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The Use of an Araldite Coated Iron Casting as a Liner for a Supersonic Wind Tunnel

By

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The use of an araldite coated iron casting as a liner
for a supersonic wind tunnel

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SUMMARY

The use of cast iron and araldite appears to overcome the disadvantages of wooden liners. The surface finishing is no more difficult than with wood and the overall manufacturing time is comparable.

The use of a pair of male templets to define the profile is recommended. Considerable care should be taken in the manufacture of the templets, and use should be made of a curvature gauge during manufacture.

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ADDENDUMNote on Araldite

The resin used in the present application was a mixture of Araldite 'D' and Araldite 'F' with powdered french chalk as filler. This is a cold-setting type which has been developed to give a material which is workable by existing techniques with standard tools, in the carpenters' shop.

Values of the physical properties of this mixture are not known precisely, but it should not differ materially from Araldite 'D' alone, about which the following is known:-

Modulus of Elasticity	4.2×10^5 p.s.i.
Coefficient of Thermal Expansion (with filler)	40 to 60 $\times 10^{-6}$ per °C.
Specific Gravity (with filler)	1.25
Volume shrinkage during setting	0.2 to 0.3%.

1 Introduction

Most liners in use in supersonic wind tunnels at the R.A.E. are manufactured in teak, with a surface coating of phenolic resin about 0.006 in. thick. This type of construction has been used because of its simplicity together with the fact that there is available in the R.A.E. the necessary woodworking skill to meet the high standard of accuracy required.

However there are disadvantages in the use of wood. The low strength means that a large number of attachment points are necessary and consequently, unless a stiff base is provided, a large number of locating points in the tunnel are required. Shrinkage of the wood may also be significant. In one instance a variation in throat height of 0.020 in. has been measured over a period of time for a pair of liners (for $M = 2.5$ in a 9 in. tunnel) with a thickness of wood of 5 in. at the throat. Such shrinkage would be even more serious on liners for high Mach numbers when the throat height is small and the thickness of wood at the throat correspondingly large. The liners are generally made of one inch thick planks of teak glued together to produce the required width of liner. In one or two instances shrinkage across the width of the liner has led to splitting of the joints.

There existed therefore a requirement for an alternative design of liner, overcoming these disadvantages and retaining a surface which could be finished by normal woodworking methods. The choice fell upon the use of an iron casting with a coating of araldite. It was hoped that this combination would give a casting of good stiffness and stability, in which the necessary attachment points could be machined, together with a surface which could be worked in a simple manner.

To test the method a liner for $M = 1.4$ was made for the No.14 (9 in. x 9 in.) Intermittent Supersonic Tunnel. Such a liner was needed and was a simple test since in this tunnel a single-sided nozzle can be used and consequently only one shaped liner had to be manufactured.

2 Design and manufacture of liner

A sketch of the liner is given in Fig 1. The casting is of half-inch thickness of box form with webs at the positions of the attachment bosses. Provision was made for the full eight pairs of holding down bolts as used with the wooden liners, although it was anticipated that these would not all be required.* The only machine work done on the casting was in the facing of the attachment bosses, in the cutting of threads for the mounting bolts and in the provision of locating holes for the templet dowels.

The surface coating of araldite is $\frac{1}{4}$ in. thick and overlaps the casting by $\frac{1}{2}$ in. at each side. Grooves for the rubber sealing strip are provided in the overlap. The araldite was of the cold-setting type and was applied to the casting after 'hot priming'. Powdered french chalk was used as a filler.** The resultant composition is no more difficult to work than the usual phenolic resin and possibly has an advantage that it is of greater thickness and there is thus less likelihood of accidentally breaking through the coating.

* In fact three pairs only were used without measurable deflection occurring at intermediate points with the tunnel running.

** It is important that good quality french chalk - "acid washed" - be used or a heterogeneous mixture may result.

In manufacturing previous liners the normal practise has been to use a female templet. Whilst being worked the liner is mounted on a surface table and is bridged by the templet which can be moved across the width of the liner. Any subsequent check of liner shape thus requires the use of a surface table and checking of the liner profile when installed in the tunnel is precluded. It was decided therefore to use a pair of male templets mounted on the sides of the liner. With the aid of a straight edge, profile checks could then be made at any time. The templets were mounted on a pair of dowels as shown in Fig 1.

3 Accuracy and stability of the liner

The liner was completed in July 1954. Inspection of the templets revealed a disconcerting lack of accuracy. Errors in ordinate heights amounted to as much as 0.007 in. A check with feeler gauges and a straight edge showed that the liner was within 0.002 in. of the templets. A further check was made using a simple three-legged curvature gauge. The gauge has a span of 4 in. between the fixed legs with a dial gauge graduated in tenths of thousandths of an inch as the centre leg. Fig 2 compares readings of this gauge on both templets with readings calculated from the design ordinates. The irregularities of the templets are clearly shown. In Fig 3 curvature gauge readings on both templets and liner are compared. The irregularities of the templets are faithfully reproduced in the liner.

After a period of some fifteen months during which time the liner was installed in the tunnel** for calibration the inspection of the liner and templets was repeated. Within the accuracy of the measurement (0.001 in.) the templets were found to be unchanged. On comparing with the templets a sag of the liner became apparent. The maximum value of this sag was about 0.0035 in. and occurred at 29 in. from the upstream end. The curvature gauge measurements were also repeated and are shown in Fig 4. The agreement between liner and templets is very much as in Fig 3. The small change of curvature due to the sag is not measurable with the curvature gauge.

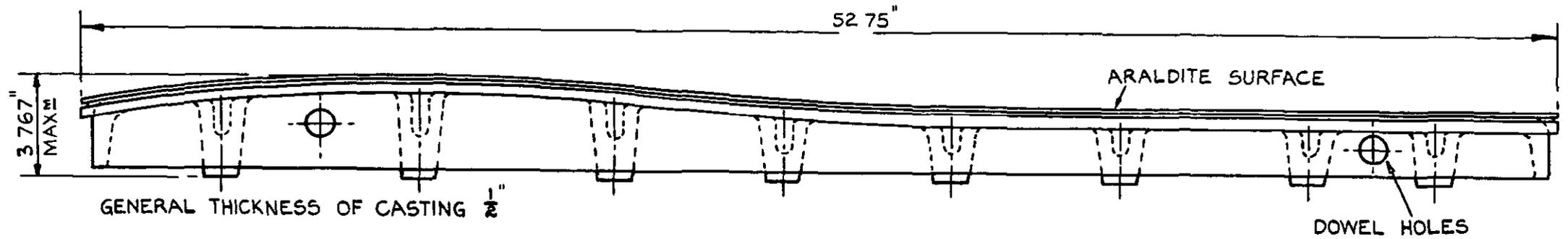
The distortion of the liner may be due to the fact that the casting was not aged and the removal of part of the front web may also have had some effect. However the distortion is considered not to be significant in use of the liner.

4 Conclusions

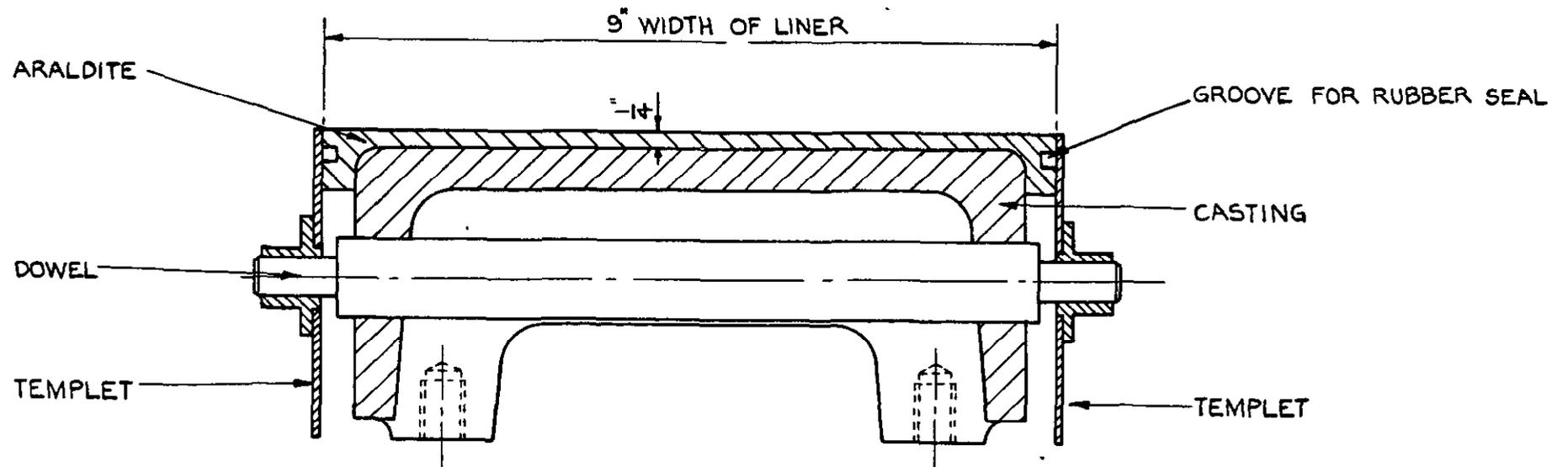
- (i) The cast iron-araldite liner is more stable than wooden liners. Some slight distortion is apparent over a period of fifteen months. This might well have been eliminated by suitable aging of the casting before use.
- (ii) The liner is stiffer than a wooden one and consequently needs less attachment points to the tunnel.
- (iii) The surface finishing of the liner is no more difficult than for a wooden liner. The overall manufacturing time is comparable, apart from the necessary aging of the casting.
- (iv) The use of a pair of male templets is recommended rather than of a female templet. A curvature gauge should be used on the templets during manufacture.

* Improved techniques of templet manufacture have now been developed.

** It was found that the front web of the liner fouled the tunnel structure and part of this web was removed.



(a) M=1.4 LINER. (SCALE $\frac{1}{5}$)



(b) SECTION THRO' DOWEL SHEWING TEMPLITS IN PLACE. (SCALE $\frac{1}{2}$)

FIG.1 (a&b). ARALDITE COATED CAST IRON LINER M=1.4.

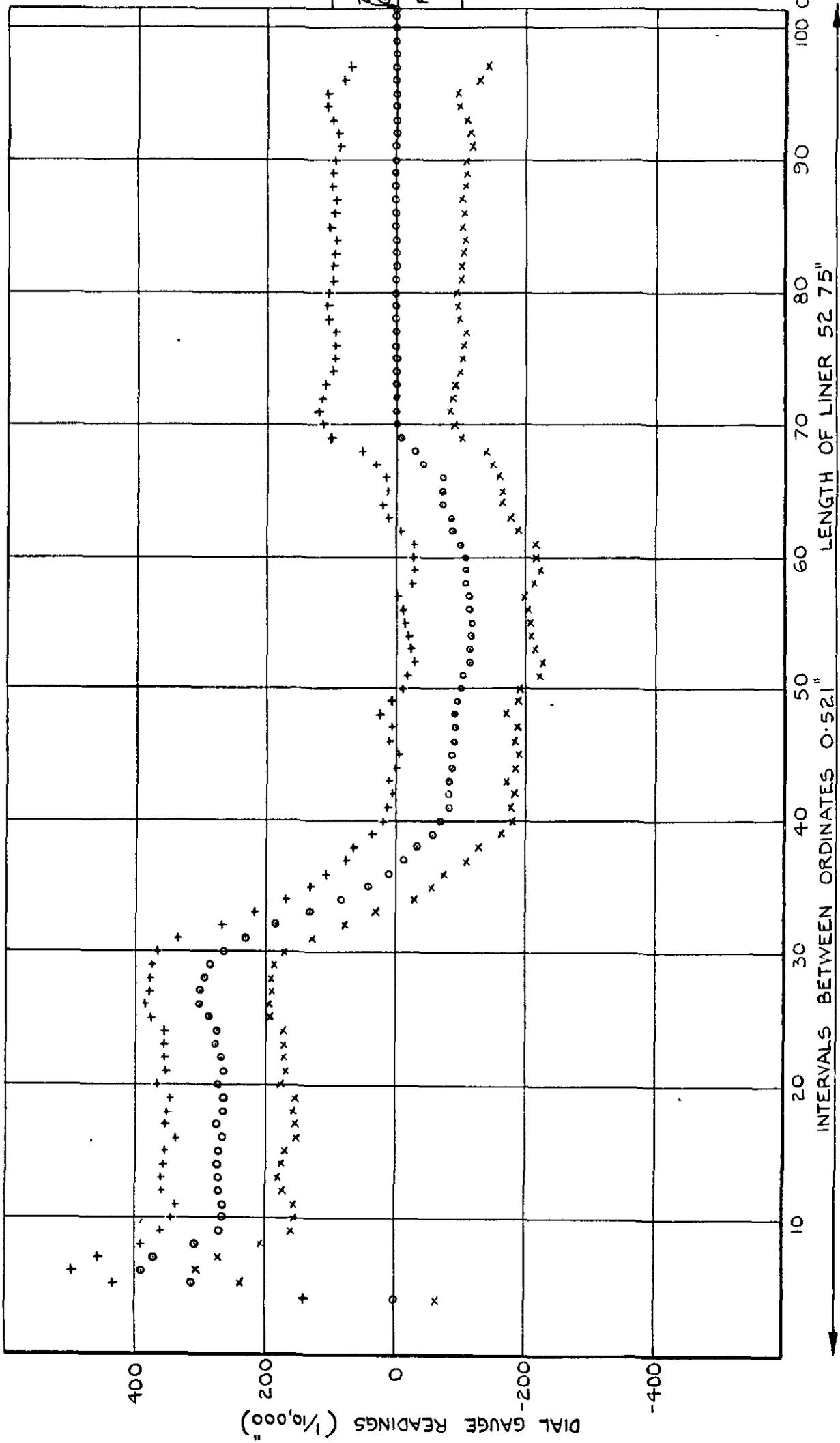


FIG. 2. COMPARISON OF CALCULATED & MEASURED CURVATURE GAUGE READINGS. (TEMPLETS)

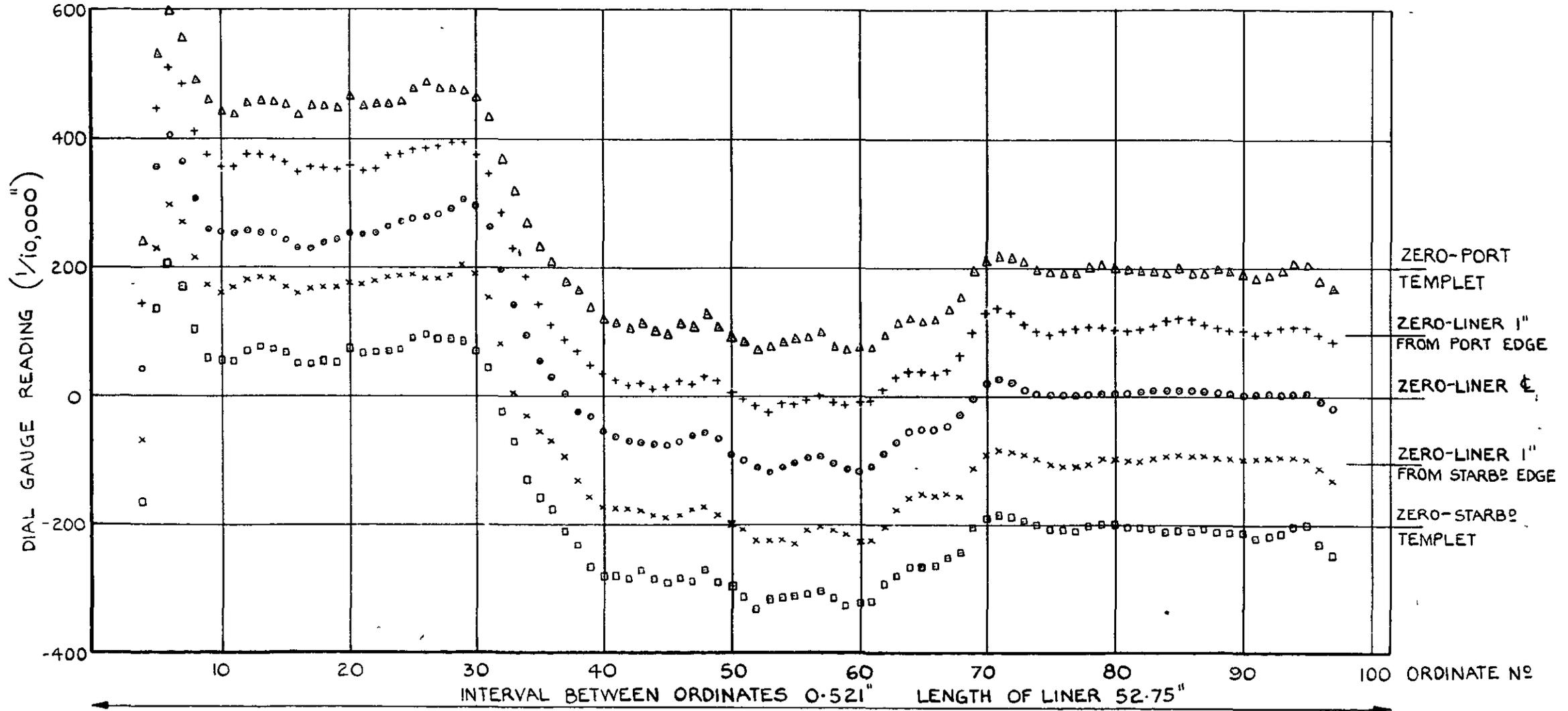
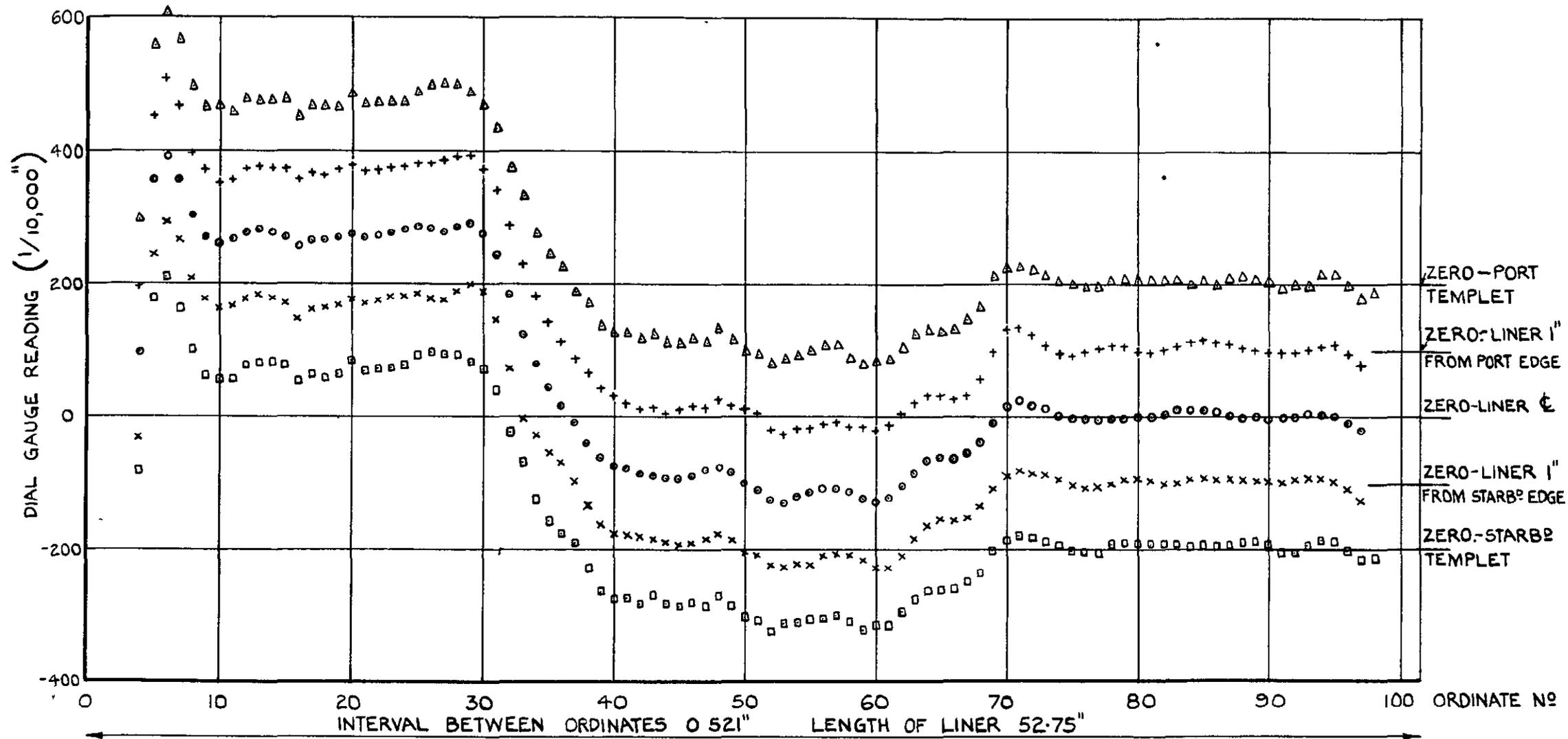


FIG.3. CURVATURE GAUGE READINGS ON LINER & TEMPLTS.
 (JULY 1954)



**FIG. 4. CURVATURE GAUGE READINGS ON LINER & TEMPLETS.
(OCT. 1955)**

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