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A 200 LITRE PER MINUTE STANDARD FOAM BRANCHPIPE

by

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SUMMARY

Constructional details of a 200 litre per minute foam branchpipe are given. The foam properties using protein foam at various concentrations and pressures, together with the properties using a range of foam liquids in common use have been determined. The throw and dispersion have been measured. Comparisons with six commercial branchpipes have been made.

KEY WORDS: Branchpipe, foam.

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INTRODUCTION

The design and construction of a 5 l/min laboratory foam branchpipe[1,2], and of a 50 l/min branchpipe suitable for use with hose reels[3], have already been described. This report describes a continuation of the studies, leading to the design of a 200 l/min branchpipe, suitable for use as a precisely defined standard for experimental fires. It can also be used for comparing the performance of other branchpipes. It may be adapted for general use by the fire services.

Important features of a foam branchpipe are that it should be robust and simple to construct. It must not be too heavy and be convenient to use. It must be mechanically efficient in inducing air into the foam solution to produce a foam with a large surface area using the minimum concentration of foam liquid. It must operate well at the water supply pressures normally encountered. The foam jet must carry a sufficient distance to avoid the fireman having to approach the fire within the tolerable radiation zone. The foam jet should disperse so that the foam falls gently on to the fuel surface, but should remain sufficiently compact to facilitate efficient direction of the foam on to flaming areas of fuel. All these attributes have been considered in the experimental programme.

Some foam branchpipes are designed to induce the foam concentrate into the water stream. This feature has not been included because in standard tests it is preferable to use a premixed solution of foam concentrate to ensure precise proportioning, while in fire service practice an inductor integral with the pumping appliance, or an in-line inductor close to the appliance, can be used.

Ideally a branchpipe should have a device to permit the fireman to adjust the discharge from solid jet to fully-dispersed jet. This facility was not considered necessary on a branch to be used for standard tests and because of the difficulty in designing such devices no efforts were made in this direction.

The discharge from the new branchpipe was fixed at 200 l/min to support the change to metric units.

FOAM LIQUIDS USED IN THE INVESTIGATION

During the development of the branchpipe many batches of all types of foam liquid were used. For performance tests on the final design the following were used:

Protein A1	–	From UK Manufacturer A – conforming to Defence Standard 42 – 3.
Protein A2	–	From UK Manufacturer A – conforming to Defence Standard 42 – 3.
Protein B	–	From UK Manufacturer B – conforming to Defence Standard 42 – 3.
Protein C	–	From UK Manufacturer C.
Fluoroprotein A1	–	From UK Manufacturer A – conforming to UK draft Defence Standard.
Fluoroprotein A2	–	From UK Manufacturer A – conforming to UK draft Defence Standard.
Fluoroprotein B	–	From UK Manufacturer B – conforming to UK draft Defence Standard.
Synthetic C	–	From UK manufacturer C conforming to HO Specification No.28.
Synthetic D	–	From UK Manufacturer D conforming to HO Specification No.28.
Fluorochemical E	–	Made in Belgium – Grade FC200 – for use at 6 per cent.
Fluorochemical F	–	Made in UK for use at 6 per cent.
Fluorochemical G	–	Made in US for use at 3 per cent.

BRANCHPIPES USED IN THE INVESTIGATION FOR COMPARISON PURPOSES

FRS branchpipe	– the newly designed branchpipe
Branchpipe A1	– from UK manufacturer A – nominal capacity 225 l/min at 7 bar
Branchpipe A2	– From UK Manufacturer A – nominal capacity 225 l/min at 7 bar. Similar to A1 with the addition of gauze baffles.
Branchpipe B	– From UK Manufacturer B – 244 l/min at 7 bar – with valve settings for induction and premix.

Branchpipe No 2 - UK Manufacture - 225 l/min at 7 bar. The branchpipe described in UK Defence Standard 42-3 - no longer manufactured.

'National' branchpipe - US manufacture - 225 l/min at 7 bar. Has dispersal device which can be retracted to give a compact jet and extended to give a dispersed jet.

'Elkhart' branchpipe - US manufacture. A water spray-jet with a detachable foam tube. The spray jet was adjustable to 40, 60, 95 or 125 US gal/min. The spray/jet can be adjusted while the branchpipe is operating.

EXPERIMENTAL PROCEDURE

Branchpipe construction

A prototype branchpipe was constructed by scaling-up from the 50 l/min branchpipe developed earlier. This prototype, which was constructed of brass, was similar to the finally adopted design the details of which are given in Figs 1-9; and Fig 10 shows photographs of the final design, assembled, and dismantled to show its component parts. The prototype however permitted the following variations to be made:

(a) Either of the two orifices could be replaced

(b) The length of the 76 mm dia foam-making section could be increased or decreased

(c) The foam outlet nozzle could be increased or decreased in diameter and/or length

(d) A cone, of a range of diameters, could be fixed in the outlet nozzle to cause dispersion. The longitudinal position of the cone could be varied slightly

(e) A single, or several, baffles could be fixed at any position(s) in the 76 mm dia foam-making section. Baffles of a number of shapes could be used - these included semi-circular, quadrant, axial disc, peripheral flange, perforated plates, rectangular bars

(f) A cone could be fixed in the outlet from the throat into the 76 mm dia foam-making section. Cones of various sizes could be used and their longitudinal location varied from complete entry into the throat to clear of the throat

(g) The air inlet holes were larger and could be adjusted in area by partially obscuring with a metal band.

Fig 11 shows a selection of the baffles etc used in the tests.

FOAM PRODUCTION AND SAMPLING

Foam solution was prepared in a 600 litre tank at the recommended concentration and fed to the branchpipe using a fire-service pumping set. The town's water supply was used to prepare the premix and varied in temperature, according to the time of the year, between 12 and 20°C. The branchpipe was supported in a stand which permitted the direction and elevation of the jet to be varied. The discharge pressure was observed from a gauge close to the inlet to the branchpipe.

Foam samples were collected in a 50 litre plastic bin at 10 m from the branchpipe outlet. On reaching the required discharge pressure the foam was directed into the bin and collected for a period of between 15 and 20 s. Samples of foam were then taken from the bin for physical measurements.

The quality of the foam was assessed by determining its expansion, shear stress, and quarter-drainage time. These measurements were compared with those obtained using the standard 5 l/min laboratory branchpipe with a sample of the same premix at the same temperature.

Expansions were determined by weighing a 2.5 l sample. Shear stresses were determined using a torsional vane viscometer with a vane 31.8 mm wide x 31.8 mm high x 1.22 mm thick, rotating at 8.5 rpm. The yield value was measured. Quarter drainage times were determined in a 6.320 l pan (20 cm dia x 20 cm high) as described in Fire Research Note No 972[4].

Many tests were judged by measuring only the expansion and shear stress; the more time-consuming drainage test being used on the more important samples.

DISTRIBUTION PATTERNS

Eighty eight plastic bins were used to obtain a distribution measurement.

Each bin, of circular shape, and tapered to facilitate storage had the following characteristics:

Capacity	=	50 l
Internal dia at top	=	0.4 m
Height	=	0.575 m
Av weight when wet	=	2.13 kg.

The bins were arranged in rectangular array - 0.425 m between centres. There were 8 rows of 2 bins nearest the branchpipe, then 17 rows of 4 bins, and finally 2 rows of 2 bins at the extremity of the jet, in the most appropriate position to collect all the foam. A small proportion of the foam fell short of the nearest row of bins but this was insufficient to significantly affect the results obtained. The branchpipe was adjusted to an elevation of 15° with the nozzle 0.6 m higher than the top of the bins. The distances of the near and far rows of bins from the branchpipe outlet were measured. Foam was produced and when steady operation at the required pressure was established the branchpipe was swung rapidly to direct the foam over the array of bins, and a stopwatch was started. Foam production was stopped just before any of the bins overflowed, and the time of foam collection was noted. This varied from 10 s to 40 s. The weight of foam collected in each bin was then determined.

The net weights in each of the cross rows was computed to provide data on the range of the foam stream. The weights in the individual bins were then converted to application rates and summed in groups of 5 l/m^2-min. This permitted density of discharge and compactness of discharge to be calculated.

All the calculations were interpreted on the total weight of foam collected in all the bins, and it was assumed that the foam which fell between the bins would be distributed in a like manner.

These distribution measurements work well with jets which are well dispersed and permit a collection period of 1 minute or more, but with jets not so well dispersed the errors at the start of the test when the branchpipe is swung into its collection position, and at the end of the test when foam is stopped, became proportionately greater. In the tests reported using branchpipe A2, with which the discharge remained almost as a continuous rope, it was necessary to stop collection after 10 seconds, a large porportion of the discharge falling into one bin. Under these conditions the test method is of low accuracy.

GENERAL EXPERIMENTAL POINTS

When investigating changes in the mechanical details of the branchpipe a single variable was tested at several levels so that the significance of the variable could be judged. For instance, 4 slightly different lengths of outlet nozzle, or the effect of 0, 1, 2 or 3 hemispherical baffles would be tested. Usually tests would be made with protein foam and only occasionally would the other foam liquids be used as they tend to foam more readily. Tests were routinely made in duplicate and always compared with the 5 l/min standard branchpipe results.

When the commercial branchpipes were tested the plastic bins were not available to obtain distribution measurements and their throws were estimated by observing the fall of the foam in reference to a row of marker posts, providing only a rough guide of their performance. With the 'National' branchpipe, with the jet dispersed, the collection bin had to be brought nearer to the branchpipe - from 10 m to 3 m.

When the Elkhart branchpipe was used the adjustment of the spray/jet markedly affected the foam quality. With a compact spray setting, foam of poor quality and a long throw was obtained. As the spray setting was adjusted to a wider pattern the foam quality improved and the throw decreased, until a critical point was reached and the foam tube choked and liquid spurted from the air inlets. Tests were made with two settings of the spray/jet, both close to the critical point, to obtain the best quality foam. The spray/jet was used at the 60 US gpm setting.

EXPERIMENTAL RESULTS

Figures 1-9 give constructional details of the recommended standard 200 l/min branchpipe.

Table 2 gives the comparisons between the 200 l/min branchpipe and the 5 l/min standard branchpipe using eleven samples of foam liquid of the 4 principal types. These results are depicted in Fig.12.

Figure 13 shows the effect of varying the discharge pressure on the discharge rate and foam properties using 4 per cent protein B.

Figure 14 shows the effect of varying the concentration of protein B at 7 bar discharge pressure.

Table 2 gives the results of the comparisons between the new branchpipe and six other branchpipes and these are depicted in Fig.15.

Figure 16 gives the results of the distance of discharge measurements for the new branchpipe together with comparative data using branchpipes A1 and A2.

Figure 17 gives the density of discharge measurements.

Figure 18 gives the compactness of discharge measurements.

DISCUSSION

Branchpipe construction

The design for the 200 l/min branchpipe fulfils most of the desirable characteristics given in the introduction. Particularly successful is the achievement of a simple design which is easily reproduced and will favour the adoption of branchpipes to this design as reference standards. The valve[5] used on the branchpipe has a steel body because a suitable stainless steel or alloy valve could not be found and it would be desirable to adopt one of the latter which are now available. However, throughout an experimental period of over 12 months, the steel body valve gave no trouble.

The new branchpipe weighs 4.65 kg with valve and coupling. Other branchpipes, adjusted for valve and coupling had the following weights:

Branchpipe	A1	=	2.7 kg
"	B	=	2.8 kg
"	No.2	=	11.6 kg
National		=	7.3 kg
Elkhart		=	5.5 kg

The new branchpipe's weight is judged to be acceptable for use as a test branch and not unreasonable for general use. In the test branch the metal gauges have not been unduly reduced and some reductions could probably be safely made for general use. If, however, the branchpipe was constructed from light alloy, with alloy valve and coupling, its weight would be very acceptable for general use.

Variations in mechanical details

It is exceedingly difficult to adjust the mechanical details of the branchpipe to give a foam of good quality and a jet with a long throw. Any significant variations from the recommended design details will in all probability result in a reduced performance in some respect. Foam properties may be improved by introducing baffles into the foam-making section but there is a danger that the back pressure will be increased and the expansion will fall. Small changes to the outlet from the branchpipe can have large effects. Increase in back-pressure as a result of reducing the outlet diameter or increasing the nozzle length, or fitting dispersion devices, will reduce expansion and most probably the shear stress and drainage time.

Before the final design was arrived at, an alternative design which included two semi-circular baffles and a dispersion disc in the nozzle was developed. This gave marginally better foam properties than the final design but when tested on 81 m^2 area petrol fires it was found that the throw, which was approx. 35 ft was not quite sufficient to permit the firemen to operate from a safe distance. Further tests showed that to obtain a satisfactory throw no baffles must be included and that by choosing the correct outlet dimensions foam of a good quality could still be obtained.

Some of the alternative orifice arrangements, such as a plate with 8 holes, or one with 4 converging jets, gave some indication of superiority but not sufficient to outweigh the simplicity and anti-fouling advantages of the two simple orifice plates.

It was found necessary to keep the air inlet holes as close as possible to the orifice plate, otherwise droplets of liquid which fly out, at an obtuse angle from the edges of the crifice, hit the air inlets and caused the branchpipe to dribble.

Partial obscuration of the air inlets showed that these are not a limiting factor on expansion.

The optimum possible performance on expansion is to accelerate the air in the narrowest cross-section of the branchpipe to the velocity of the water jet leaving the orifice, we can thus calculate a theoretical expansion for the branchpipe, which is the ratio of the downstream orifice area to the throat area. For the recommended design this gives a theoretical expansion of 11.25. In Table 2 the two tests with synthetic foam gave expansion of 12.0 and 12.1 slightly above the theoretical value. This may be because some compression occurs in the throat, or another possible explanation is inclusion of additional air during the passage of the foam through the air and when splashing into the collecting bin.

Some tests indicated that the branchpipe would operate equally well with a smaller orifice to restrict the flow to 150 l/min (33 gpm) at 7 bar. This may be useful to extend the range of application rates for experimental fires, but a fuller assessment of this variation would first be necessary.

No variations were made in the diameter of the foam-making section of the branchpipe This was selected as the maximum diameter which would permit the branchpipe to be picked up or held by the barrel, and the minimum diameter which might operate satisfactorily as judged from knowledge of other branchpipes.

Guidance on the mechanical design was frequently obtained from the details of 5 and 50 l/min branchpipes designed previously. The following table shows some of the comparisons made; similar ones were made with the commercial branchpipe and for velocities when baffles were introduced.

Table 1

Comparisons of branchpipe dimensions - assuming expansion 8

Branch-pipe size l/min	Foam tube dia. mm	Foam tube vel. m/s	Throat vel. m/s	Outlet vel. m/s	Theoretical expansion Throat diams.	Length of throat. Throat diams.	Orifice to throat outlet. Throat diams.	Foam tube length. Tube diams.
5	19	2.4	20.8	5.25	8.35	2	13.5	11.5
50	51	3.3	8.4	11.2	23.7	1.6	4.4	9.5
200	76	5.83	17.1	16.7	11.25	3.8	3.8	5.9

In the many experiments with baffles, of widely different designs, none were found to be superior to semi-circular baffles. Because of the high foam tube velocity, semi-circular baffles reduced the expansion and throw, and two arcs slightly less than semi-circles were an improvement. This permitted a portion of the high velocity stream leaving the throat to continue to the nozzle without changing direction, and this increased the throw.

A flush central disc in the outlet nozzle would give a good dispersion of the foam, providing the outlet nozzle diameter and the disc diameter were carefully chosen. Dispersion of the jet is however difficult to ensure because the low shear stress fluorochemical and synthetic foams disperse more readily than the higher shear stress protein foams. The discharge velocity is also a major controlling factor. Narrow diameter outlets which result in high exit velocities will cause the jet to disperse well. This is assisted by the narrow diameter outlet increasing the back pressure and reducing the air intake, giving a foam with lower expansion and shear stress, which disperses more readily.

When commencing a test with the branchpipe and the pressure is slowly increased from the pump, the foam at first issues as an unbroken rope, and begins to break-up as the pressure increases. It was thought that this held promise of providing a simple control of dispersion, but when the pressure was reduced by partially closing the branchpipe valve the discharge did not revert to an unbroken rope. Presumably the turbulence in the jet, caused by the partially open valve, caused instability in the foam stream. Pressure control at the pump might provide some practical advantages by, for instance, selecting a higher pressure (say 8 bar), when stiff protein foam is used and a dispersed jet is required, or selecting a lower pressure (say 6 bar) when a more solid stream is required, as for instance to assist direction through a small aperture, such as a tank manhead.

Tests varying the length of the foam making section established that the finally selected length is the shortest permissible, without adversely affecting the foam properties.

<u>Foam properties and comparisons with the 5 l/min branchpipe</u>

The data in Table 2, depicted in Fig.12, show that the new branchpipe makes foam with equally good properties as does the laboratory branchpipe when the more readily foaming synthetic and fluorochemical foam liquids are used. But with the higher shear stress, protein based foams, the new branchpipe is slightly inferior to the laboratory branchpipe. Since the expansion shows a fall this suggests that the lower performance is connected with the orifice and throat design and if these can be improved to maintain the expansion the other foam properties will probably also equal those using the laboratory branchpipe. The overall average values in Table 2 show that the new branchpipe produces foam with a 16 per cent lower shear stress, but only a 5 per cent lower drainage time than does the laboratory branchpipe. This signifies an advantageous change in the bubble size distribution giving more fluid foams with drainage times not reduced proportionately.

The effect of discharge pressure

The results depicted in Fig.13 show that 7 bar is a good choice for normal operating pressure; the shear stress and drainage time are close to the maximum and higher pressures do not improve them significantly. The branchpipe maintains its performance well at lower pressures and an effective foam was produced down to 4 bar (58 psi). The change of expansion with discharge pressure is interesting. Operating at a discharge rate of 132 l/min, 1088 l/min of air are induced; operating at 240 l/min 1450 l/min of air are induced. The increase in the amount of air induced dces not match the increase in liquid flow rate and the expansion falls from 9.25 to 7.05.

Almost all the experimental tests on the branchpipe design were at 7 bar pressure and the effects of design changes on the relationship between discharge pressure and expansion were not noted. It is possible that appropriate modifications in design could enable the higher expansions to be maintained at the higher flow rates, and this is an interesting aspect for future studies.

The effect of concentration

The results in Fig.14 show that, with the batch of protein used, 6 per cent concentration was required to approach closely to maximum shear stress and expansion. It is usual for protein concentrates to approach maximum expansion and shear stress at 4 per cent concentration. It is most probable that these characteristics are a property of the protein concentrate rather than the branchpipe. The drainage time continues to rise progressively with concentration because of the increasing viscosity of the liquid.

Comparisons with other branchpipes

The results of the comparisons with other branchpipes are given in Table 3 and are shown in Fig.15 from which it can be seen that the new branchpipe matched quite closely the No.2 branchpipe, which had been selected as a test branch in Defence Standard 42-3 because of its good performance. Of the other branchpipes UK A1 & UK B had better throws than the new branchpipe but markedly inferior shear and drainage values. The only other branchpipe to have shear and drainage values approaching those of the new branchpipe was UK A2 and this had the lowest throw of those tested. The new design has been substantially successful in obtaining good foam properties without large sacrifice of the throw. The throw values shown in Table 3 and Fig.15 are estimates made by judging the fall of the foam against a row of marker posts. Because the foam falls over a range of distances these single value estimates provide only approximate comparisons.

Distribution measurements

Some of the distribution measurements are of limited accuracy because of the short collection times which were necessary. This method using plastic bins with an area of 0.125 m^2 and a capacity of 50 l requires the density of discharge not to exceed 50 l/m^2 min to give a collection time of 1 min which is considered satisfactory. Measurements with densities up to 100 l/m^2 min and collection times of $\frac{1}{2}$ min are close to the limits for this method.

In Fire Research Note 1045, which describes the design of a 50 l/min branchpipe, a maximum density of discharge of 50 l/m^2 min in any 0.4 m dia. bin was suggested as a specification requirement. At 50 l/m^2 min, the typical amount of foam required for extinction, say 5 l/m^2, would be applied in 6 s which represents a reasonable period to direct the branchpipe to another area to avoid waste of foam by over-application. Thus we see that branchpipe streams should disperse sufficiently to permit measurement by this method.

In spite of the limitations with poorly dispersed jets, the method permits distribution patterns to be quantified and useful comparisons made, for which no more satisfactory method has been developed.

Figure 16 depicting the jet throw shows that the new branchpipe discharges 75 per cent of the foam beyond $11\frac{1}{2}$ m (38 ft) while 25 per cent of the foam was beyond 15 m (50 ft). Calculating on a minimum application rate of 3 l/m^2 min the largest fire we would expect to use the 200 l/min branchpipe for would be 9.2 m dia. (30 ft) and therefore to project 75 per cent of the foam onto the fire the firemen would have to advance to $1\frac{1}{4}$ diameter distance from the edge of the fire. This should be tolerable with kerosine fires and some wind and normal firemen's uniform but difficulties would be encountered with a gasoline fire, in calm conditions and using a foam which did not give very rapid control. A small allowance can be made for the fact that the distribution measurements were made on a branchpipe angle of only 15° and without any wind assistance for the foam jet.

Figure 16 also shows that the new branchpipe has a curtain pattern, the major portion of the foam falling over the range 9-16 metres. This may have advantages on spill fires, but only extensive experience of its use on a variety of large fires will determine this. If the outlet nozzle from the branchpipe was increased in length - say from 82 mm to 120 mm - and slightly increased in diameter to offset the increased back pressure, the foam stream would probably issue with less turbulence and the 'curtain' fall out would be reduced and the 75 per cent throw increased, without reducing the maximum throw. Studies of such changes should be considered for future work.

The density of discharge curve for the new branchpipe in Fig.17 shows that over half the foam falls at a density between 50 and 100 l/m^2 min and the branchpipe must therefore be manoeuvred rapidly to avoid over-application. The density of discharge is also an index of the force with which the foam hits the fuel surface, causing fuel x foam mixing, and delaying or preventing extinction. We have no data on what are reasonable application densities to ensure sufficiently gentle application. It is judged that 50 l/m^2 min will be acceptable and that above this rate fuel x foam mixing problems may become important. Extensive practical experience with the branchpipe is required to arrive at a valid assessment of an acceptable maximum density.

The compactness of discharge depicted in Figure 18 shows that 75 per cent of the discharge falls within an area of $3\frac{1}{4}$ m^2. This is a good value and should permit an adequate accuracy in directing foam into residual patches of flame - but it must be remembered that the high density zone is an elongated ellipse and not circular. Again, extensive practical experience will provide a better assessment of desirable values for the compactness figure.

The curves for branchpipes A1 and A2 in Figs 16, 17 and 18 illustrate how this test method quantifies the important differences between branchpipe jet characteristics. These two branchpipes are different versions of the same model, A2 having a gauze insert in the foam-making section which results in foam with superior physical properties as seen in Fig. 15 . A1 without the gauze has a long throw, disperses well, and has a low application density but poor compactness. A2 with the gauze has a short throw, does not disperse, and has a very high application density but good compactness. We see the difficulty of obtaining desirable dispersion characteristics without sacrificing foam quality.

CONCLUSIONS

1. Constructional details are given for a 200 l/min foam branchpipe which is simple to construct and can serve as a reference standard for use in fire tests, or for comparing the performance of other branchpipes, or be adapted for general use by the fire services.

2. The new branchpipe produces foam with superior physical properties to the foam from branchpipes in general use, but comparisons with the FRS standard 5 l/min branchpipe showed that further improvements in physical properties are possible.

3. The dispersion of the foam stream has been measured to determine the throw, density of the pattern and the compactness. Extensive practical experience with the branchpipe should provide more definite views on the preferred dispersion characteristics and lead to further refinements in the design details.

4. The expansion of the foam falls as the operating pressure is increased. Further design studies may result in expansion being made independent of the operating pressure - which would be advantageous.

5. The branchpipe can probably be adapted to operate equally well with a smaller orifice to reduce the discharge to 150 l/min and so extend the range of application rates for experimental fires.

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REFERENCES

1. BENSON, S P, GRIFFITHS, D J, TUCKER, D M and CORRIE, J G. Foam branchpipe design. Department of the Environment and Fire Offices' Committee Joint Fire Research Organisation Fire Research Note No.970 1973.

2. BENSON, S P, GRIFFITHS, D J and CORRIE, J G. A 5 l/min standard foam branchpipe. Department of the Environment and Fire Offices' Committee Joint Fire Research Organisation Fire Research Note 971 1973.

3. BENSON, S P and CORRIE, J G. A 50 l/min standard foam branchpipe. Department of the Environment and Fire Offices' Committee Joint Fire Research Organisation Fire Research Note No.1045 - January 1976.

4. BENSON, S P, MORRIS, K and CORRIE, J G. An improved method for measuring the drainage rate of fire-fighting foams. Department of the Environmental and Fire Offices' Committee Joint Fire Research Organisation Fire Research Note No.972 1973..

5. Argus Hexagon Ball Valve. Size NW32 - $1\frac{1}{4}$ in BSP. Powerite Ltd. 27A Queen Street, Wolverhampton.

Table 2

Comparison of foam properties – 5 l/min and 200 l/min branchpipes (averages of duplicate tests)

Foam liquid	5 l/min branchpipe				200 l/min branchipe				200 l/min results as percentage of 5 l/min results		
	Expansion	Shear stress N/m^2	20 cm – 25 per cent drain time min – s	Foam temp °C	Expansion	Shear stress N/m^2	20 cm – 25 per cent drain time min – s	Foam Temp °C	Expansion per cent	Shear stress per cent	20 cm – 25 per cent drain time per cent
4 per cent Protein A1	7.98	22.4	9 – 37	9.8	7.85	17.1	8 – 26	10.5	98.5	76.5	88
4 per cent Protein A2	8.57	24.9	11 – 21	13.4	7.82	20.0	9 – 42	10.0	91.5	80.5	85.5
4 per cent Protein B	8.28	18.2	8 – 47	9.6	7.95	14.7	7 – 37	10.5	96	81	86.5
4 per cent Protein C	6.45	8.8	4 – 53	10.0	7.03	7.26	6 – 50	10.0	109	82.5	139
4 per cent Fluoroprotein A1	8.24	29.3	11 – 33	9.4	7.27	19.8	8 – 53	10.2	88.5	67.5	77
4 per cent Fluoroprotein A2	8.55	28.8	12 – 20	9.3	7.65	23.5	9 – 45	10.5	89.5	81.5	79
4 per cent Fluoroprotein B	8.85	12.7	9 – 10	10.0	8.48	8.55	9 – 00	10.1	95.5	67.5	98
6 per cent Fluorochemical E	9.9	4.2	5 – 08	11.6	9.7	4.5	5 – 16	11.7	98	107	102

Cont'd ...

Table 2 cont'd

6 per cent Fluorochemical F	7.8	2.9	4 - 54	9.4	10.2	3.3	4 - 35	10.0	131	113	94
3 per cent Fluorochemical G	7.0	4.0	5 - 29	10.6	7.0	2.6	4 - 43	10.9	100	65	85.5
3 per cent Synthetic C	9.2	10.3	13 - 45	9.3	12.0	8.8	13 - 47	10.2	130	85	100
3 per cent Synthetic D	9.2	7.9	12 - 14	9.5	12.1	7.7	12 - 26	10.2	132	97.5	101
		Average		10.1				10.4	105	84	95

Table 3

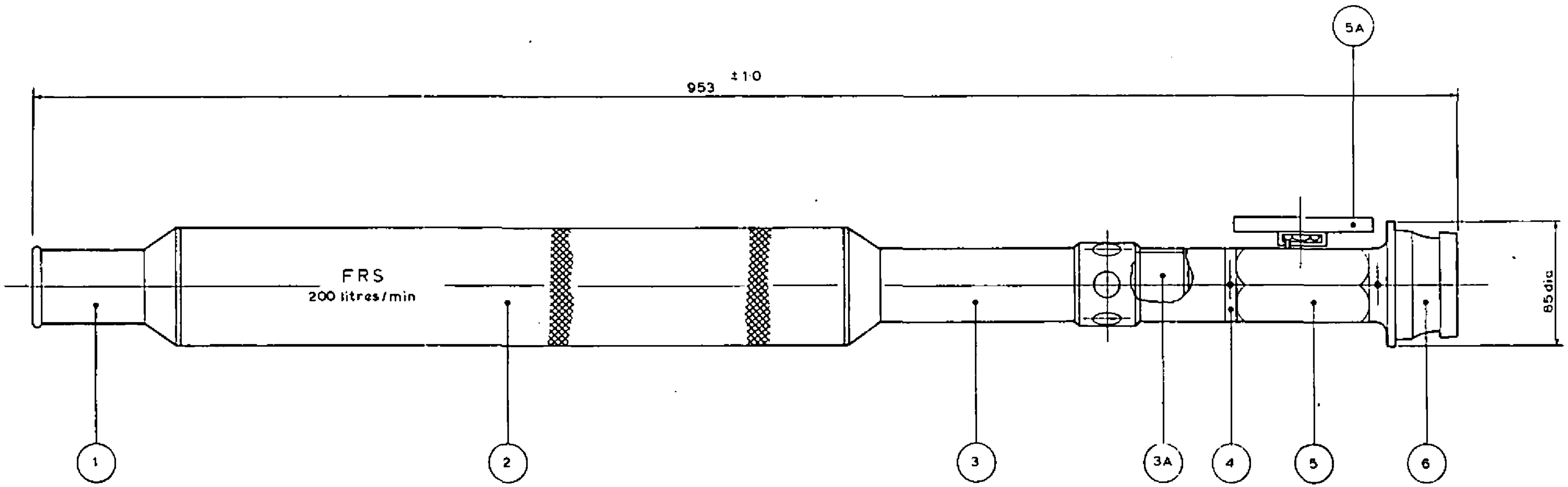
Comparisons of foam from seven branchpipes using 4 per cent protein and 7 bar discharge pressure

Average of duplicate tests

Test No	Branchpipe	Foam temp °C	Expansion	Shear stress N/m^2	20 cm - 25 per cent drain time min - s	Approx. throw -m
87, 88	UK B	10.0	7.7	6.6	4 - 47	16 +
89, 90	UK A1	10.0	8.5	10.1	5 - 49	16 +
90A, 91	UK A2	10.0	8.2	13.7	6 - 58	10.5*
92, 93	No.2	10.0	9.45	15.5	7 - 13	14.5
94, 95	US 'National' Disperser retracted	10.0	8.1	9.7	5 - 51	13.5**
96, 97	US 'National' Disperser extended	10.25	7.65	7.45	5 - 31	4.5
98, 99	US 'Elkhart' First setting	10.6	7.9	9.25	5 - 28	12
100, 101	US 'Elkhart' Second setting	10.7	8.8	10.1	5 - 25	12
102, 81, 82	FRS	10.5	7.95	14.7	7 - 37	14.5

*The foam jet from UK A2 branchpipe barely dispersed from a 'rope-like' stream.

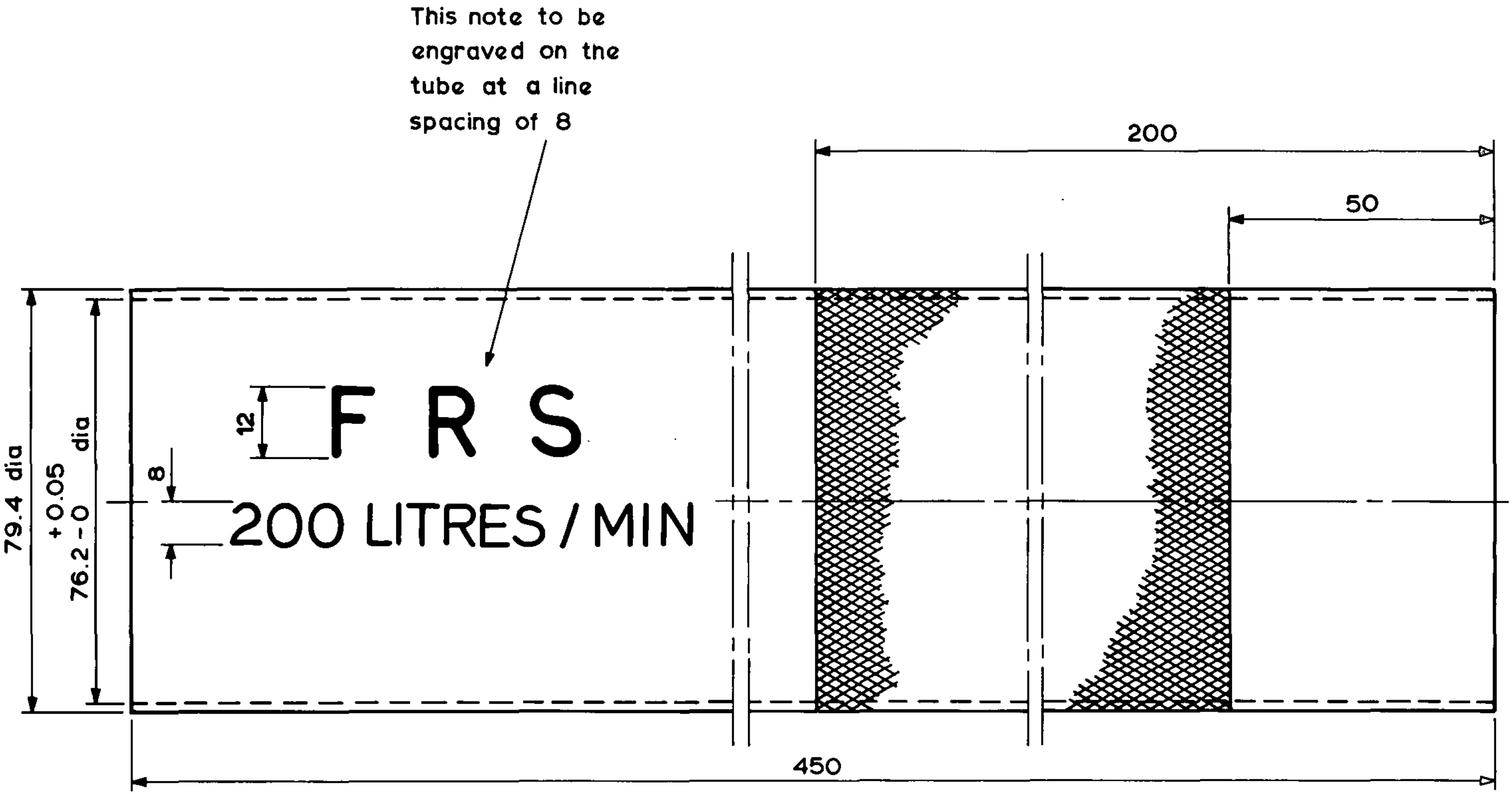
**The discharge from the US 'National' branchpipe, operating with the disperser retracted, did not align with the branchpipe and was deflected to one side.



Note:
Brazed joint between items 1,2 and 3
All screwed joints to be water tight

Scale 1-2
All dims in mm
unless stated
Tolerance ±0·1mm UOS

Figure 1 200 litre branch pipe assembly



Tolerance ± 0·1mm UOS

Matl - Brass
Fin - Clean
Scale 1-1
All dims in mm unless stated

Figure 2 Detail 2 of 200 Litre Branch pipe

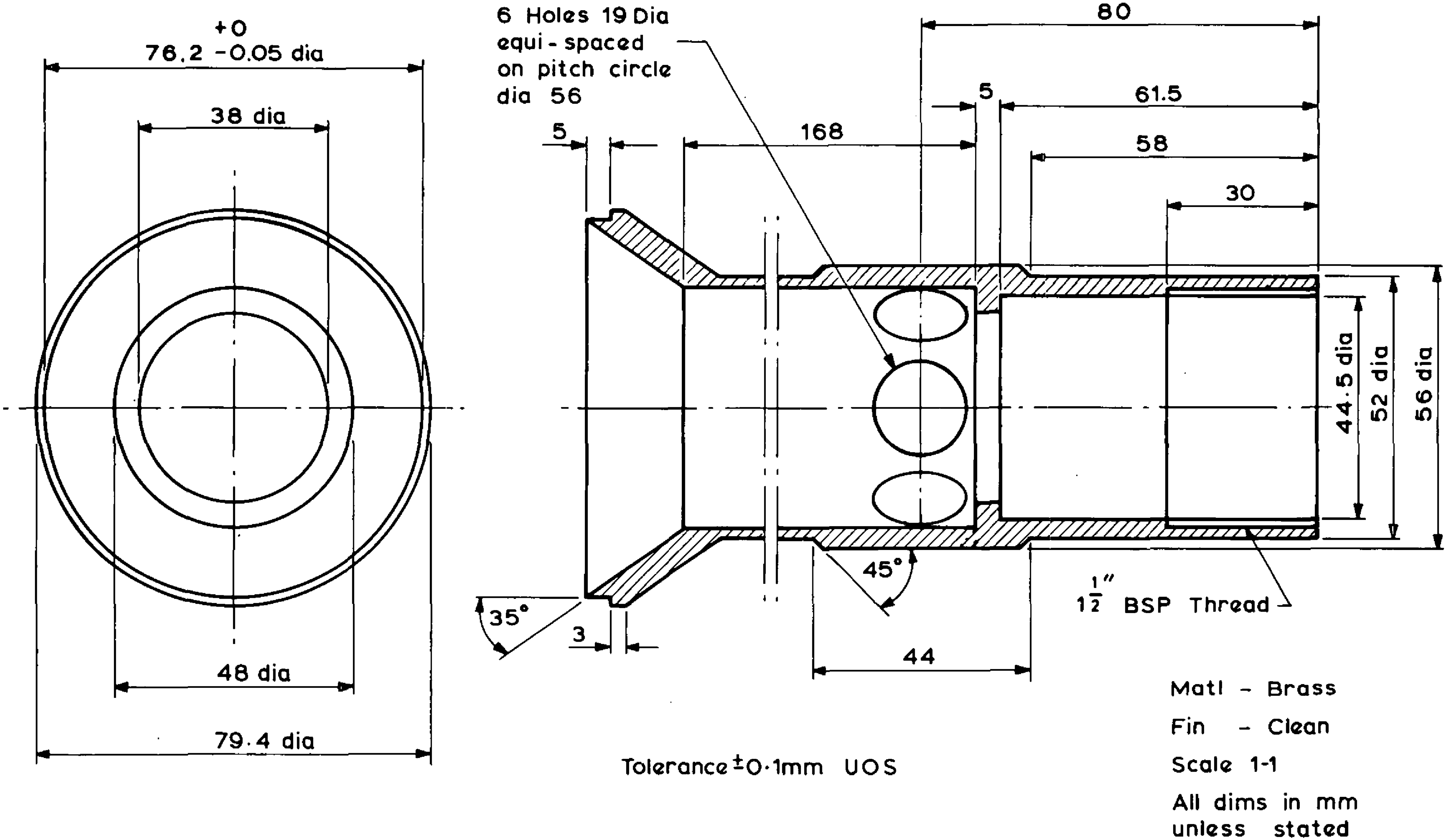
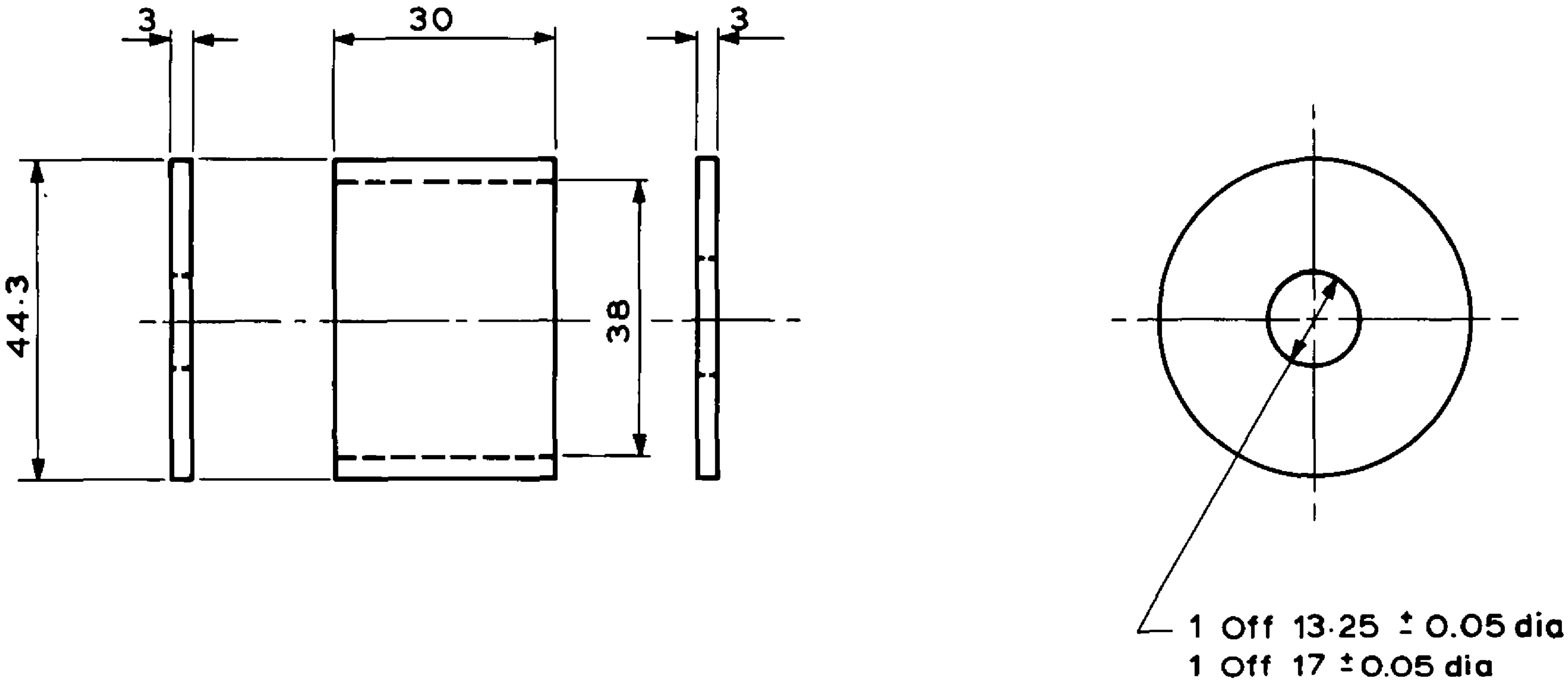


Figure 3 Detail 3 of 200 Litre Branch pipe



Orifice plates

Matl – Brass

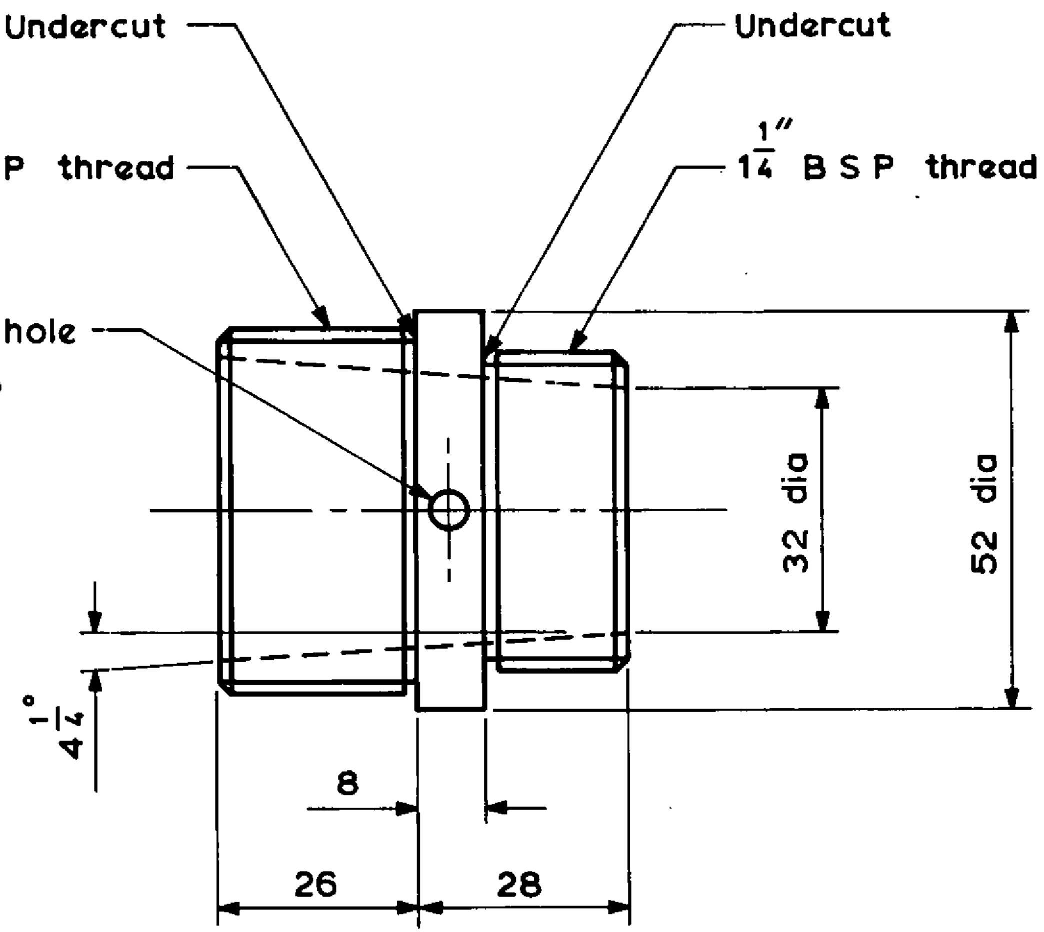
Fin – Clean

Scale 1-1

All dims in mm
unless stated

Tolerance ± 0·1mm UOS

Figure 4 Detail 3A of 200 Litre Branch pipe



Tolerance ±0·1mm UOS

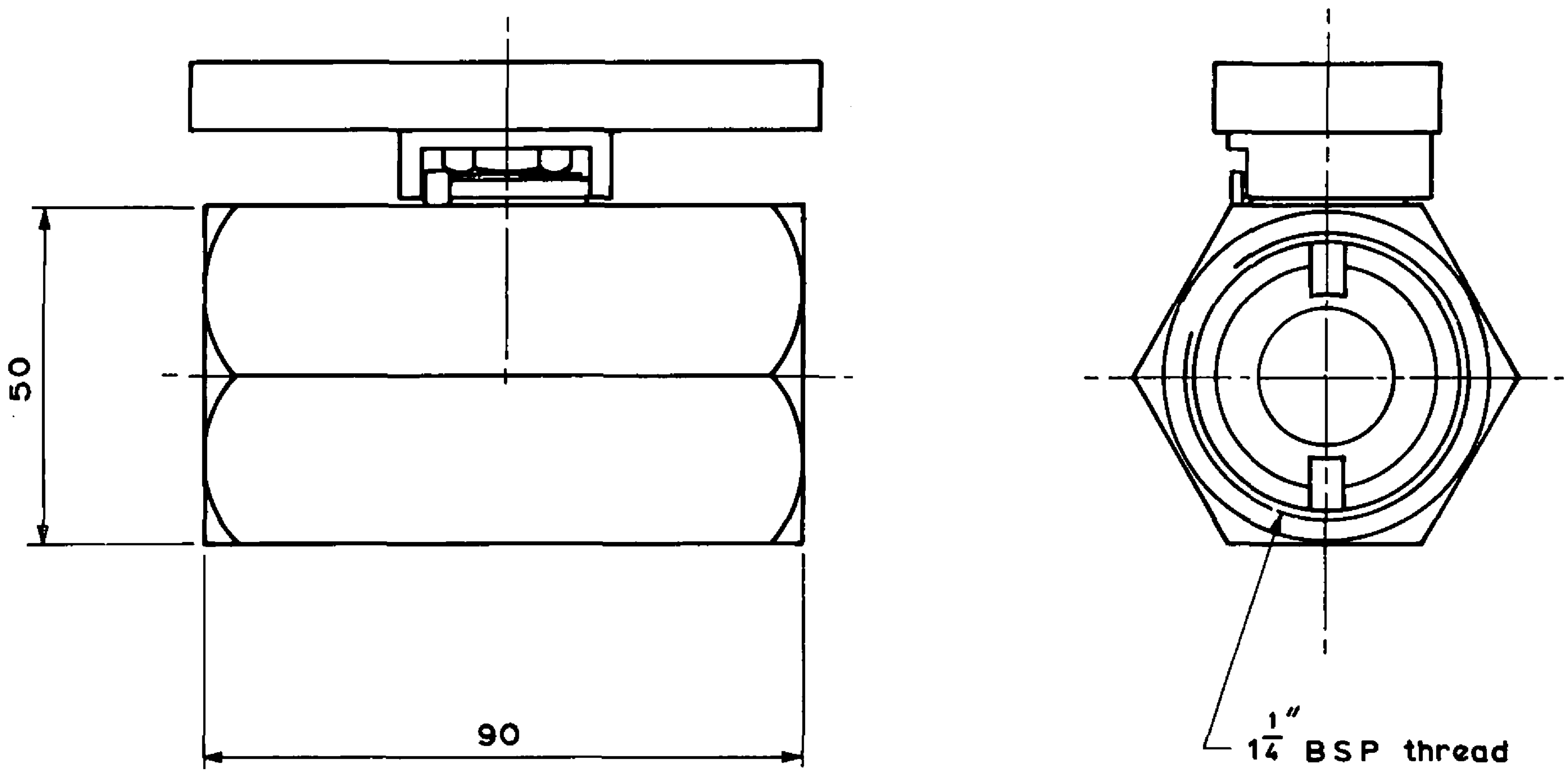
Matl – Brass

Fin – Clean

Scale 1-1

All dims in mm unless stated

Figure 5 Detail 4 of 200 Litre Branch pipe



1¼" Ball valve

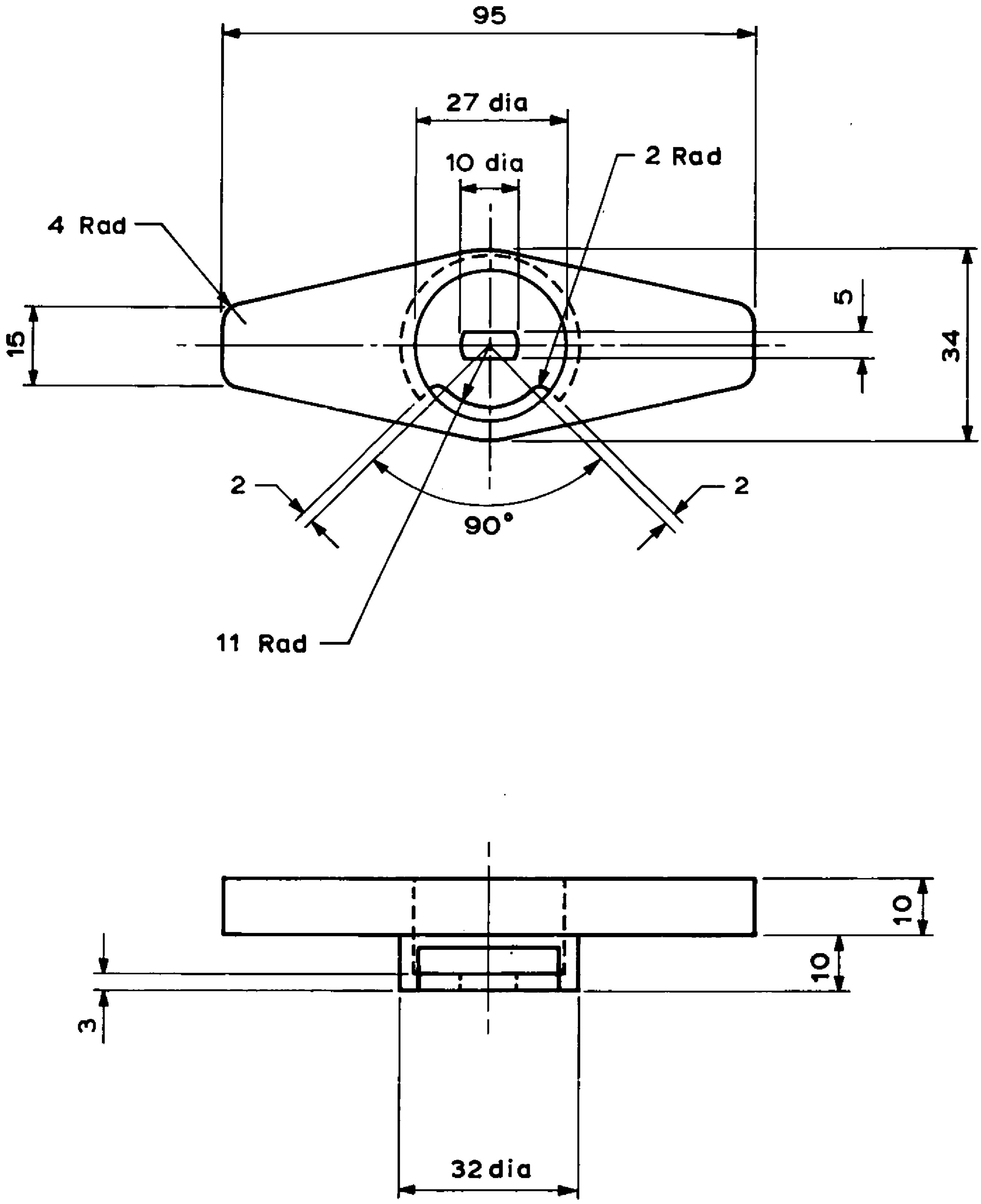
Tolerance ±0·1mm UOS

Fin – Clean

Scale 1-1

All dims in mm unless stated

Figure 6 Detail 5 of 200 Litre Branch pipe



Tolerance ± 0·1mm UOS

Matl – Brass

Fin – Clean

Scale 1-1

All dims in mm unless stated

Figure 7 Detail 5A of 200 Litre Branch pipe

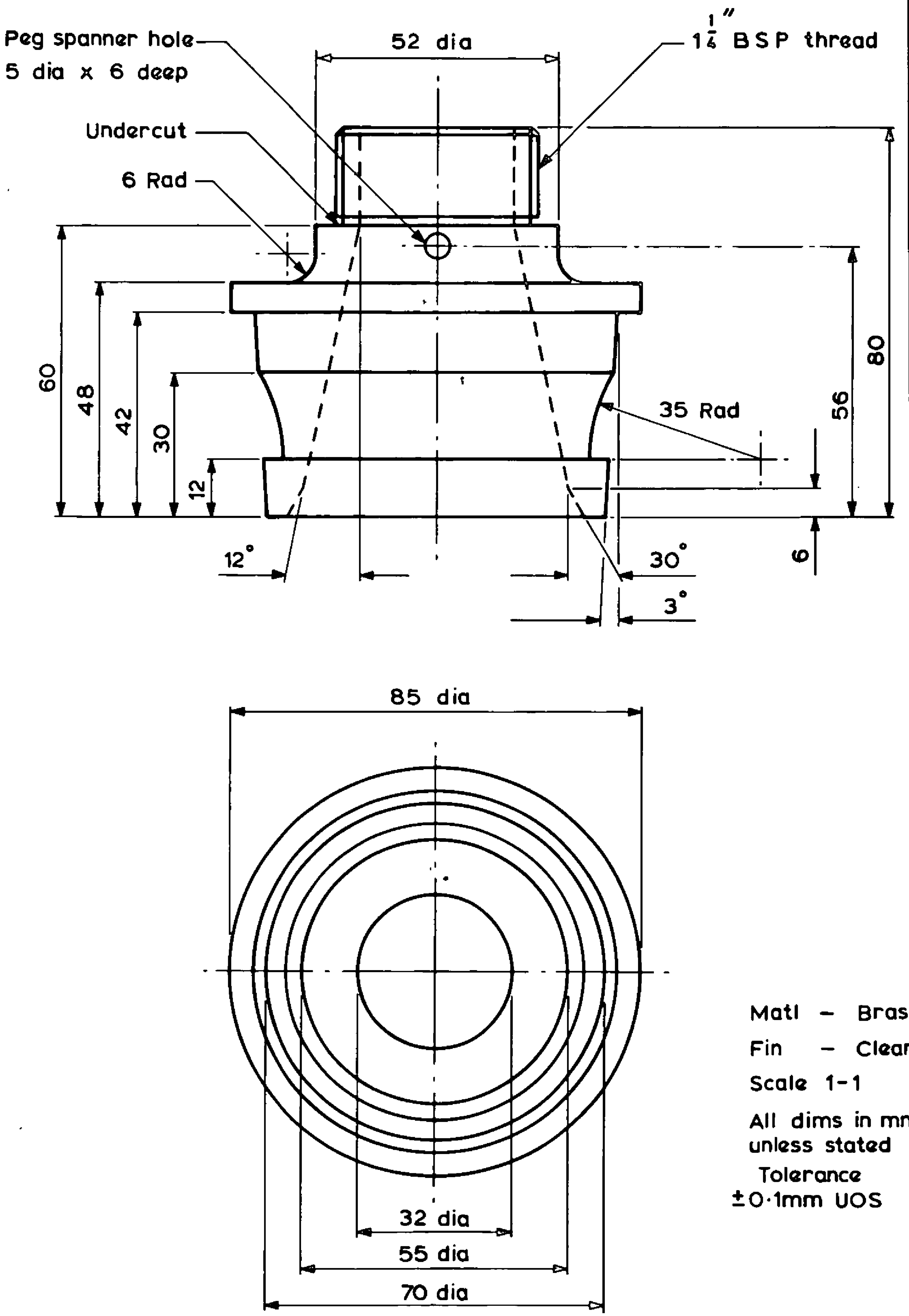
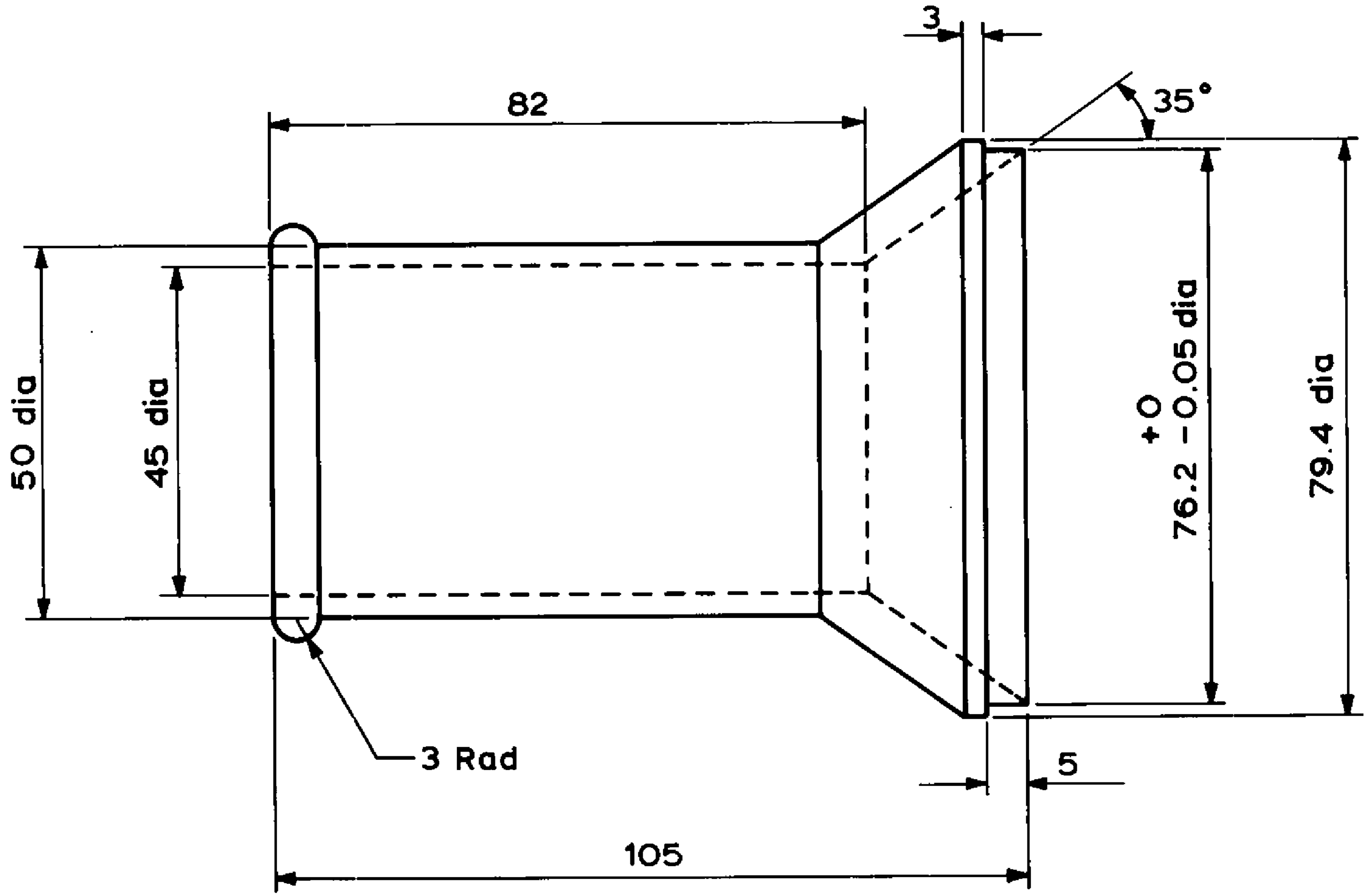


Figure 8 Detail 6 of 200 Litre Branch pipe



Tolerance ±0·1mm UOS

Matl – Brass

Fin – Clean

Scale 1-1

All dims in mm
unless stated

Figure 9 Detail 1 of 200 Litre Branch pipe

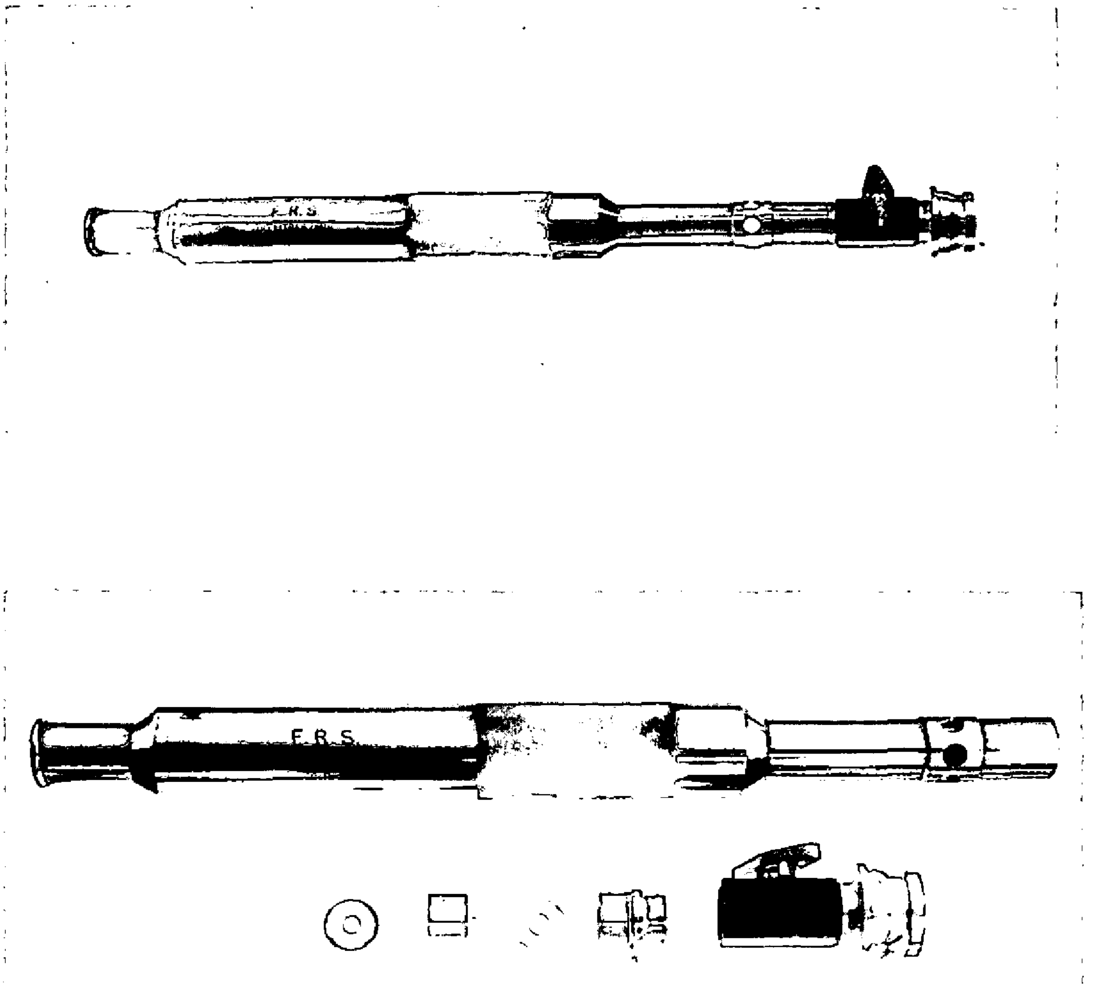


FIG.10 THE FINAL DESIGN OF BRANCHPIPE ASSEMBLED, AND DISMANTLED TO SHOW ITS COMPONENT PARTS

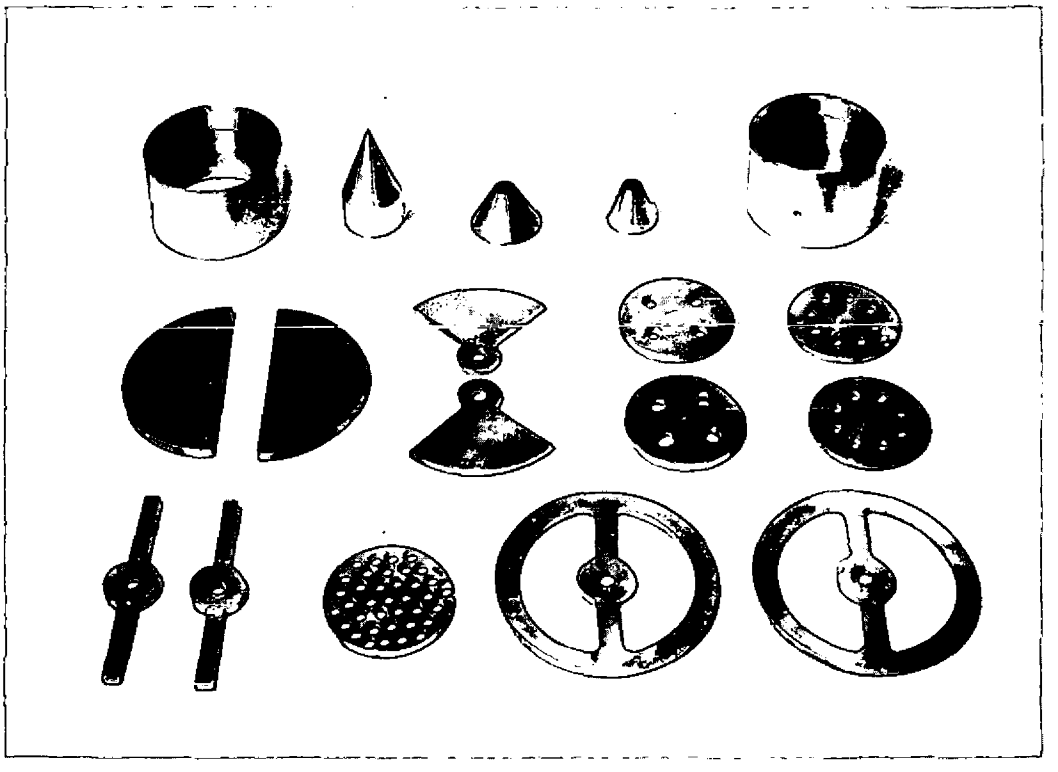


FIG.11 SELECTION OF BAFFLES ETC USED IN THE TESTS

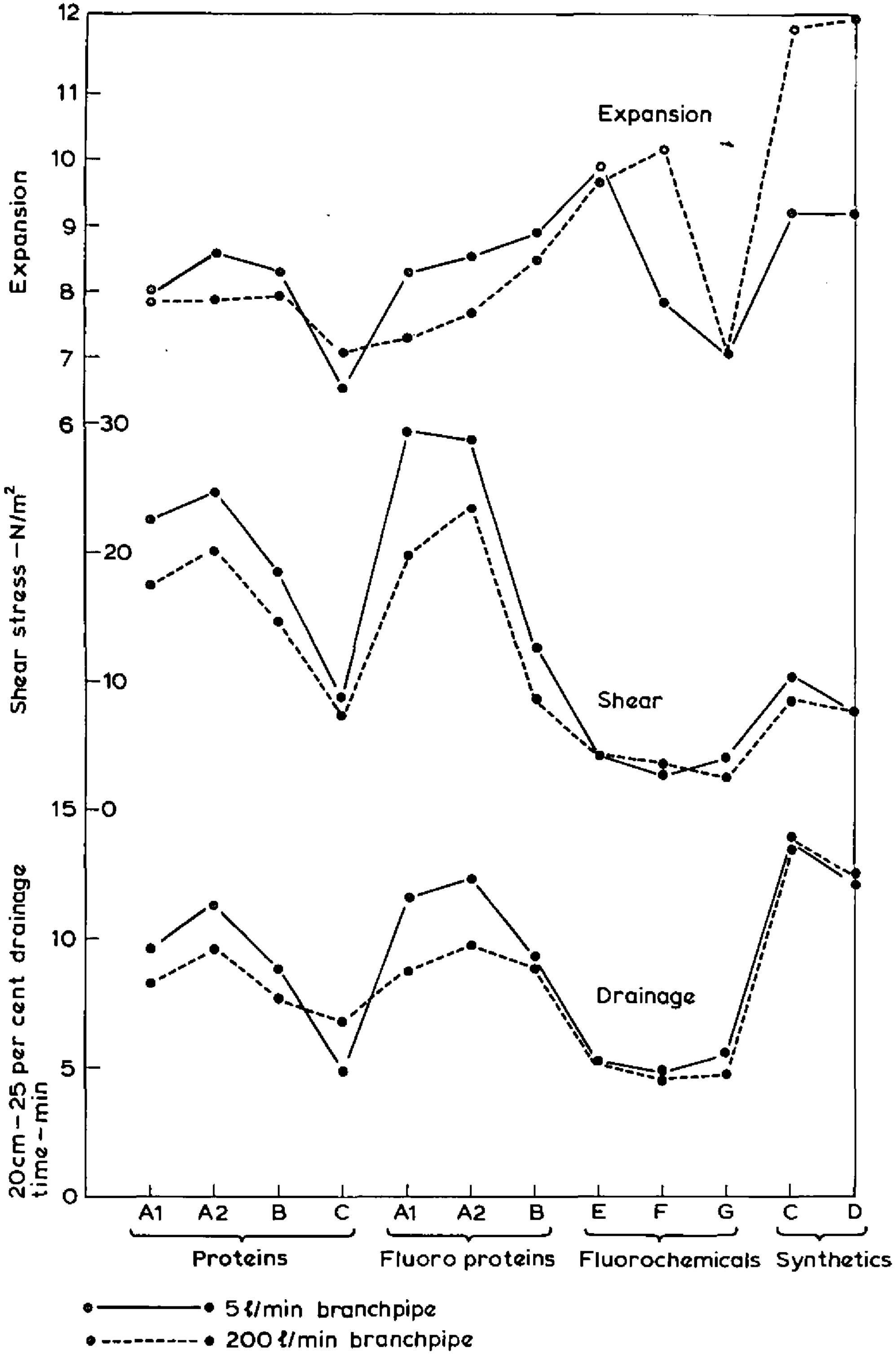


Figure 12 Comparison of foam properties with

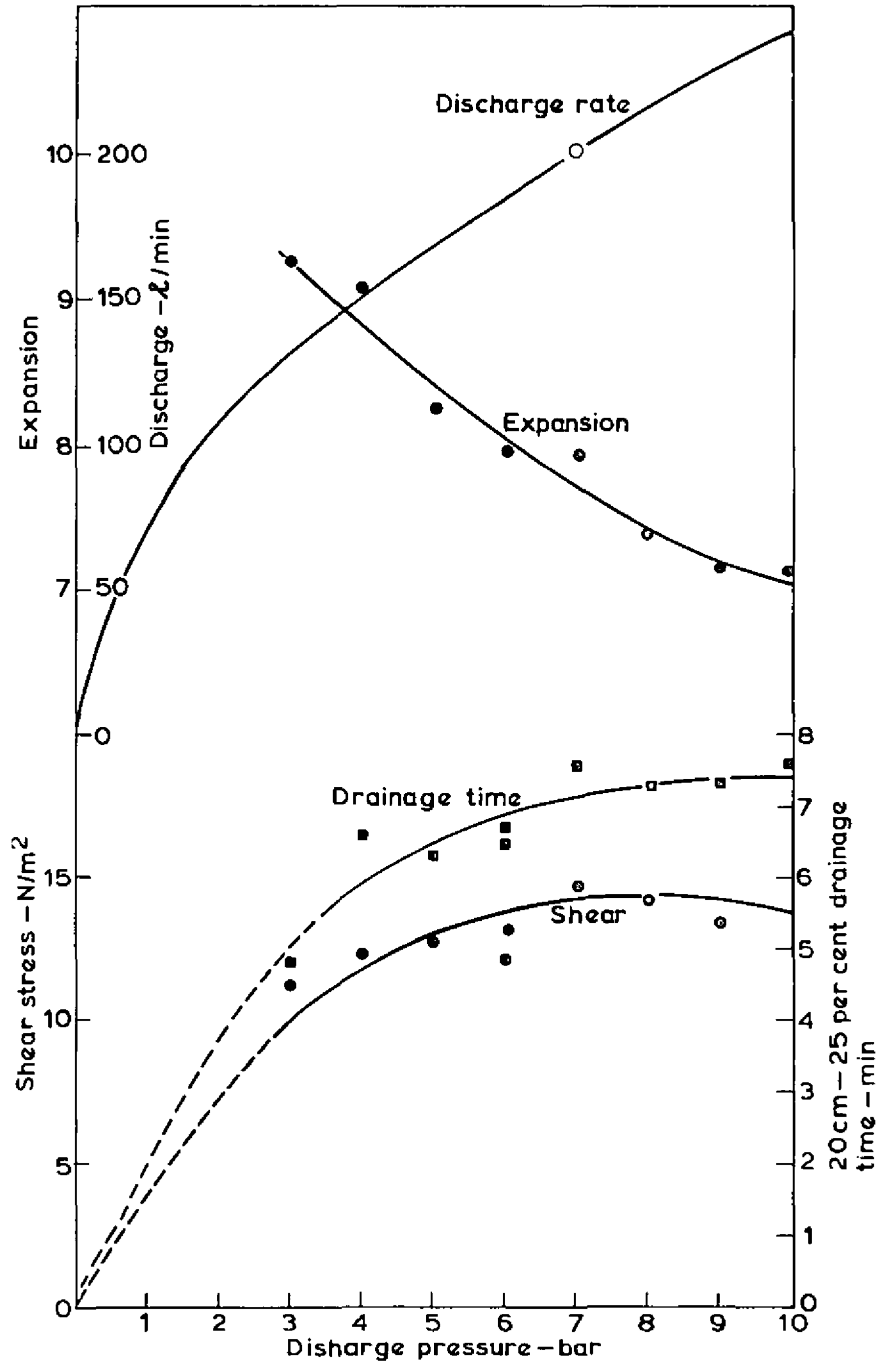


Figure 13 The effect of discharge pressure on rate and foam properties using 4 per cent protein B

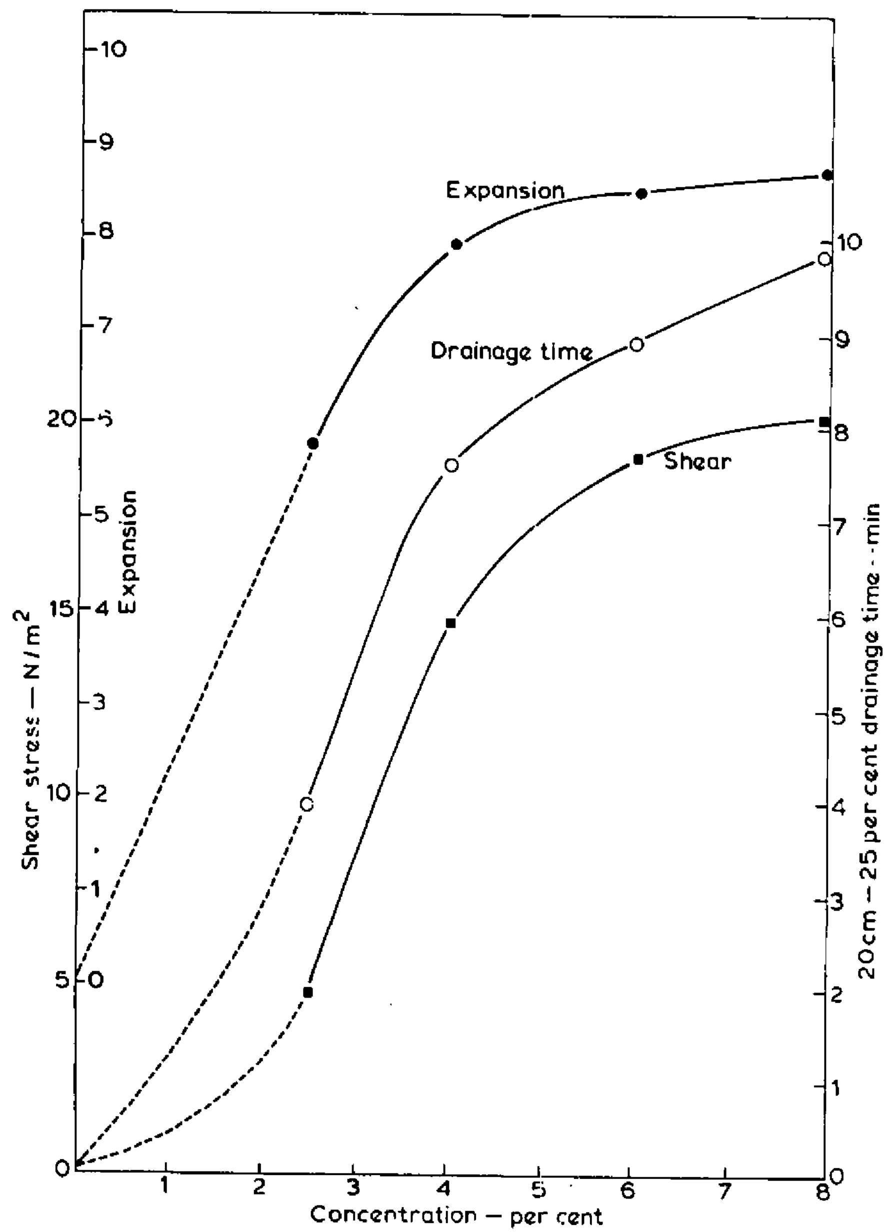


Figure 14 The effect of concentration on foam properties with protein B foam at 7 bar discharge pressure

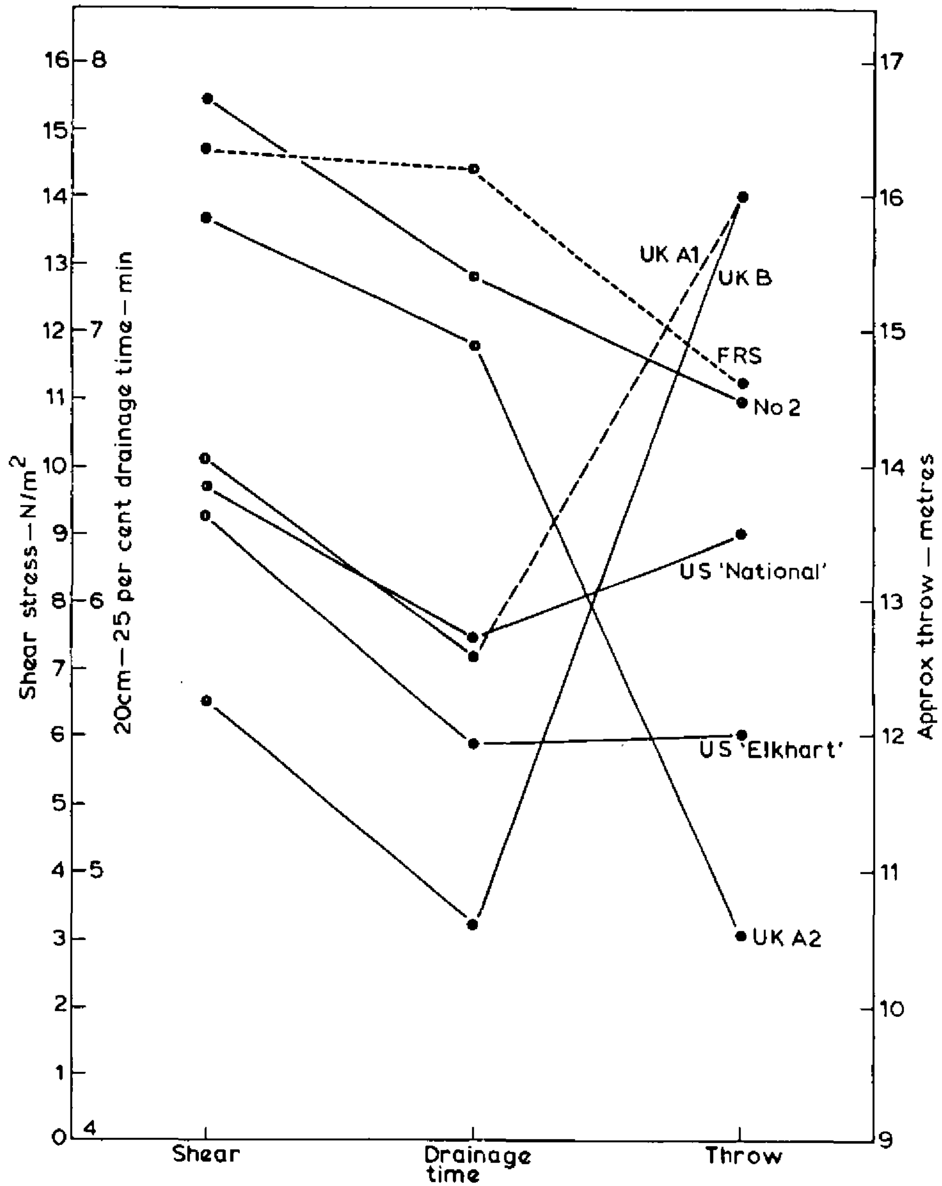


Figure 15 Comparisons of foam from seven branch-pipes using 4 per cent protein and 7 bar discharge pressure

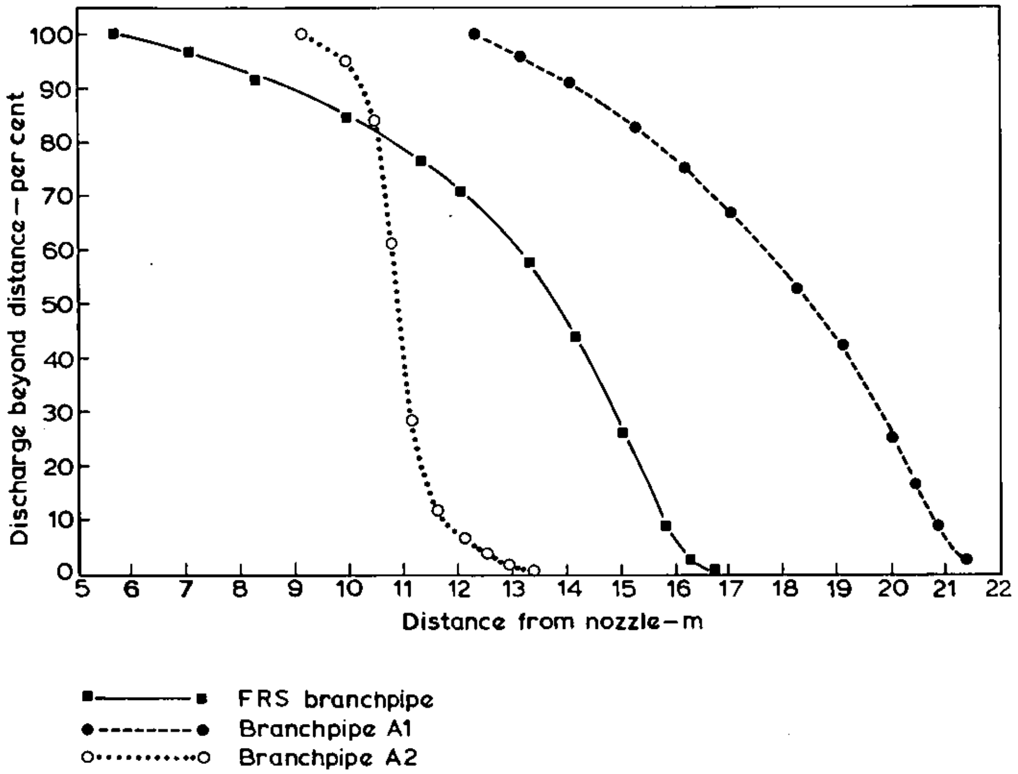


Figure 16 Distance of discharge (4 per cent protein, 7 bar pressure, 15° elevation)

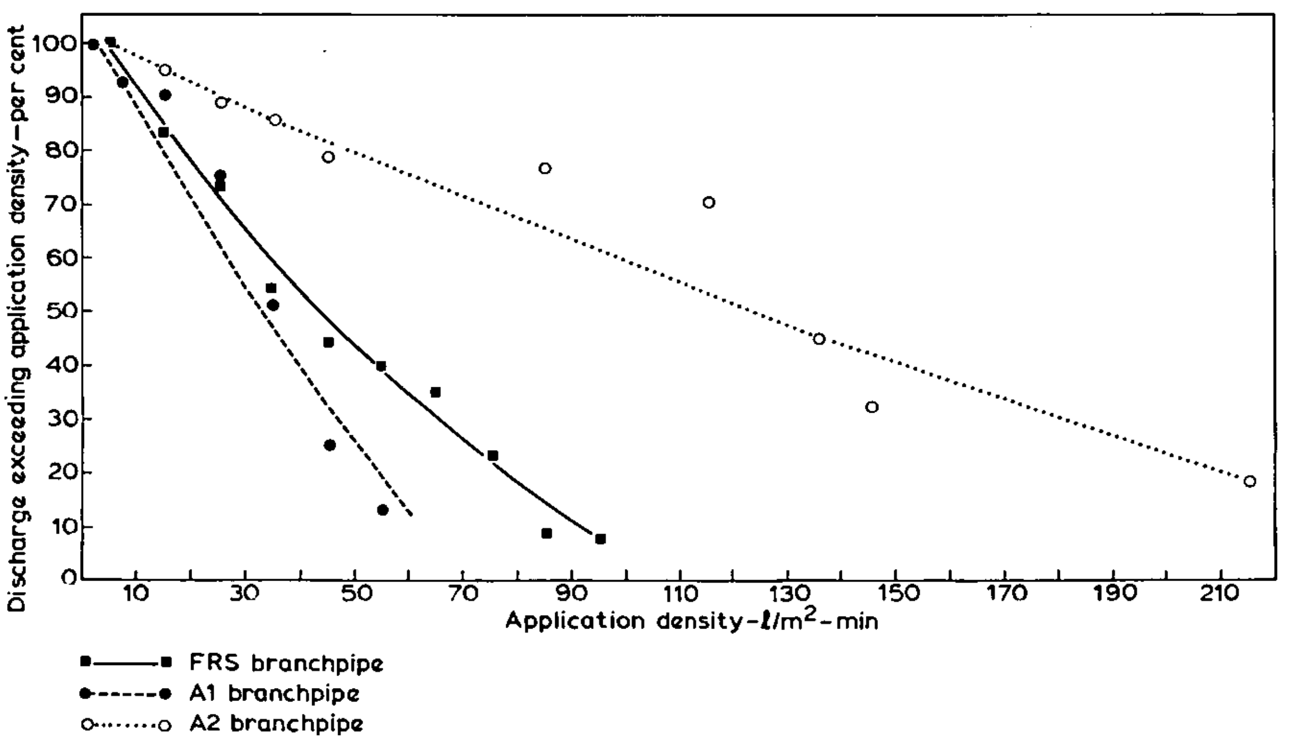


Figure 17 Density of discharge (4 per cent protein, 7 bar pressure, 15° elevation)

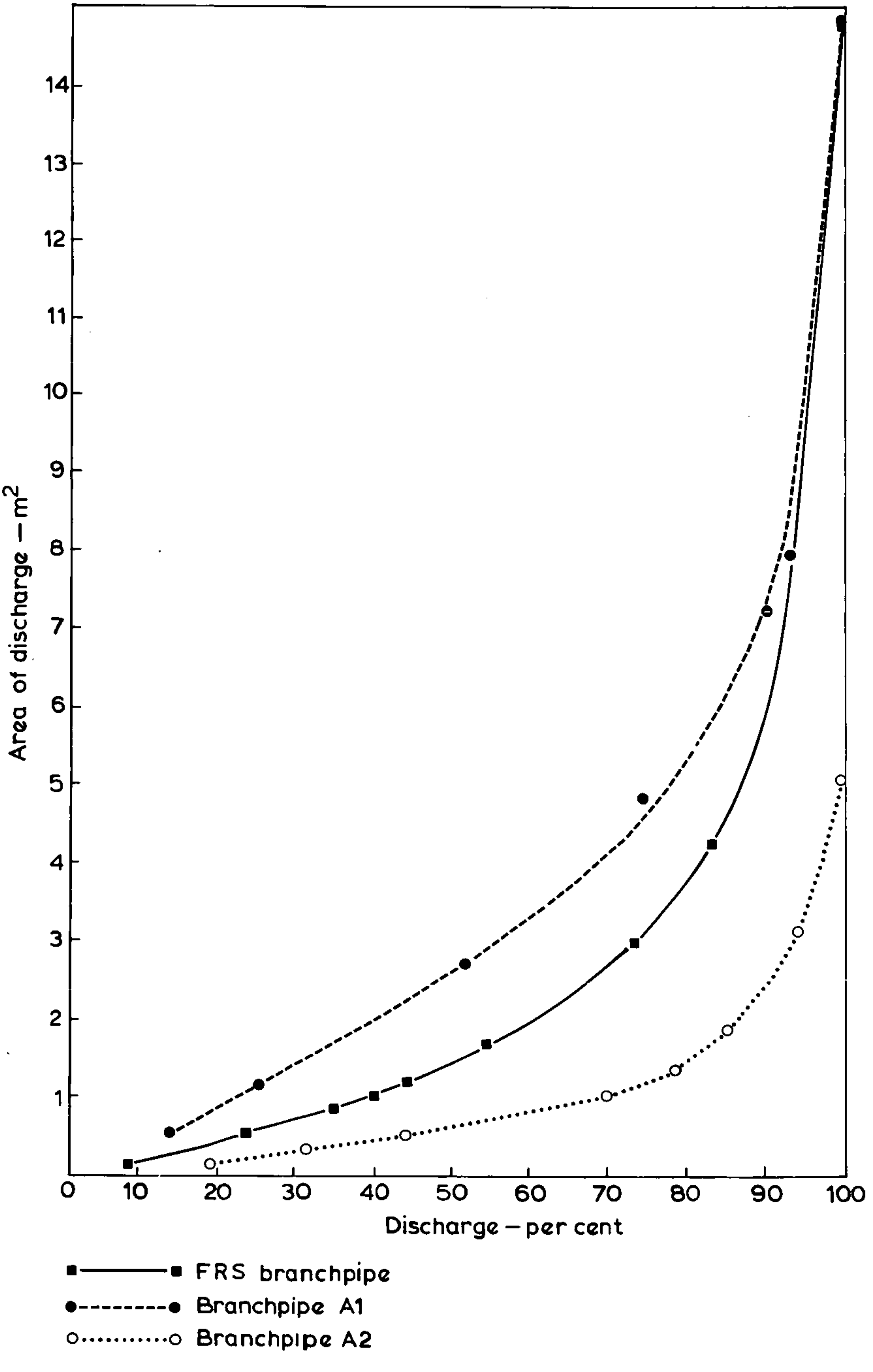


Figure 18 Compactness of discharge (4 per cent protein, 7 bar pressure, 15° elevation)