counterpoised. Unless alterations have been carried out to the container, there should be no need to adjust the counterpoise weight. Failure to balance usually indicates water in the container. A small screen is placed in front of the generator to prevent foam and spray reaching the container and the foam is generated by feeding diluted foam solution and air to the generator at suitable pressures, which are determined by trial and error to give foam of the required expansion. The clean, dry bucket is placed under the hole in the container to collect any liquid draining. When suitable foam is being produced, the screen is removed and the generator is moved forward to fill the container. At this point, the clock is started and the filling time is recorded. The container should be filled as evenly as possible. The clock is allowed to run on, and when the container is full, the generator is moved away and the weight of foam is measured on the balance. To this figure is added the weight of liquid (if any) in the plastic bucket. This gives the weight of foam generated during the filling time. The expansion is obtained by dividing the volume of the foam container (130 litres i.e. 1.3×10^5 ml) by the weight of the foam. Half the weight of foam is now set on the balance and the time for the balance to reach equilibrium again is noted. The <u>half drainage time</u> is taken as this time, minus <u>half</u> the filling time. (This is an approximation which takes into consideration the fact that during the filling time the amount of foam is steadily increasing). A sample calculation is shown in Appendix 1.

This procedure can be repeated with foams of different expansions, and expansion may then be plotted against half drainage time. Results so far have indicated a linear relation (Fig. 6). It is useful to have a known compound for checking the apparatus periodically. Extremes of temperature and humidity, and the presence of large quantities of dust, should be avoided in the room in which the apparatus is to be used.

Discussion

It can be seen from Fig. 6 and Table 1 that the eight compounds tested fall into two groups. The first group is characterised by half drainage times of five minutes or less at an expansion of 1000, and by an increase in half drainage time at lower expansions. The half drainage time of compounds in the second group is more than fifteen minutes at expansion 1000, and decreases at lower expansions. For equipment producing foam of expansion in the range 800 to 1000 (i.e. high expansion foam), compounds in the second group will produce the most stable foam. Compounds in the first group may prove to be satisfactory when used in equipment producing foam of expansion less than 500 (i.e. medium expansion foam), which is not intended for filling volumes or transporting through long lengths of ducting, corridors etc.

Further experimental work is necessary to decide the range of usefulness of each group of compounds but in a draft specification[1] for high expansion foam liquids, a minimum acceptable half-drainage time of 8 minutes has been suggested at an expansion of 1000, for acceptable liquids. It can be seen from Fig. 6 that this criterion separates the rapidly draining foams from those having good water retention.

Conclusions

1. An apparatus has been constructed for measuring the drainage characteristics of high expansion foam in the range of expansions 600 to 1200.

2. Foam liquids tested so far have had half-drainage times ranging from 2 to 20 minutes at an expansion of 1000.

3. A minimum half drainage time requirement of 8 minutes at an expansion of 1000 satisfactorily separates the rapidly draining foams tested from those having good water retention.

Reference

1. THORNE, P. F. Revised draft specification for high expansion foam liquids. F.R. Memorandum No. 4 (1970).

Compound	Half-drainage time (mins)
A	16½
B	17
C	20½
D	2
E	5
F	4
G	2
H	16

Table 1

Half-drainage time at Expansion 1000:1 and 20°C. (further results are shown in Fig. 6)

APPENDIX 1

Worked example

Liquid temperature 20°C.

Air temperature 20°C.

1.5 per cent solution.

Volume of basket = 130 l.

Generator.

Air 12 psig at regulator, flow rate = 210 l/min.

Liquid 12 psig in reservoir, flow rate = 160 ml/min.

Filling time 50 secs.

∴ ½ filling time 25 secs.

Wt. of foam in basket = 124 gms.

Wt. of liquid in bucket = 2 gms.

∴ Wt. of foam generated = 126 gms.

Expansion = 130 ÷ 126 x 1000 = 1050.

½ wt. foam = 63 gms.

½ drainage time = 17 mins − ½ filling time

= 17 m − 25 s

= 16½ mins at expansion 1050.

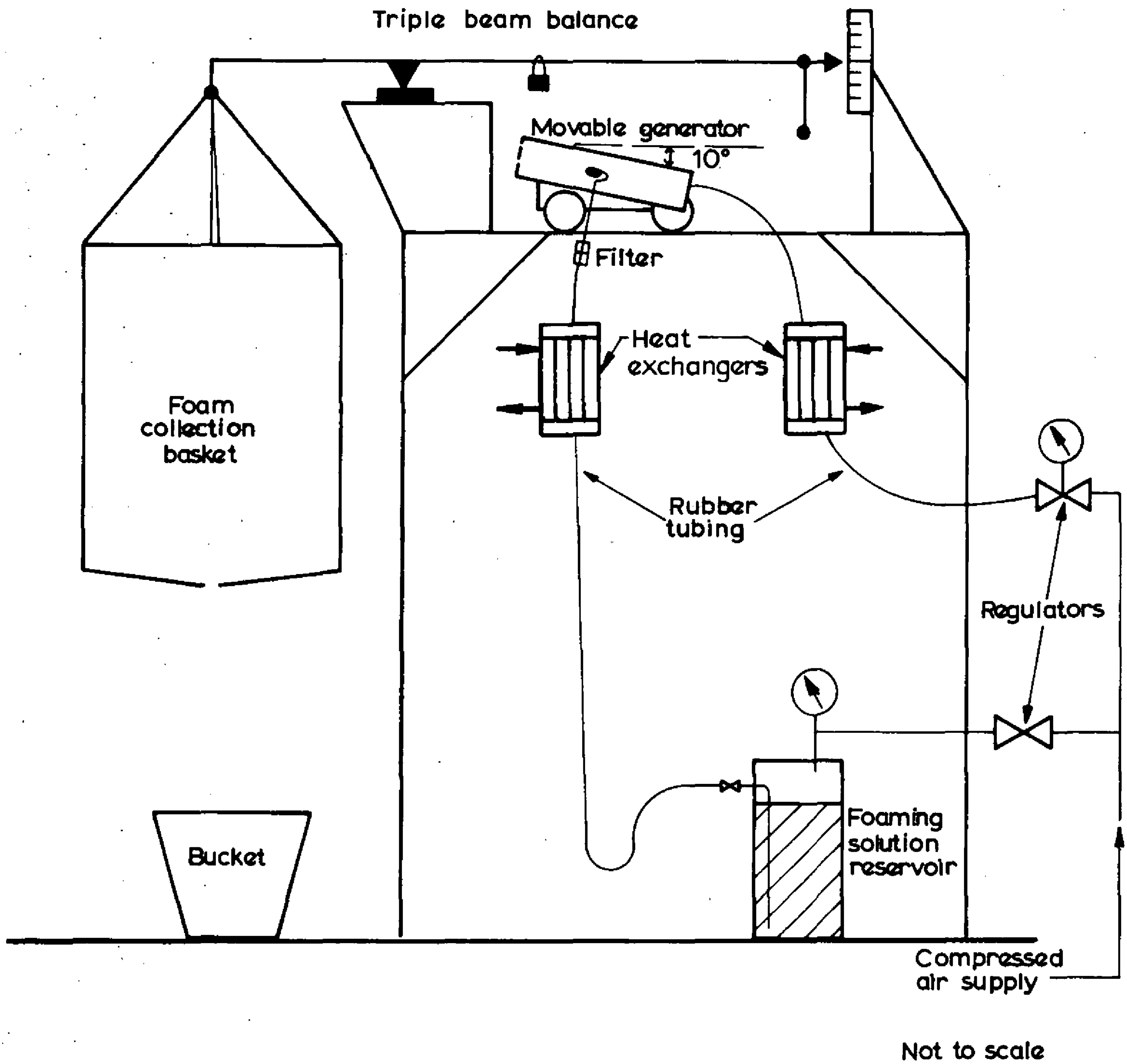


FIG. 1. GENERAL LAYOUT OF EQUIPMENT

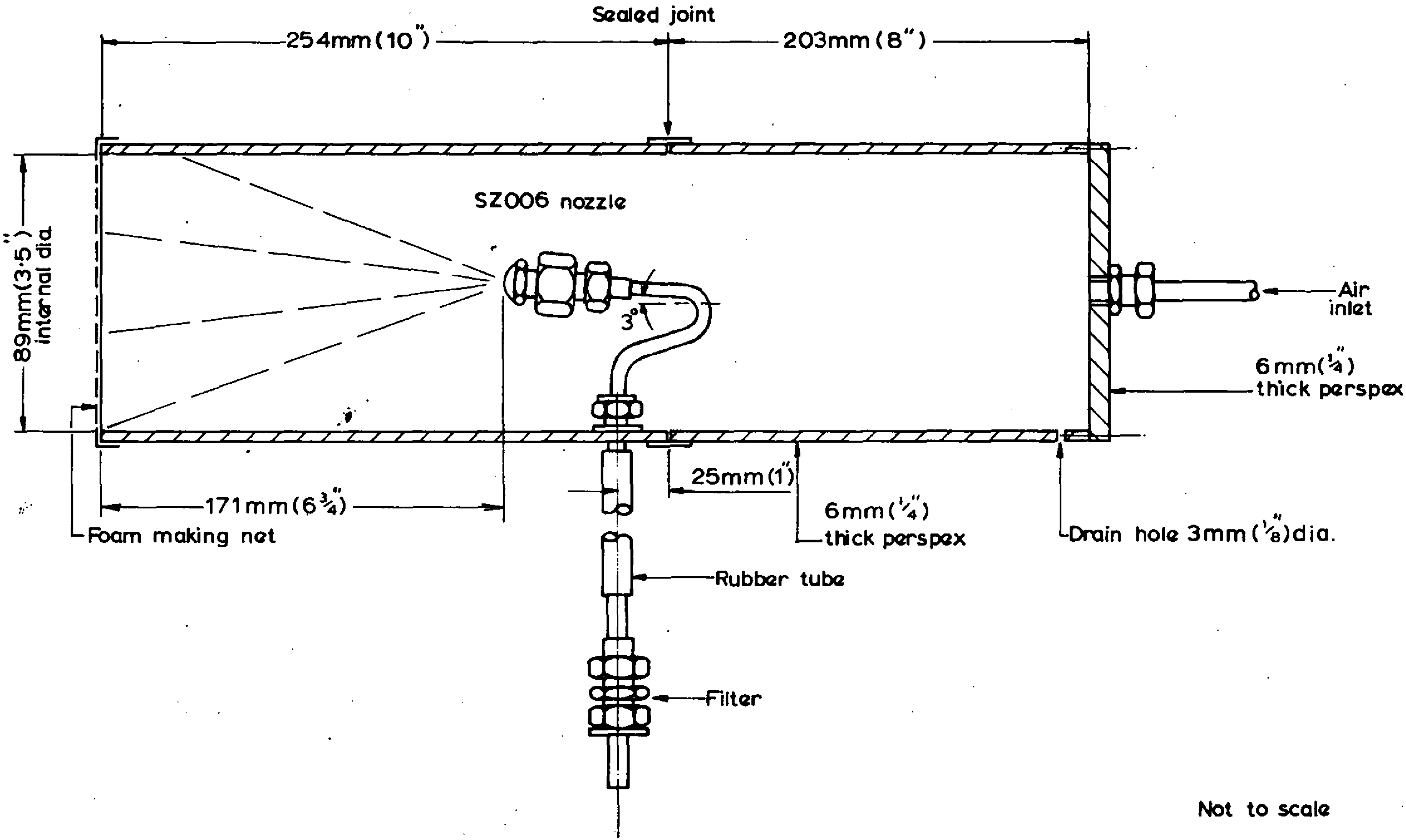


FIG. 2. DETAILS OF FOAM GENERATOR

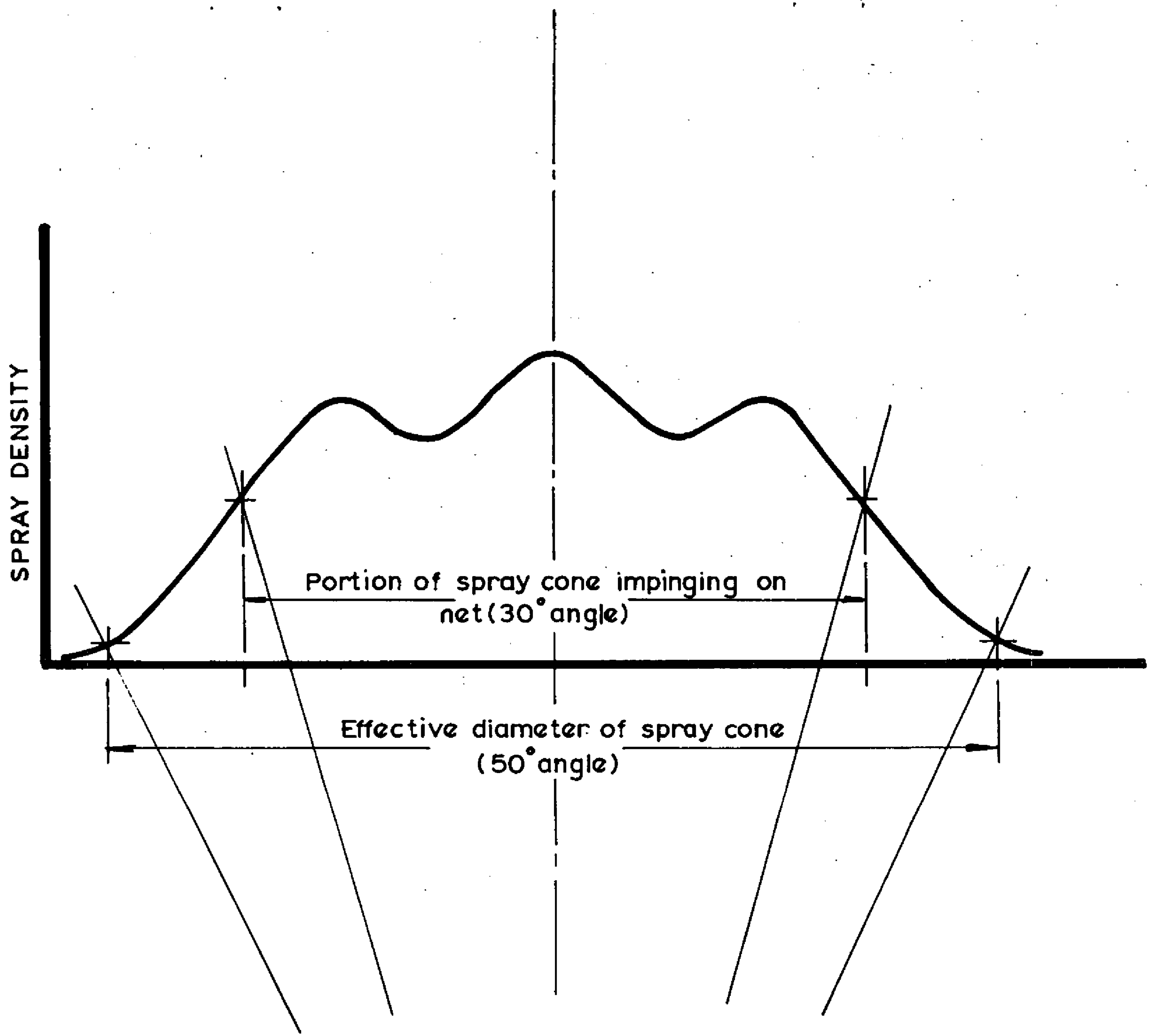
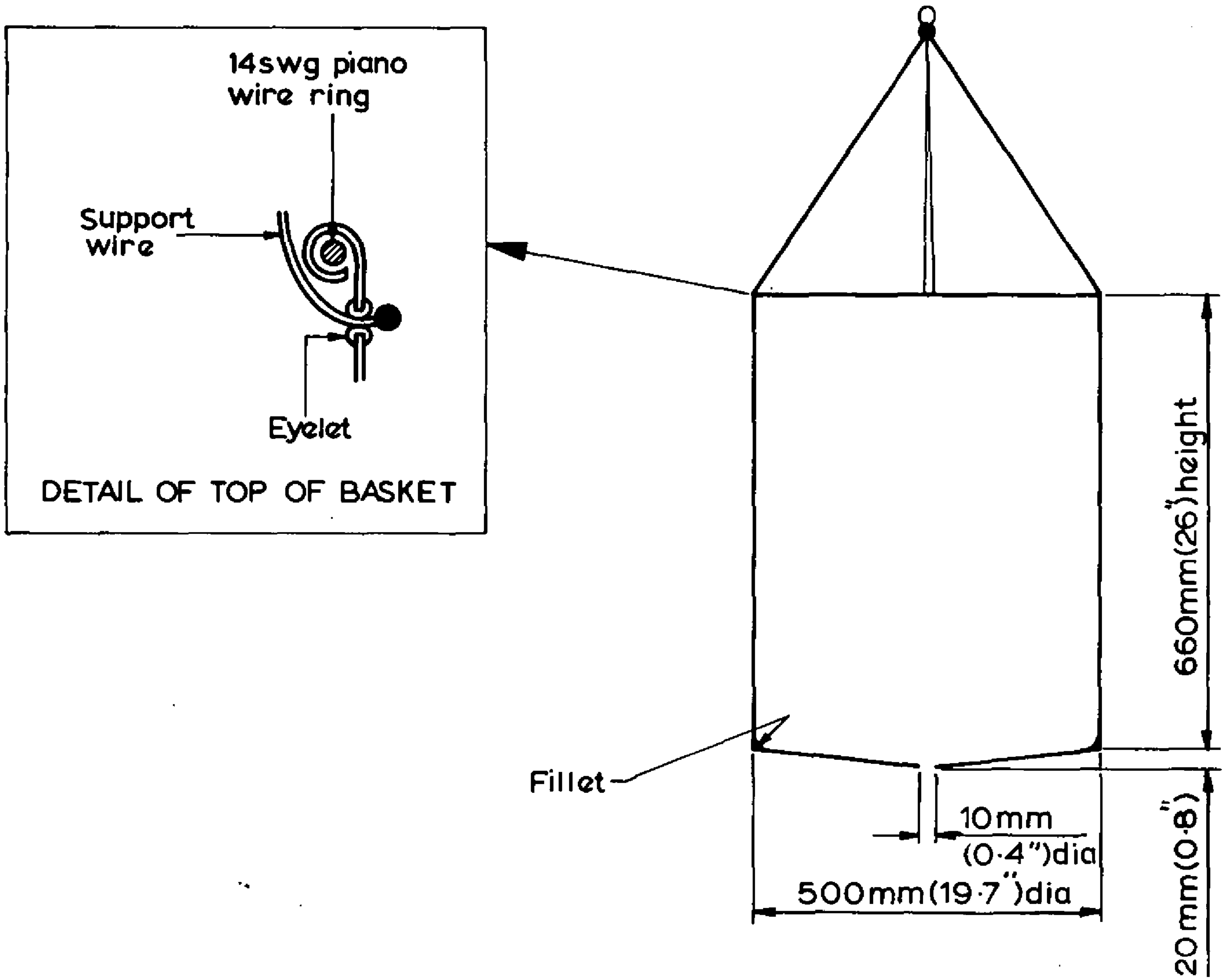


FIG. 3 NOZZLE SPRAY PATTERN



Volume = 130 litres

Material: 28 swg aluminium

Support wires: P.V.C. insulated multistrand copper wire

FIG. 4 DETAILS OF FOAM COLLECTION BASKET

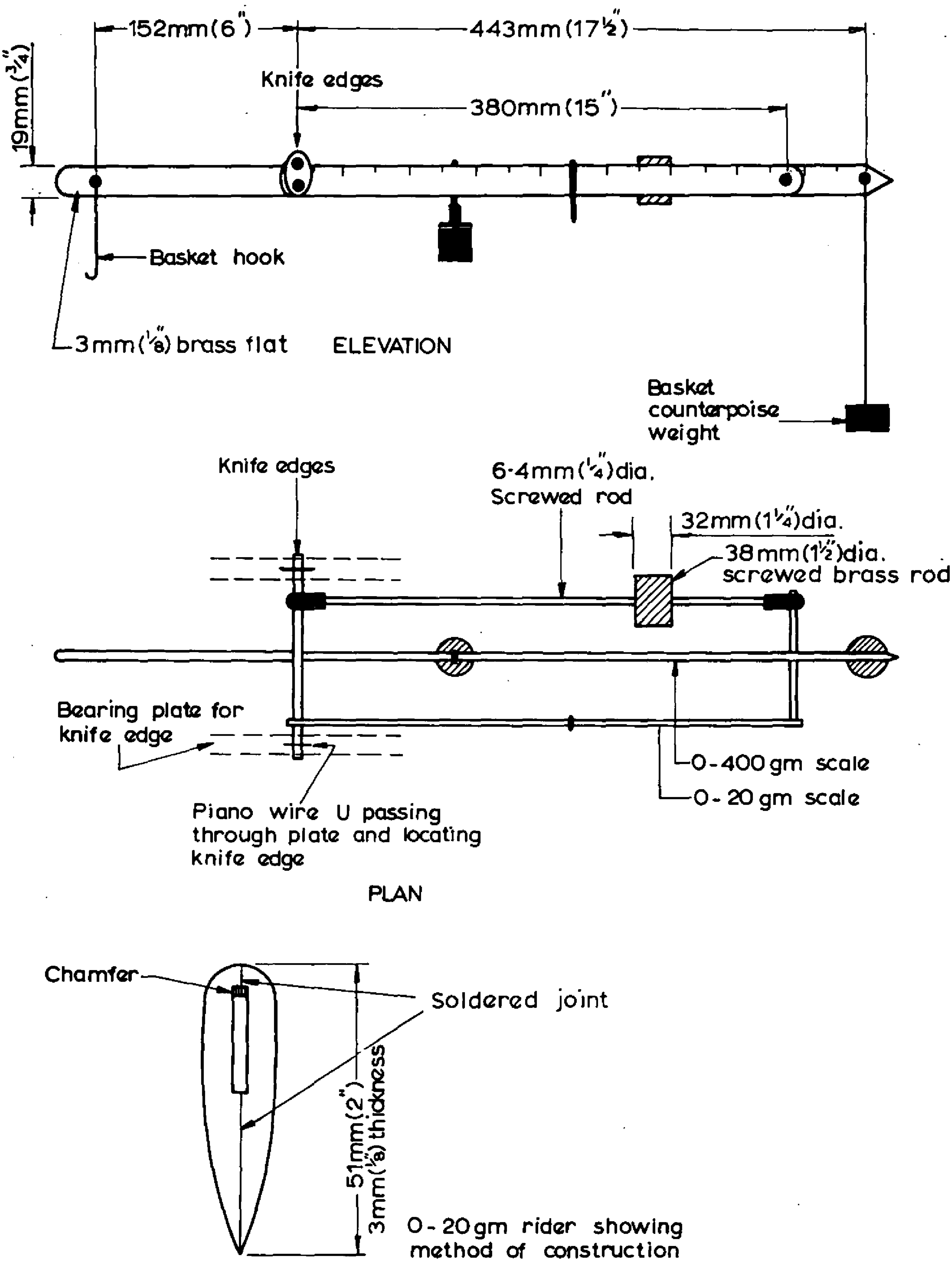


FIG. 5 DETAILS OF BALANCE

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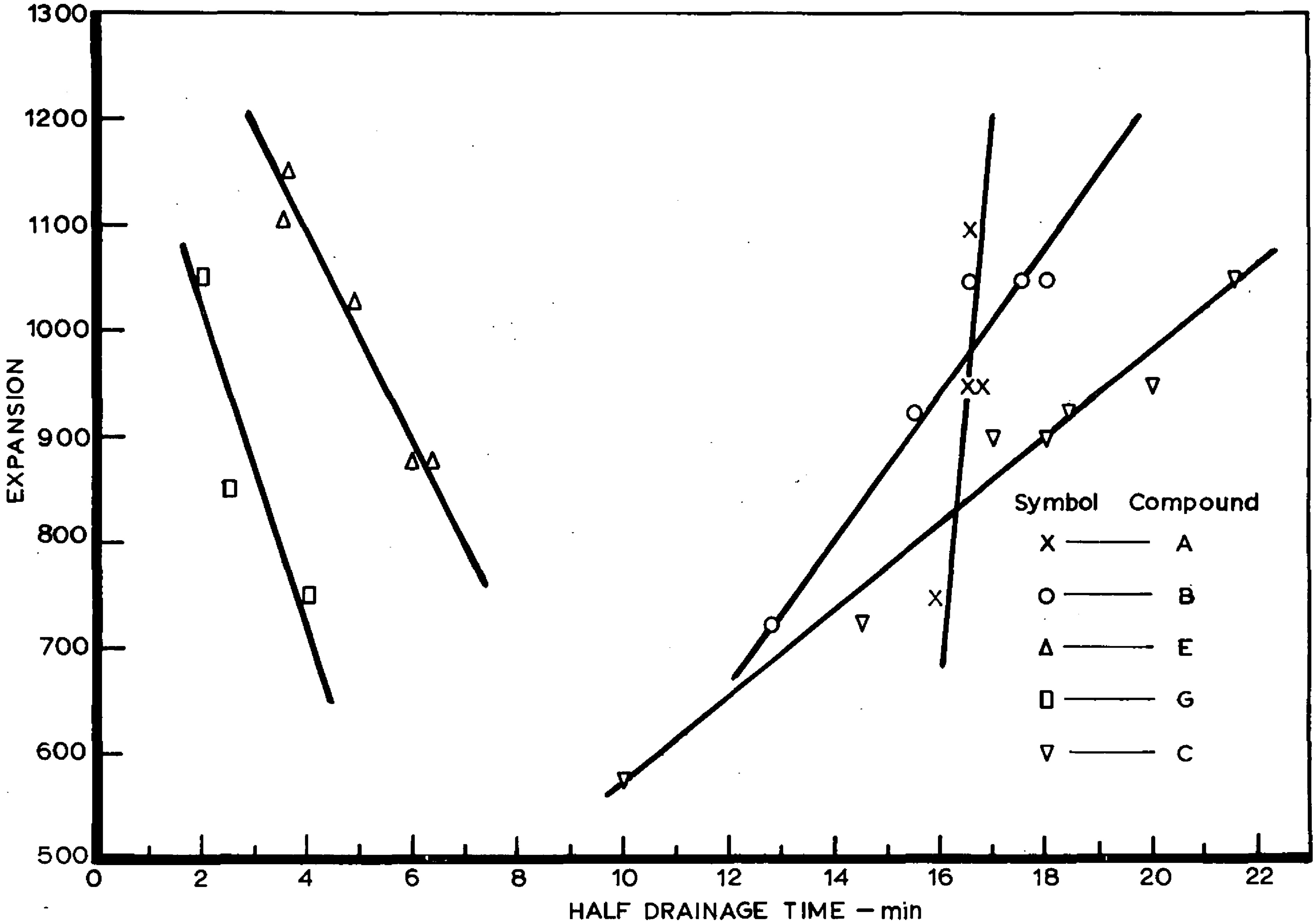

FIG.6 TYPICAL RESULTS