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GLASS FORMING PROPERTIES DIMENSIONAL STABILITY IN FORMING RANGE

BY

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ABSTRACT :

In this paper we develop for the first time a procedure for determening the dimensional stability of glasses in the forming range.

In our previous paper we determined the physical properties of glasses as linear function of glass oxides. For production engineers as the main target is to control both forming process and production cost. It was necessary for our research to find a relation between the viscosity of glass in the forming range and the resultant dimensional stability.

A case study the technique was applied to the production process of bulbs. A special die was used to control the forming temperature and thus the glass viscosity. The dimensional stability was determined by the variability of the most effective dimension of the product and a mathematical formula was introduced.

Key words :- Forming range - Viscosity - Moulding die - dimension stability - linear regression.

INTRODUCTION

For the first time we develop a technique to find a relation between the forming range viscosity and the resultant accuracy or dimensional stability of glass.

The problem is very important in glass making industries if it is possible to control the tolerances of the glass product it is possible to control strength and to find more field of application.

In the case under study the dimensional stability plays important role in the further processing of the bulbs and in the residual stresses in the finished lamps.

A special die was designed to control the forming temperature and the dimension stability was modeled as linear function of the viscosity in the forming range.

It was necessary to develop a mathematical expression that indicates the meaning of dimensional stability. For this measure the mean error between design and production nominal size and the variability of the size given by the standard deviation of this error were used.

By relating this measure of dimensional stability to the viscosity in forming range it was possible to find a mathematical expression which proved to be valuable in controlling the forming process.

GLASS FORMING PROPERTIES
DIMENSIONAL STABILITY IN FORMING RANGE

EFFECT OF GLASS VISCOSITY IN FORMING RANGE ON DIMENSIONAL STABILITY :

To find a relation between the viscosity of glass in forming range and dimensional stability of the glass product various factors are considered :-

1] The forming temperature (t_f) which was effected by the thermal removal of the glass gob is shown in Fig. (1).

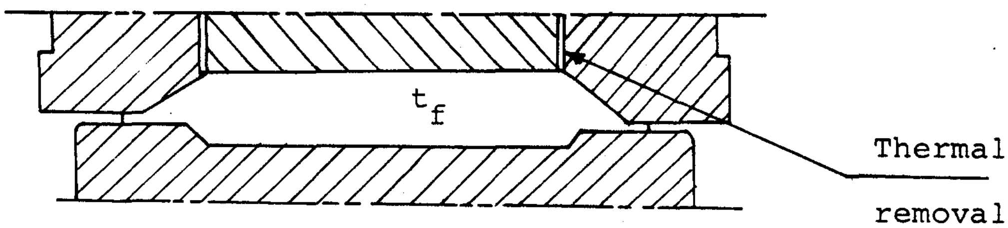

Fig. (1'

2] The forming temperature (t_f) is then measured by optical pyrometer after premoulding immediately.

3] For a certain glass type the viscosity (η) corros-ponding to the forming temperature could thus be decided based on the relation-ships discussed in previous chapters.

4] The other factors affecting the temperature (t_f) such as initial temperature of glass gop (t_g) are considered to be constant as feeder temperature control was ± 1°C and gob weight was 55 ± 0.5 grms.

5] Dimensional stability is considered to be $f = \frac{t_1' - t_2'}{t_1'}$

the average factor (fa) and factor range are then

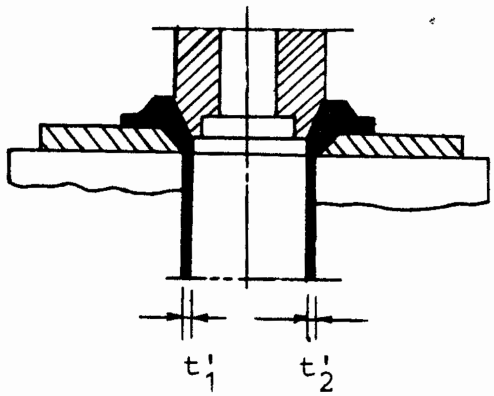

Fig.(2)

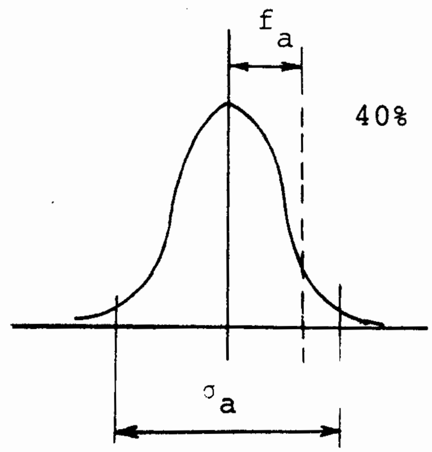

Fig.(3)

determined over a period about 3 days by taking samples of 5 pieces every one hour thus a total of 72 samples are taken ($\overline{Fa}$), and ($\overline{Ra}$) are known from while (σ_a) is estimated and $\tau = \dfrac{(F_a + 2\sigma_a - F)}{\sigma_a}$ is estimated where (F) is the design factor. (F = 60% = 0.6) see Fig. (2) and (3).

6] A relation-ship is then drawn between (τ) and (t_f) and (τ, η) were drawn up .

7] From this table (A) the relation in Fig. (a and b) is drawn which shows that in our case best conditions are reached for log η = 5.84 and τ = 0.000.

8] For the above relation we can say that

$$\tau = a_1 + b_1 \eta + b_2 \eta^2$$

where :

a_1, b_1 and b_2 are constants

$a_1 = 0.31$

$b_1 = + 0.21$

$b_2 = 0.017$

where

t'_1, t'_2 = Dimensional thickness for products is shown in Fig. (2)

9] The relation between forming temperature and viscosity logarithmic from results of table (A) is shown in Fig. (4),and the relation between forming temperature and dimensional stability of the forming process (depend on the dimensional stability factor) from results of table (A) is shown in Fig. (5).

10] In order to avoid the sticking between the top die and the cooling piston - we find that the minimum high (h_a) in mm. can be emperically determined by using the values shown in Fig. (6).
Though we did not investigate this matter we added it to enable researcher in this area to use our experience in this respect.

11] Figure (7), (8) and (9) show the die used in the research, Fig. (10) is the inside cooling piston for die and Fig. (11) and (12) depicts the position of the die in the glass forming machine type J, B.M. 20.

Table (A) : Results

t_f	σ_a	Fa	τ	Log η
850	0.222	0.463	1.3829	4.70
840	0.211	0.470	1.3809	4.80
830	0.200	0.480	1.4000	4.90
820	0.200	0.460	1.3000	5.10
810	0.180	0.372	0.7333	5.21
800	0.182	0.333	0.5329	5.40
790	0.185	0.332	0.5514	5.60
780	0.176	0.311	0.2695	5.67
770	0.167	0.281	0.0898	5.72
760	0.155	0.290	0.0000	5.84
750	0.155	0.344	0.3484	6.01
740	0.150	0.377	0.5133	6.11
730	0.144	0.430	0.8195	6.20
720	0.143	0.440	0.8811	6.30
710	0.142	0.450	0.8976	6.40

Where :

t_f = Forming temperature °C

σ_a = Standard deviation for dimensional thickness.

F_a = Dimensional stability factor (depend on the thickness).

τ = Dimensional stability of the forming process (depend on the dimensional stability factor).

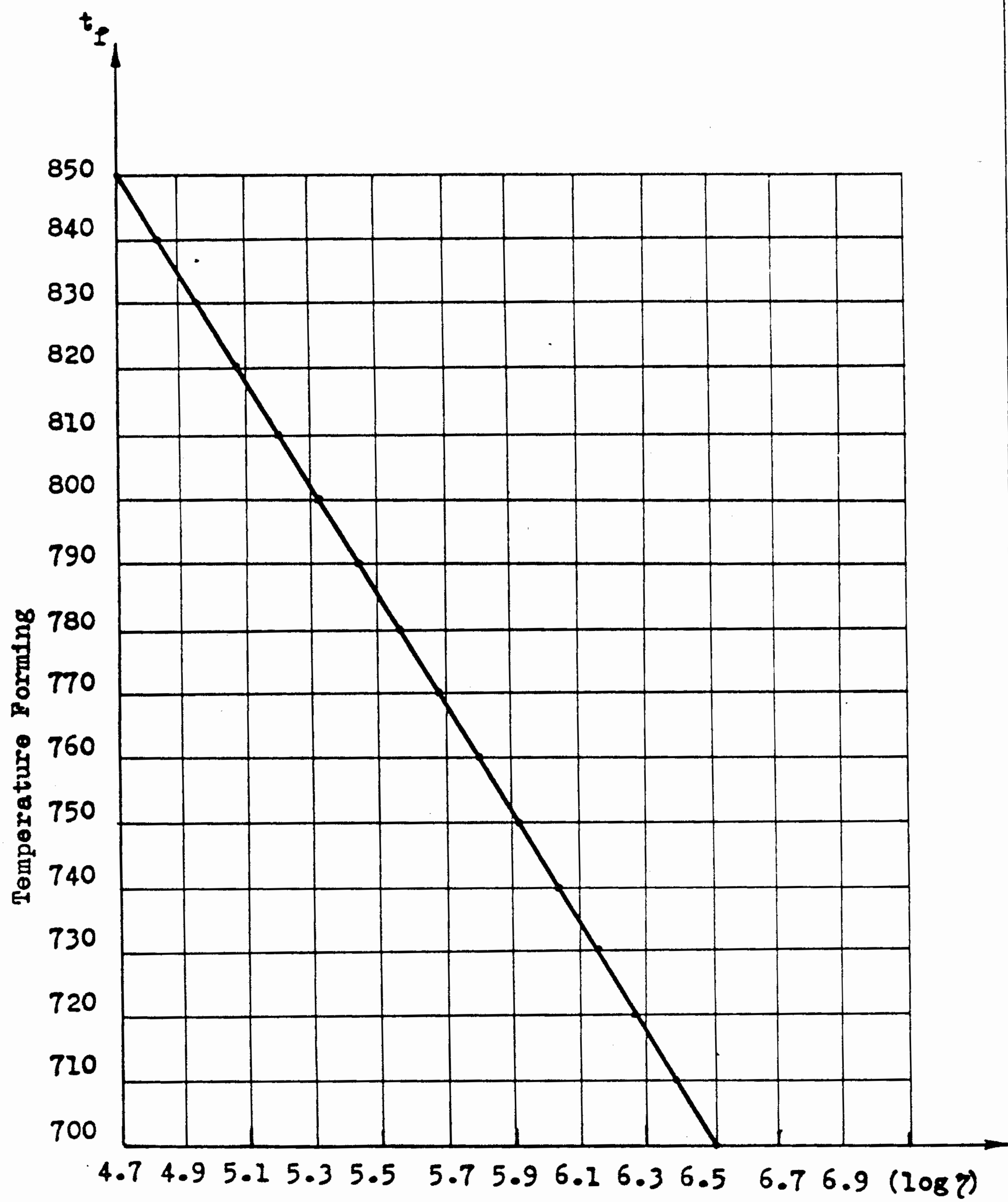

FIG.(4): Relation between temperature forming and log τ.

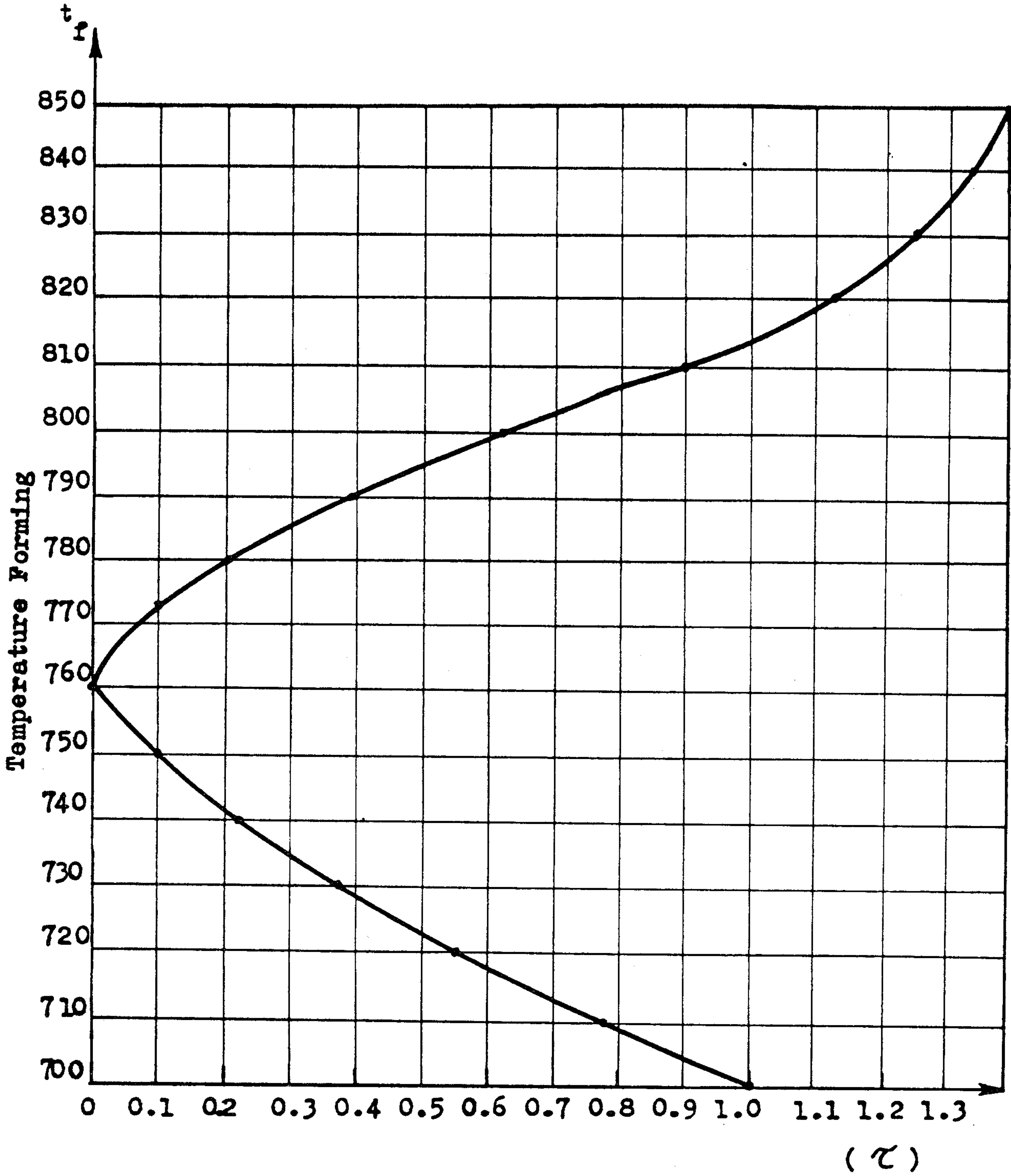

FIG. (5): Relation between temperature forming and (τ).

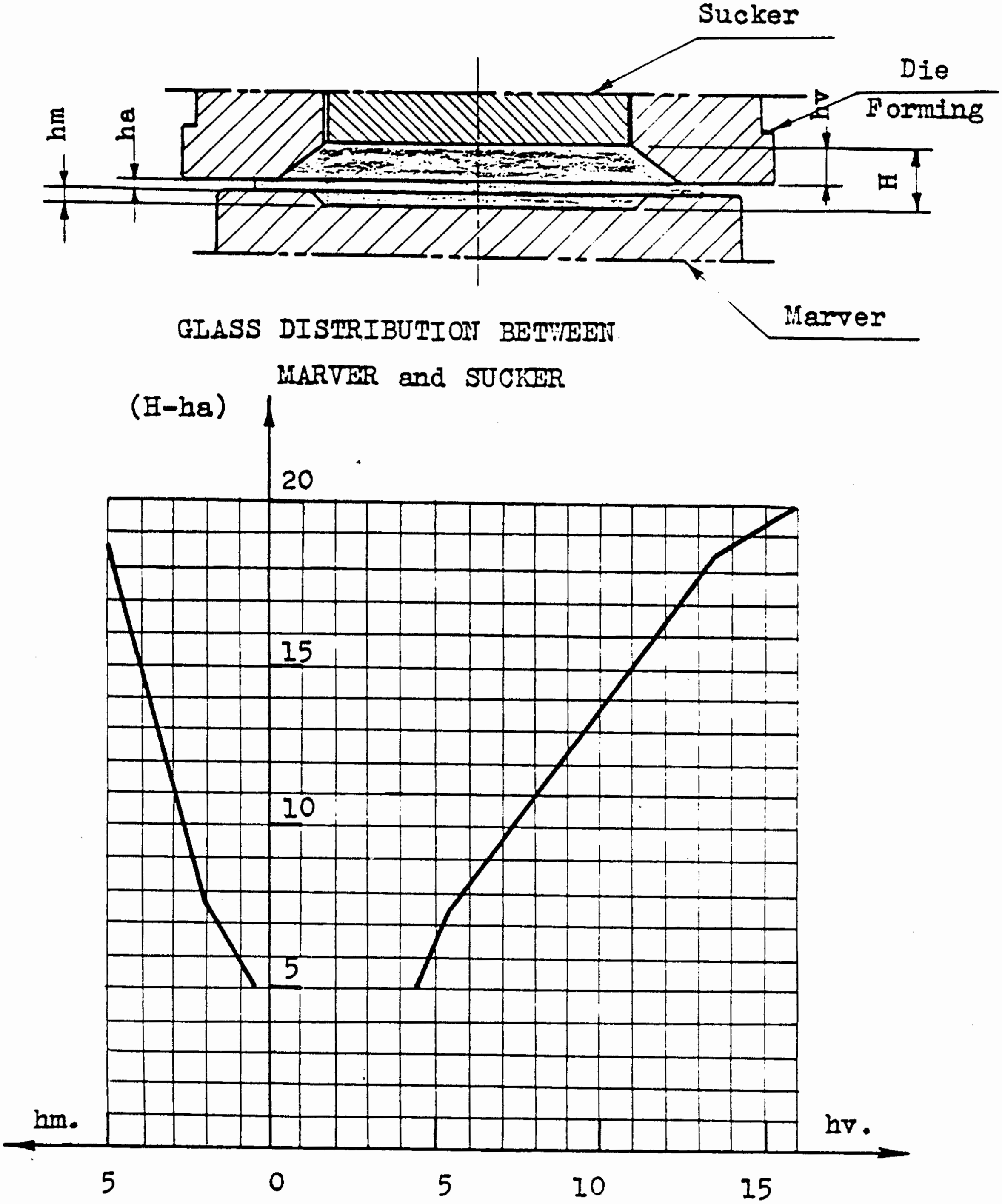

FIG.(6) : Die clearence in forming

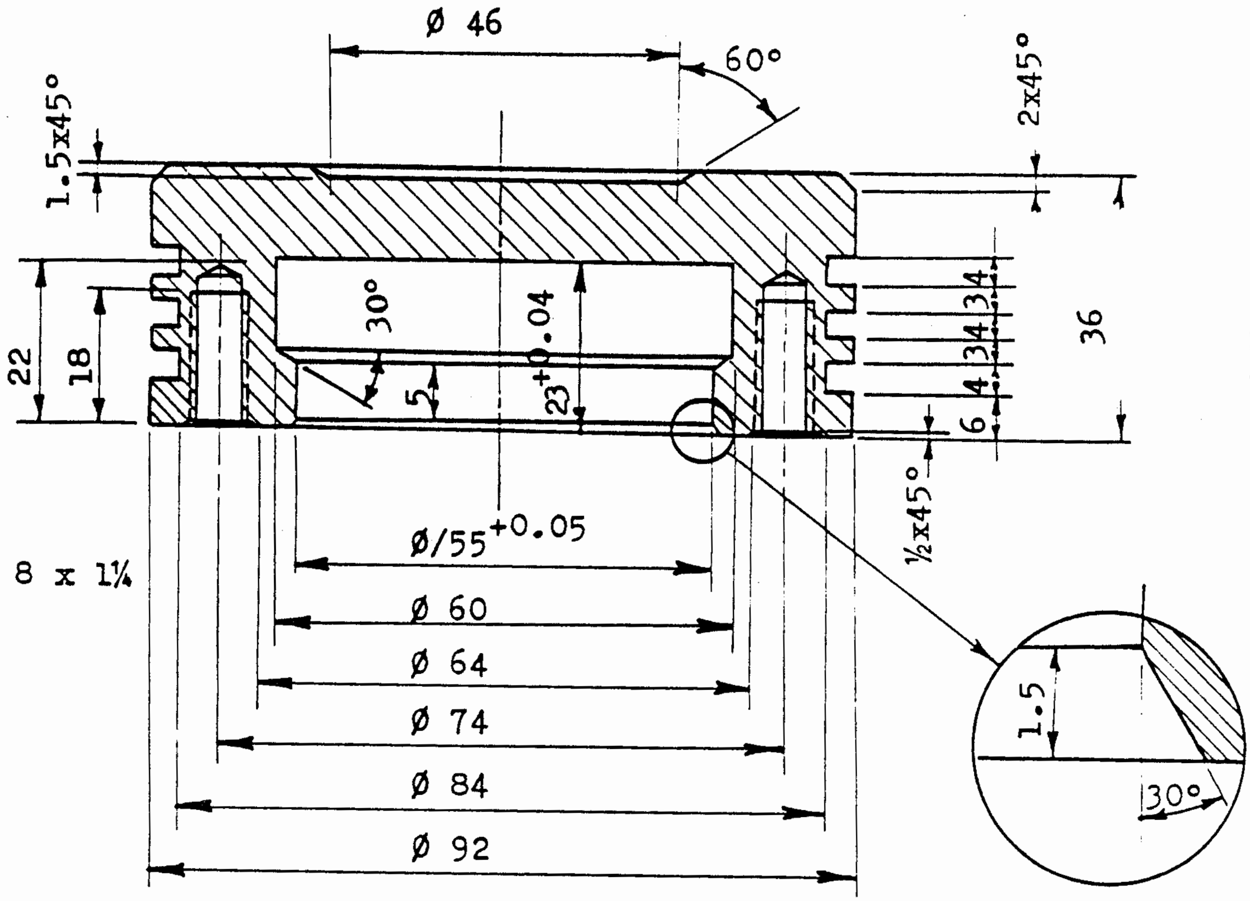

FIG.(7): Bottom Forming Die

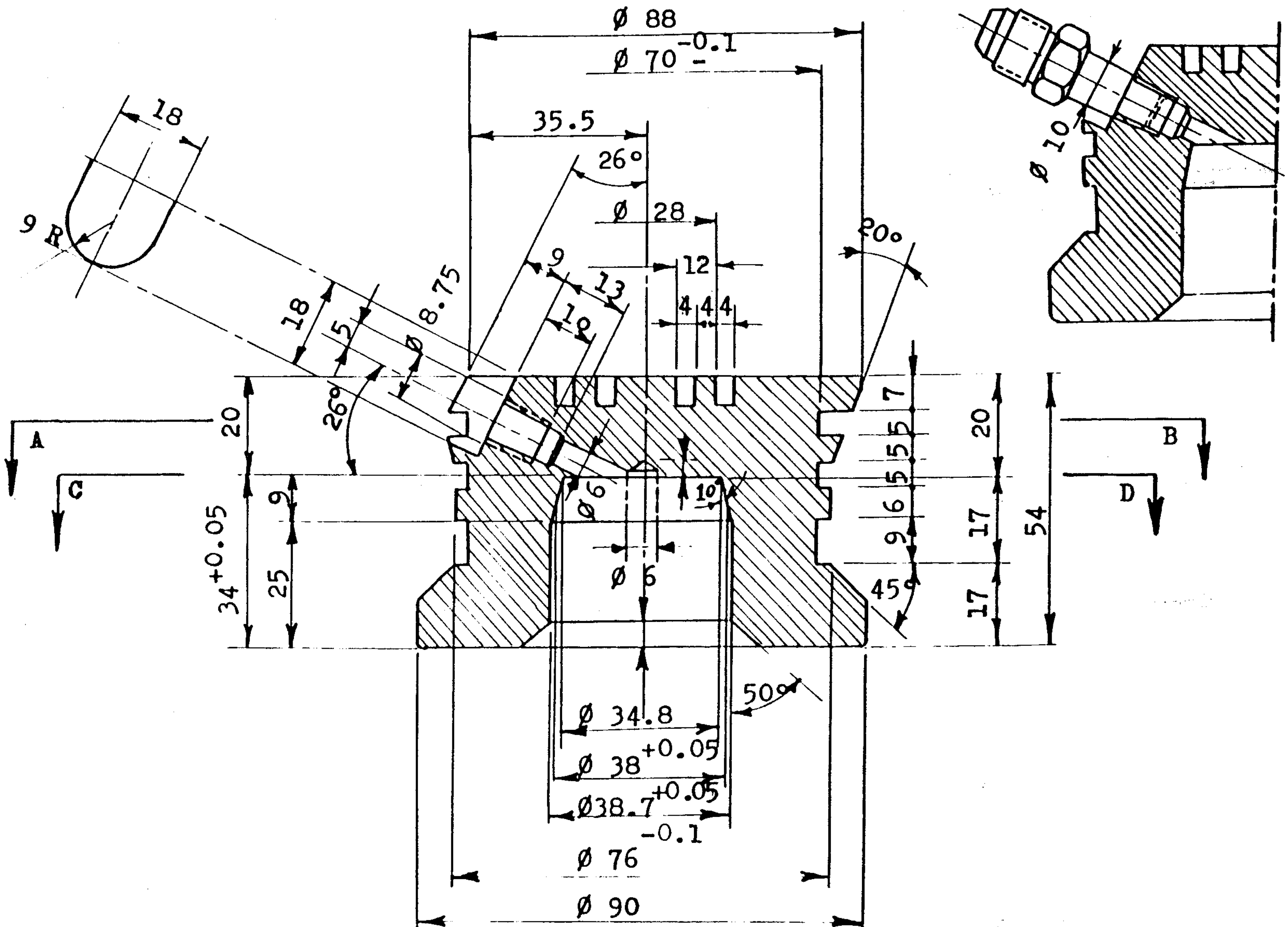

FIG.(8): Upper Forming Die

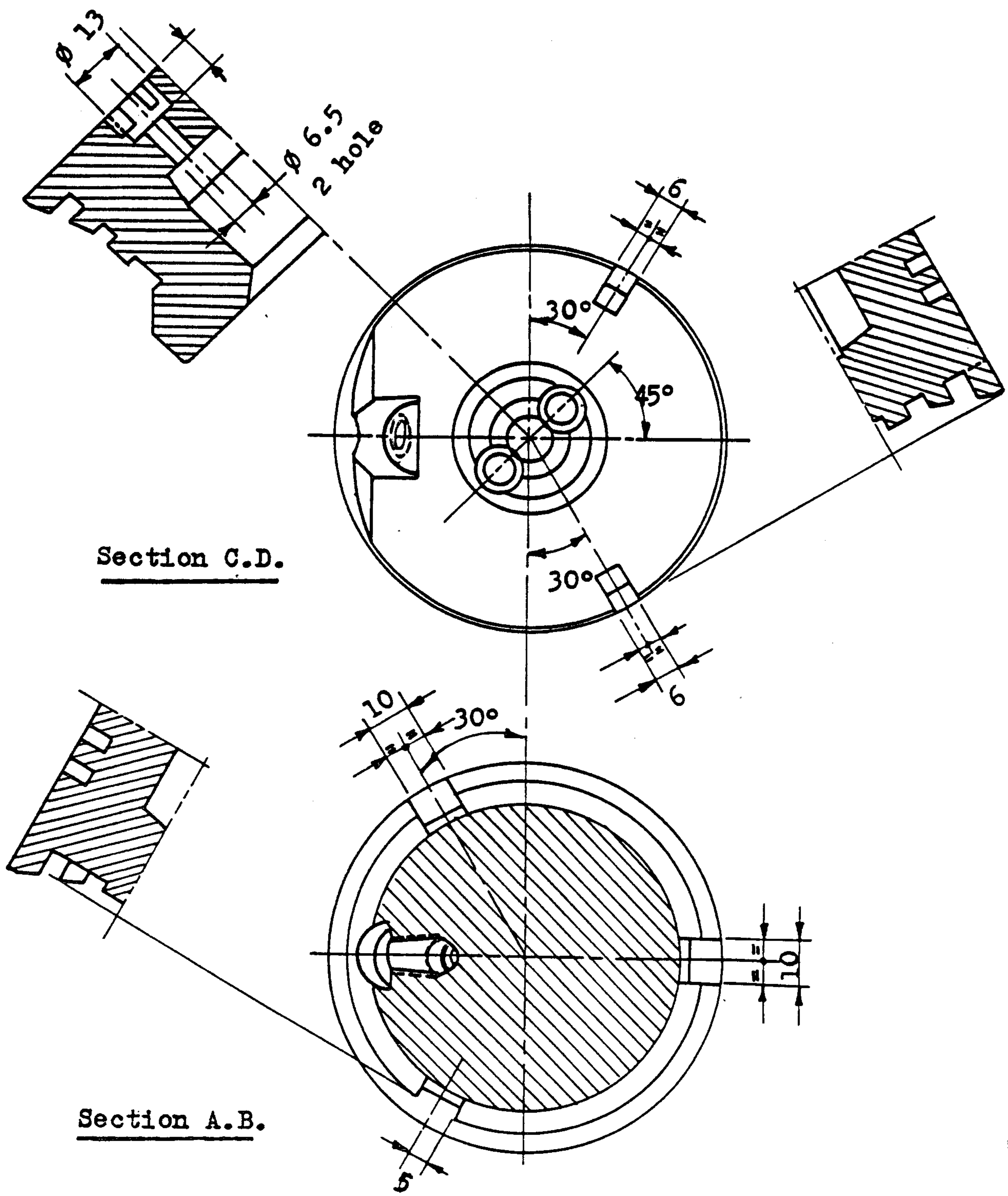

FIG.(9): Section A.B. and C.D.
in Upper Forming Die.Fig.(8)

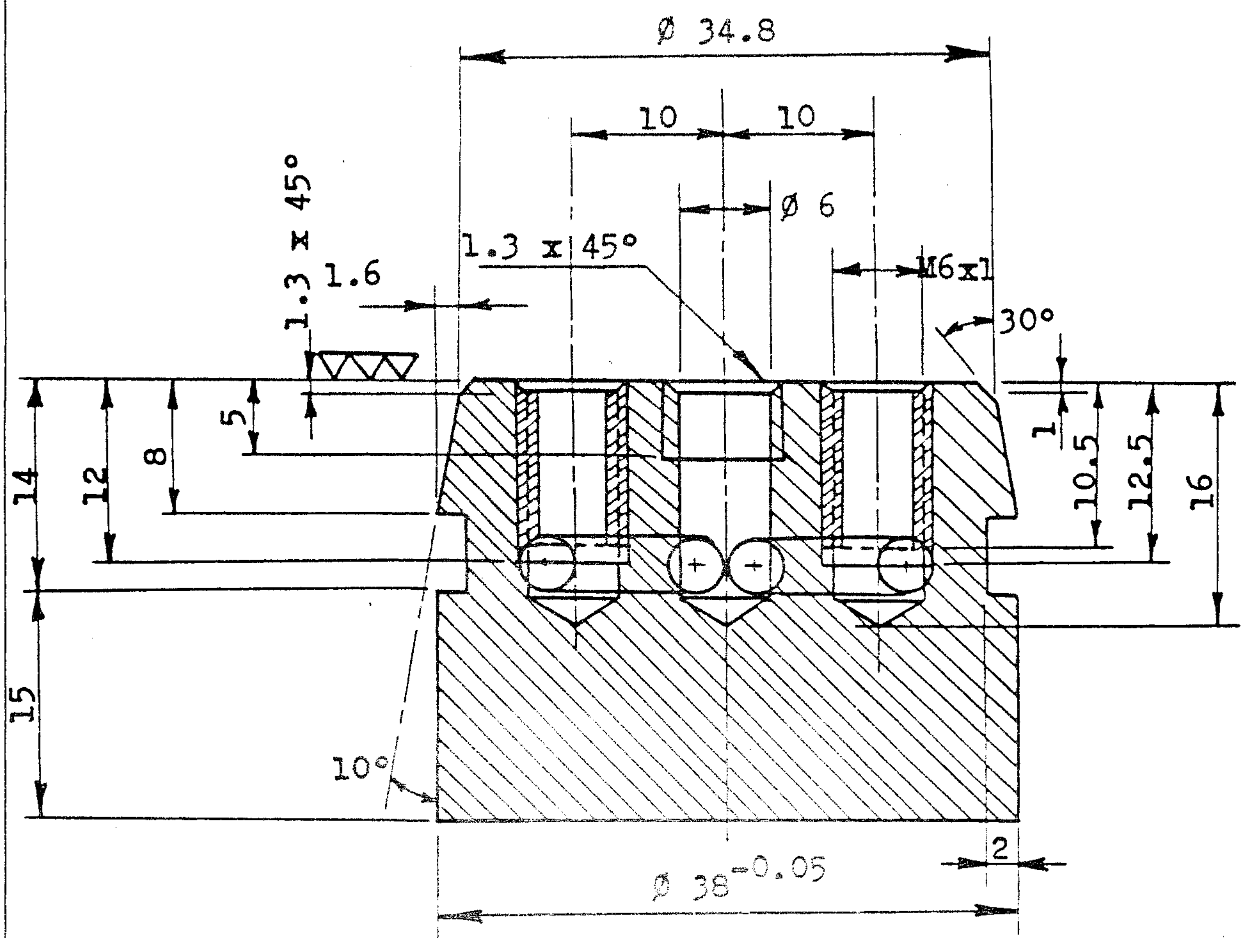

FIG.(10). Inside Cooling Piston.

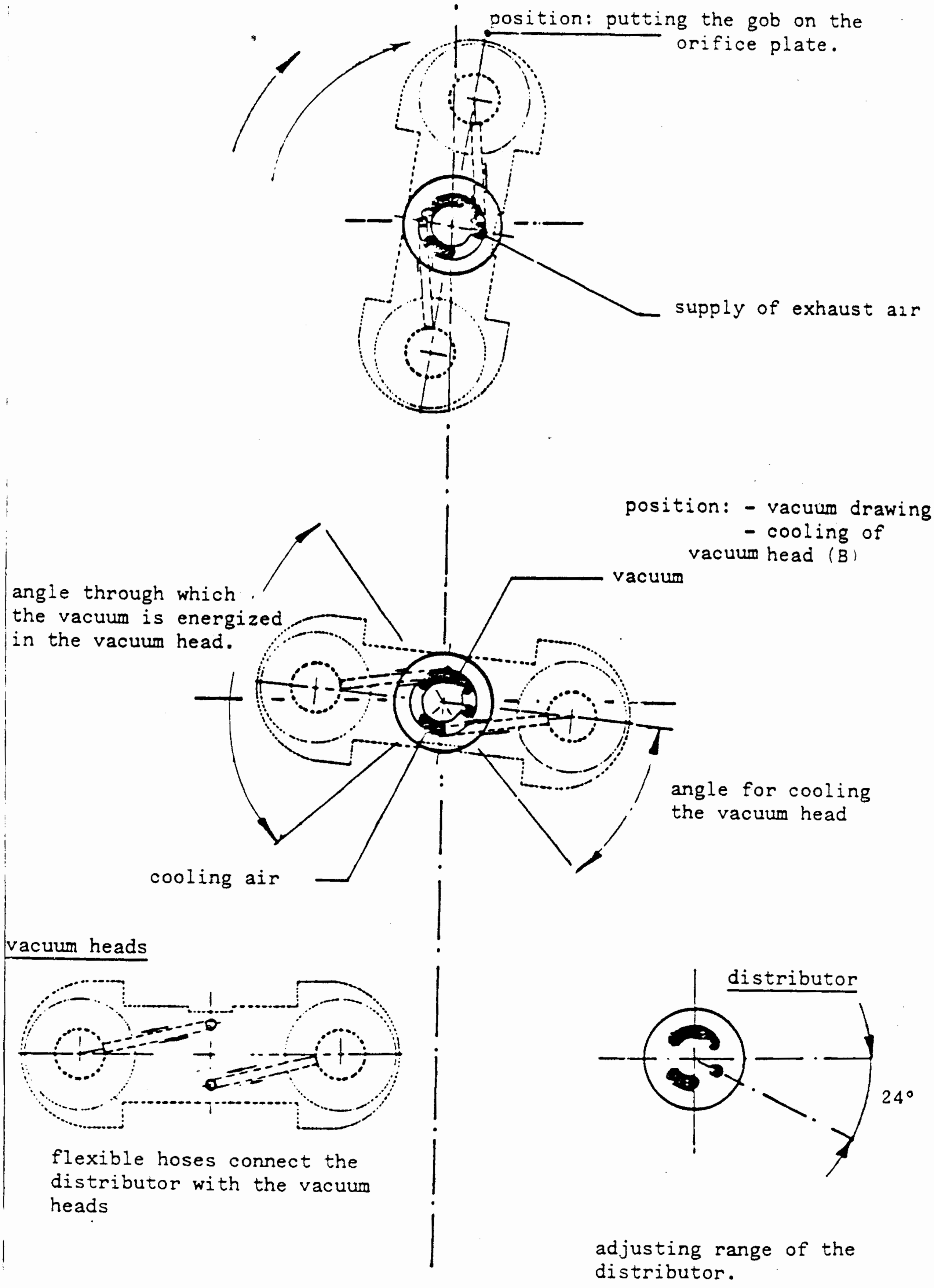

FIG.(11): Vacuum head with distributor (3 positions)

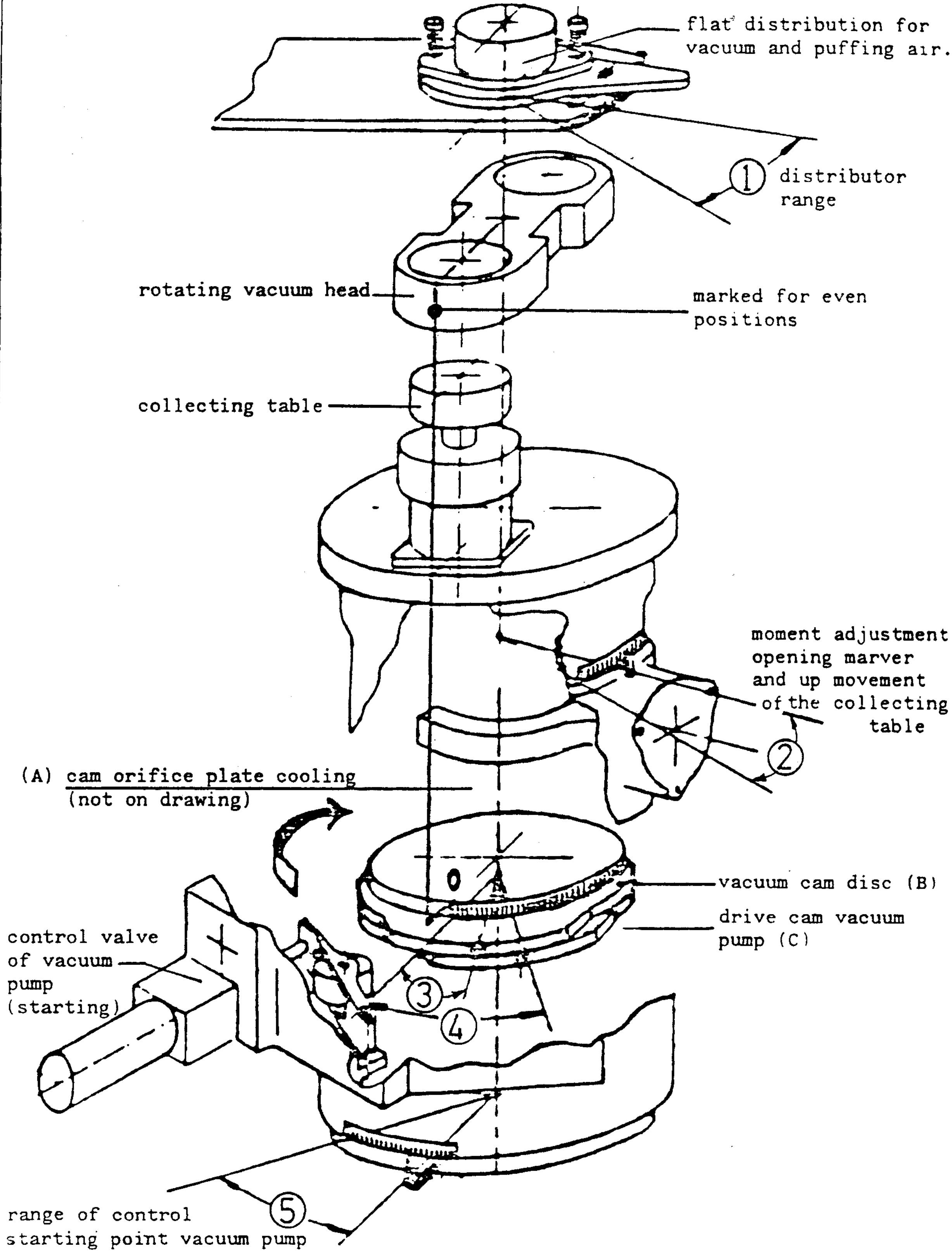

FIG.(12) Adjustments of collecting table mechanism

CONCLUSIONS

In this paper we developed relation between dimensional accuracy and viscosity of glass in the forming range. The technique can be used to product and adjust the glass viscosity so that optimum product uniformity may be achieved. In the case under study optimum condition for the adjusted glass composition was found to be at 760°C at log η = 5.6 we strongly recommend this range for the product formed by blowing and drawing of sheets and tube specially for soda-lime glasses used in electrical application.

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