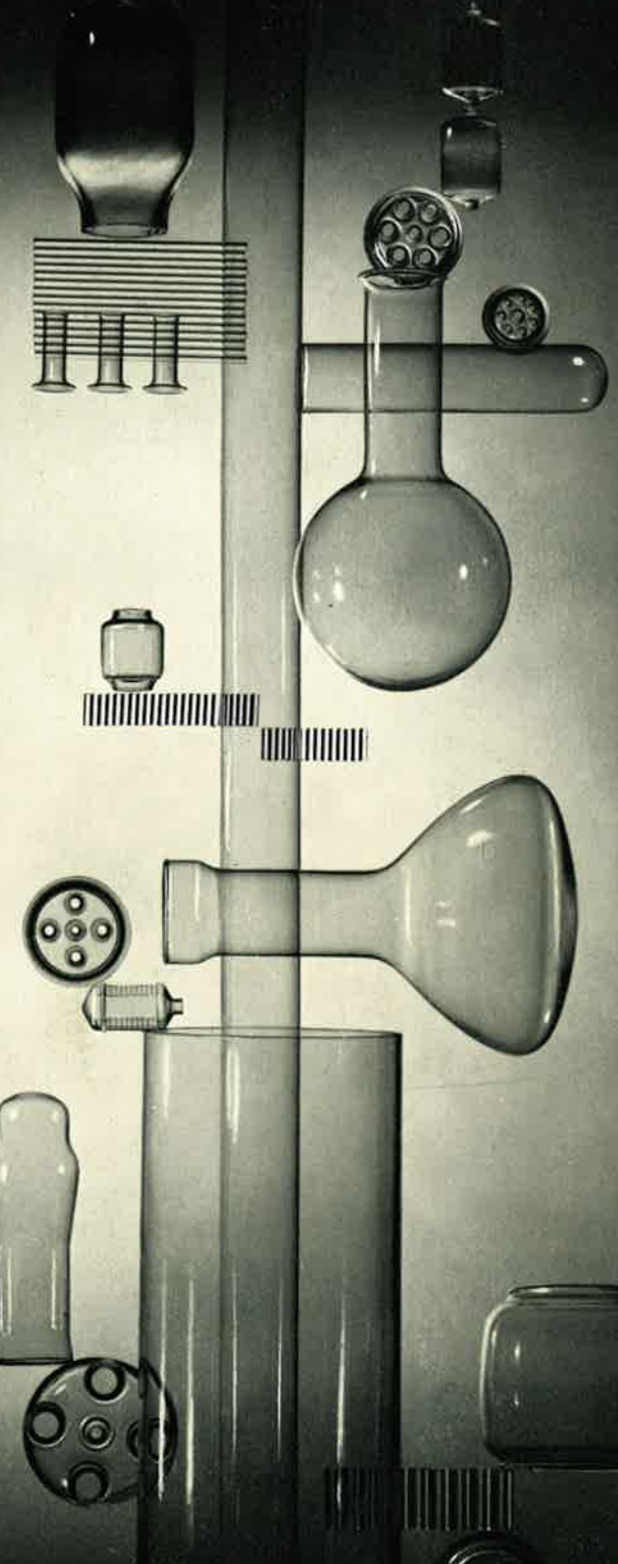
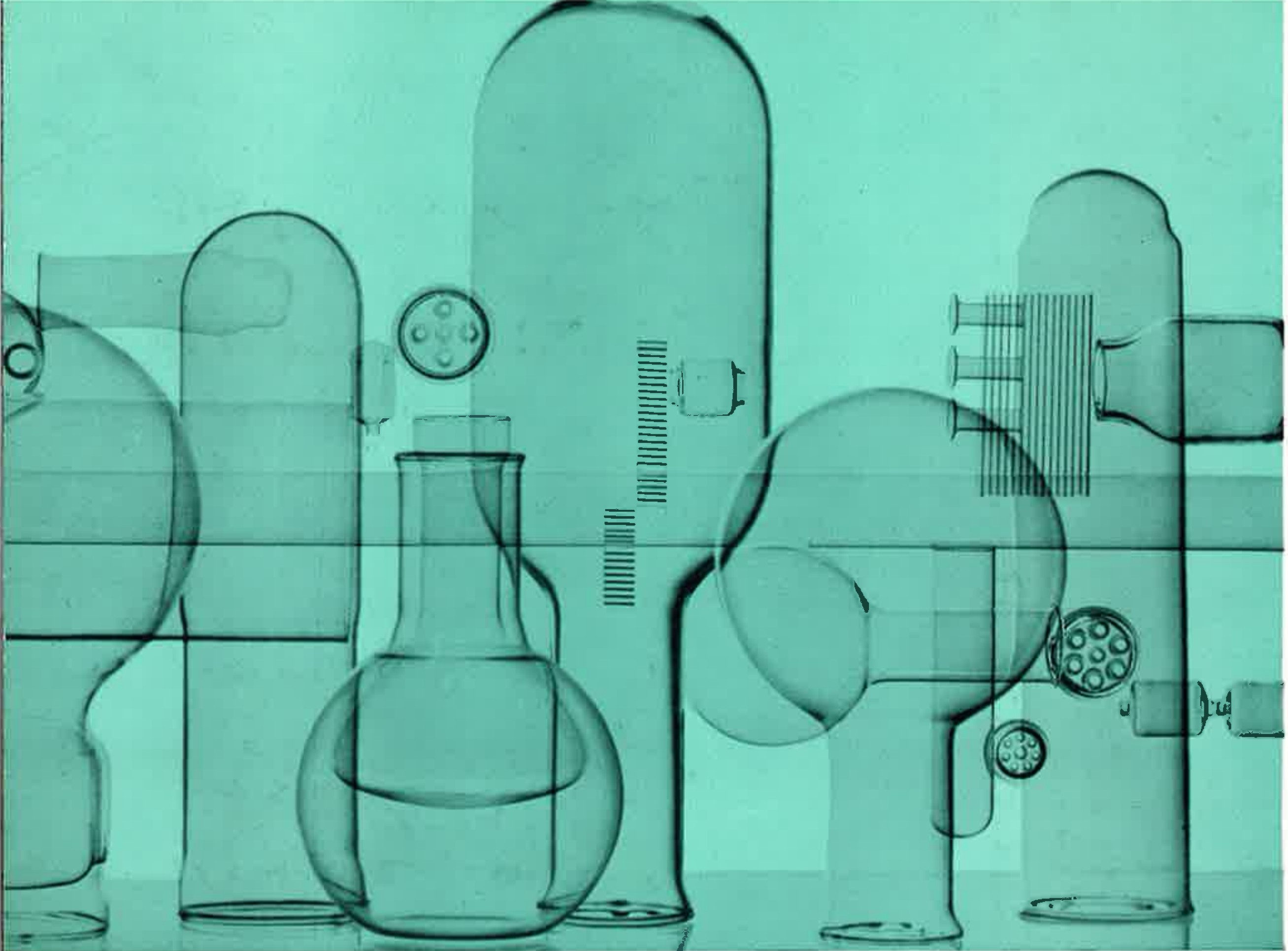
glass

D. A. Ramsey
L.E.D.
6-9-59.



A·E·I
Lamp and Lighting Co Ltd

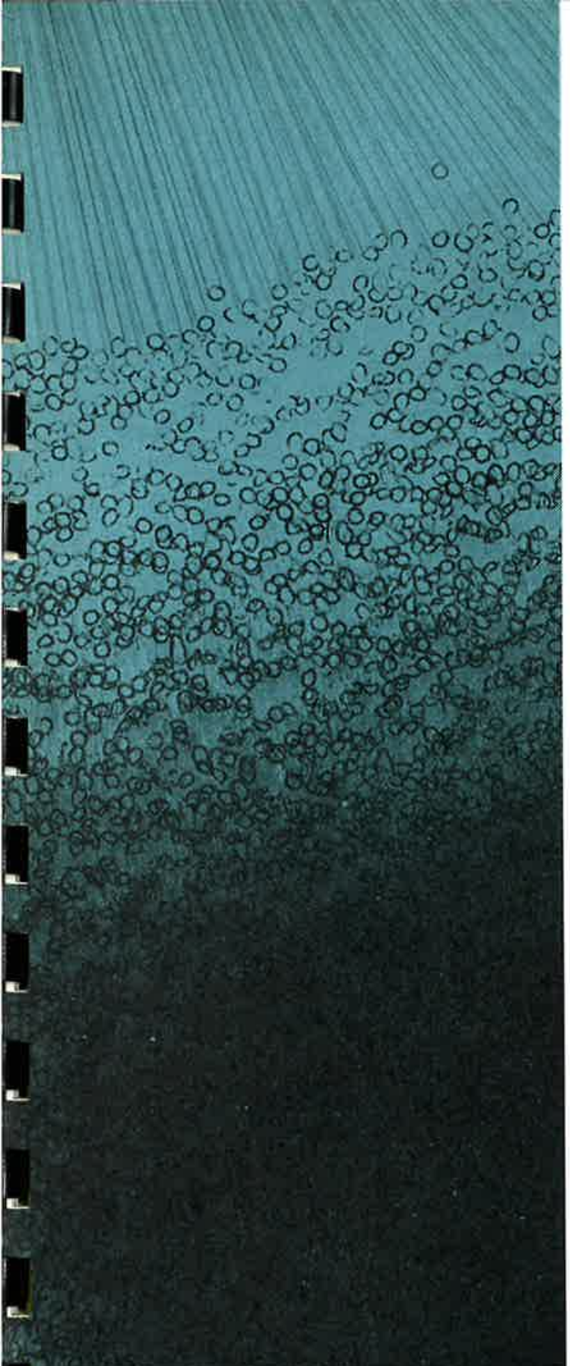
CHESTERFIELD GLASS WORKS · DERBYSHIRE · ENGLAND



Glass Advisory Service

THE GLASS Technology Department of A.E.I. Chesterfield comprises a highly qualified team of chemists and physicists who are constantly improving manufacturing methods and coping with the diverse problems accompanying the production of glass of special properties. They influence every phase of manufacture from the raw material to the finished product and they are frequently asked to apply their expert knowledge to experiment and research. Their facilities and advice are at your service.

You may have a problem concerning the application, availability or specification of a glass and if this is so you should not hesitate to write to us. All enquiries of this nature should be made to A.E.I. Lamp and Lighting Co. Ltd., Melton Road, Leicester, who will refer them to the appropriate Glass Advisory Department.



Contents

NEW GLASS COMPANY.

LIST OF COMMERCIAL GLASSES (TABLE 1).

NEW CODE REFERENCE.	PREVIOUS DESIGNATION. A.E.I.	PREVIOUS DESIGNATION. G.E.C.	GLASS TYPE.	MAIN APPLICATION.
B37	C9	W1	Borosilicate.	Sealing to tungsten.
A42	C46		Aluminosilicate.	Mercury vapour lamps and combustion tubing.
A43	C37	H26X	-do-	Sealing to molybdenum.
B48	C40	FCN	Borosilicate.	Sealing to Kovar.
B53		SBN124	-do-	-do-
B57		M6	-do-	Ampoules.
L76	C93		Leadborate.	Solder seals.
X84	C97		Calcium Aluminate.	Infra-red transmission.
X91		Na10	Aluminoborate.	Resistance to sodium vapour.
L92	C12	L1	Lead Potash.	Tubing.
X93	C42		Aluminoborate. (barium)	Resistance to Sodium Vapour.
S95	C94	X8	Soda Lime	Fluorescent tubes, vials, bench working.
S96	C19	X4	-do-	Bulbs (machine blown).
S97		X4/3	-do-	Bulbs and Tubing (Hand)

New Code Prefix letters denote type of glass:-

A = aluminosilicate.
B = borosilicate.
L = lead.
S = soda lime.
X = complicated base glass.

New code numbers represent the coefficient of expansion x 10^7

P. STATON/T/A/GOB.
12th July, 1961.

Supersedes. All information.
dated. prior.

Glassworks

SHEFFIELD ROAD CHESTERFIELD

Trade enquiries to

HEAD OFFICE MELTON ROAD LEICESTER

Telephone Number 61531

Telegraphic Address Lamplite

Glass for Industry

Any glass which seals satisfactorily to an appropriate metal is useful to the electrical industry, but within this definition the industry's requirements tend to diverge. At Chesterfield glassworks, A.E.I. Lamp and Lighting Company Ltd. is at present satisfying a great diversity of demands by producing 21 types of what might be called 'standard' glass, another 24 types of glass for special purposes, and a further 18 of coloured glass.

Two of Chesterfield's better known products are C9 glass, a borosilicate suitable for sealing to tungsten, and therefore very useful to a company engaged in the manufacture of lamps and/or valves, and C46 (an alumino-silicate glass) which will withstand temperatures of 750 deg. C indefinitely; for this reason it has been adopted by the chemical industry and such organizations as the National Coal Board for use in combustion tubes. There are of course many others in the heat-resisting range.

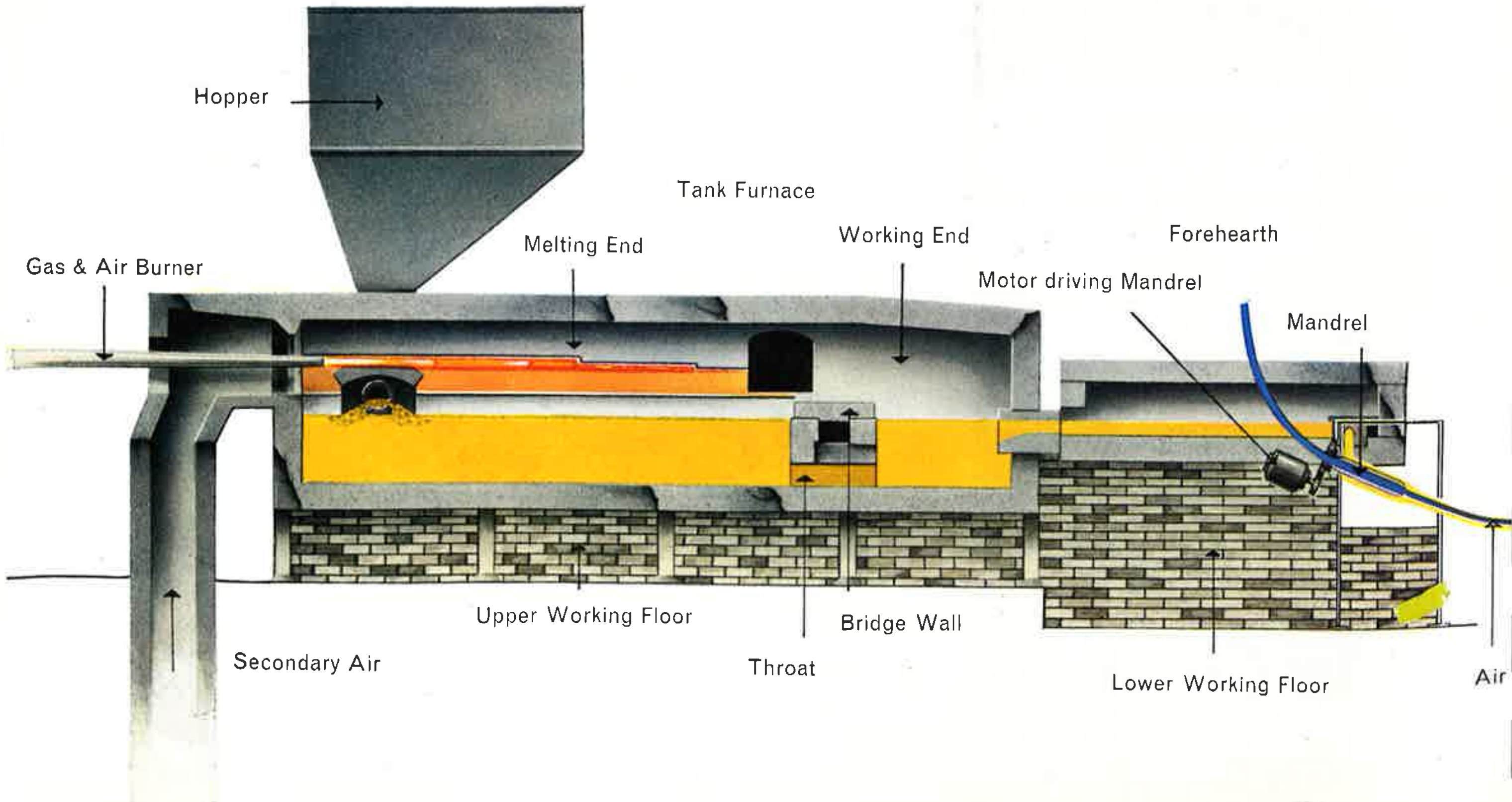
Over the years the demand for glass products has been steadily increasing and this has been met at Chesterfield by improved techniques as, for example, electric melting.

Machine Drawn Tubing

The beginning of the Danner process. Molten glass from the furnace flows on to a mandrel (the cylindrical object in the centre of the picture) which revolves slowly. The glass ribbon wraps itself round the mandrel, flows towards the lower end and is then continuously drawn by the Danner tube-drawing machine.
Temperature control is vital to this process (the temperature must be maintained to within ± 2½ deg. C). The glass tubing is protected from draughts in a metal cabinet, one of the doors of which has been opened for this photograph.

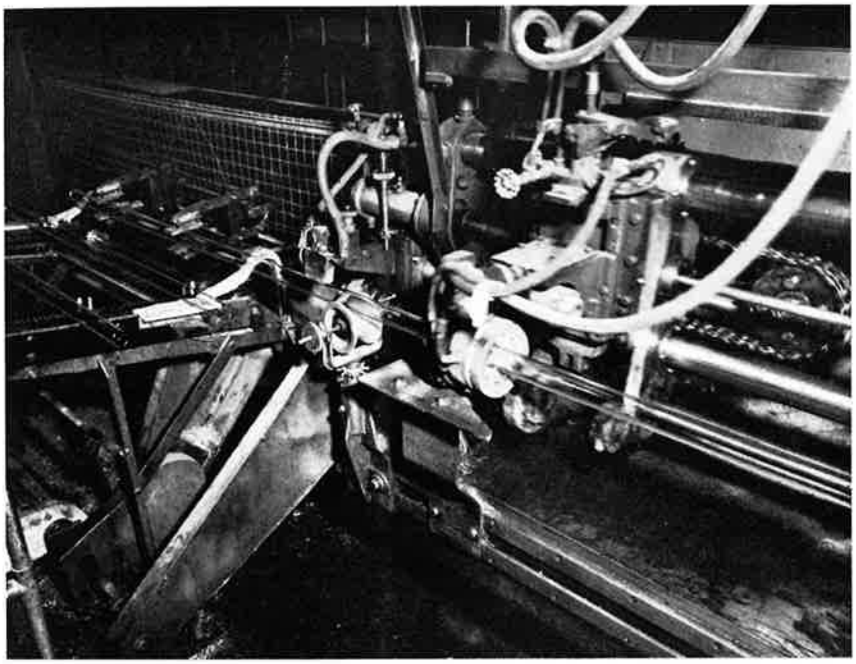
A.E.I. Lamp & Lighting Co. Ltd. produces a great variety of tubing at Chesterfield, from tubing for transistors with an internal diameter of 0·58 mm to 0·68 mm and an external diameter of 1·36 mm to 1·46 mm, to the largest tubing, approximately 50 mm in diameter.

The established mechanical method of drawing tubing is by the Danner machine, and with C94 (soda-lime) or C12 (lead glass) melting is done in a continuous tank furnace fired by oil or town's gas. Raw material is supplied to the furnace from a hopper by means of a screw feeder,

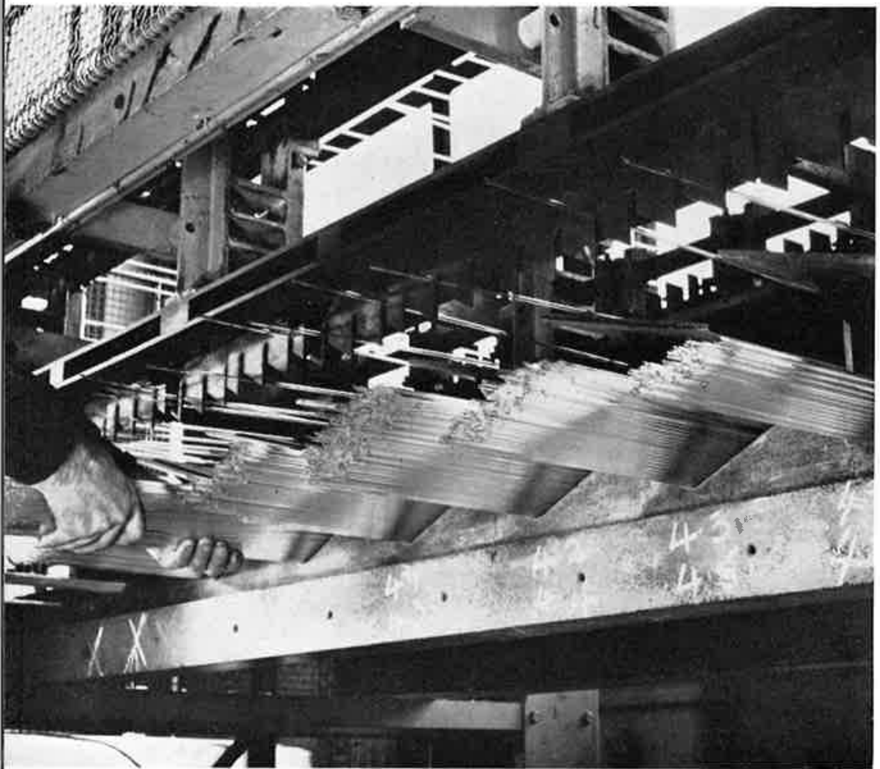


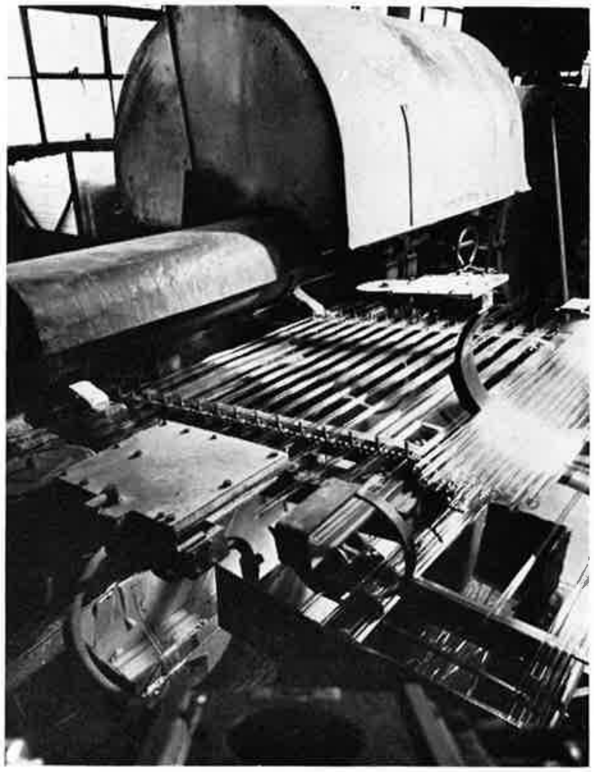
which can be adjusted so that the supply of material corresponds to the required through-put.

The 'batch', as the raw material is called, is fed through the 'dog-house' into the melting end of the furnace, where the temperature is some 1400-1450 deg. C. A wall divides the tank into two parts, one roughly twice the volume of the other. Molten glass flows from the larger to the smaller part of the furnace (where refining takes place) through a tunnel, or 'throat' in the dividing wall. A gate of refractory material controls the flow of glass via a feeder channel to the muffle, where it forms a ribbon on a fireclay 'sleeve' or mandrel. The mandrel, which slopes at an angle of about 15 deg., revolves at from five to



At this stage, the tube is cut to the required lengths on an automatic machine. As the tubing of smallest diameter is drawn at a rate of 1000 feet a minute, this necessitates a cutting rate of 250 four-foot tubes every minute. Cutting is done by applying thermal shock; heat from the ring burner (right foreground) and then a cooled block. This end-rolling machine (right) forms the collar on fluorescent tubes

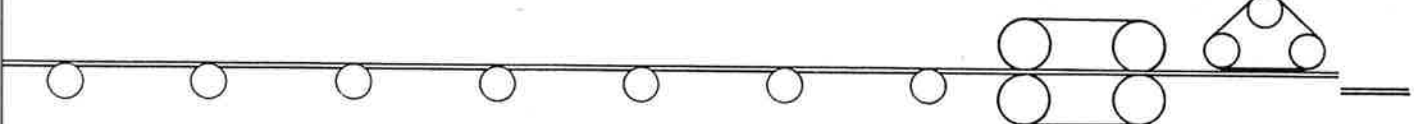




Automatic sorting (left) of exhaust tubes according to diameter. The figures indicate the minimum and maximum diameter of the tubes, in millimetres.
Standard flare tubing (right). After cutting, this tubing will go through the end-glazing process and then diameter grading

eight r.p.m.; the ribbon of glass wraps itself round the sleeve and flows towards the lower end and is then drawn continuously by the Danner machine some 150 feet away. Air for blowing the glass is supplied through a nichrome tube in the sleeve.

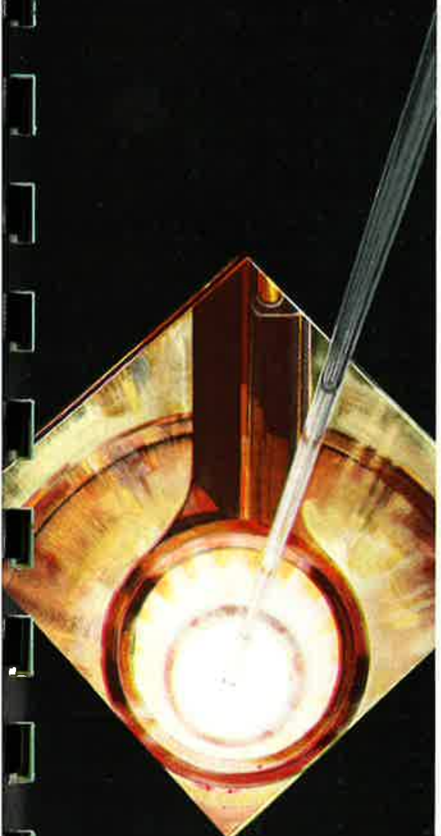
The size of the tubing depends, of course, on the diameter of the sleeve and also on the temperature of the glass, the quantity flowing, and the speed of the machine. The tubing is cut into four or five foot lengths as required. Rod may also be produced by this method, except a solid-nosed sleeve is used in order to exclude air.



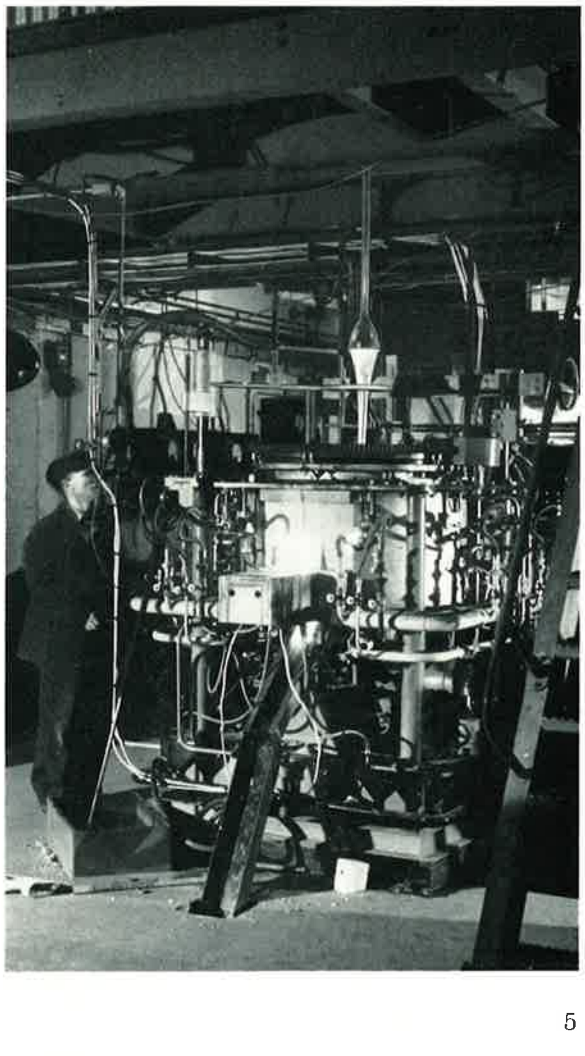
Up-Drawn Machine Tubing

The up-draw machine at Chesterfield can produce boro-silicate tubing to close tolerances. The tubing is drawn vertically to the top of a tower 50 ft. high where it is cut into the required lengths, loaded on an automatic conveyor system and taken to the lower floor for end trimming, inspection etc.

The up-draw machine is linked to an electric melting furnace, a recent introduction into the Chesterfield Glass Factory.



Looking down from the second platform at the up-draw machine. The installation of this system of drawing boro-silicate tube is expected to achieve close limit toleranced tubing



The first draw, a 'gob' of glass is taken up by hand to the top of the tower where the automatic process takes over

Tubing Products

C.9 MACHINE MADE TUBING

Outside Diameter (mm)	Wall Thickness Range
5·0— 6·0	0·75 mm—1·0 mm
6·0— 7·0	
7·0— 8·0	
8·0— 9·0	
9·0—10·0	
10·0—11·0	
11·0—12·0	
12·0—13·0	
13·0—14·0	
14·0—15·0	
15·0—16·0	
16·0—17·0	
17·0—18·0	
18·0—19·0	
19·0—21·0	
20·0—22·0	1·0 mm—1·5 mm
21·0—23·0	
22·0—24·0	
23·0—25·0	
24·0—26·0	
25·0—27·0	
26·0—28·0	
27·0—29·0	
28·0—30·0	1·0 mm—1·75 mm
29·0—31·0	
30·0—32·0	
31·0—33·0	
32·0—34·0	
33·0—35·0	
34·0—36·0	
35·0—37·0	
36·0—38·0	
37·0—39·0	
38·0—41·0	
39·0—42·0	
40·0—43·0	
41·0—44·0	
42·0—45·0	

The following formulae may be used for calculating the weight per unit length as follows:

Feet per lb. $= \dfrac{210{\cdot}7}{W\,(D-W)}$

Metres per kilo $= \dfrac{141{\cdot}4}{W\,(D-W)}$

where W is the mean wall in millimetres and D is the mean outside diameter in millimetres.

Items not listed above would have to be contracted for separately.

C.9 MACHINE MADE ROD

Outside Diameter (mm)
3·0—3·5
3·5—4·0
4·0—4·5
4·5—5·0
5·0—5·5
5·5—6·0
6·0—6·5
6·5—7·0
7·0—7·5
7·5—8·0
8·0—8·5
8·5—9·0
9·0—9·5
9·5—10·0

The following formulae may be used for calculating the weight per unit lengths as follows:

Feet per lb. $= \dfrac{840{\cdot}9}{D^2}$

Metres per kilo $= \dfrac{565}{D^2}$

where D is the mean diameter in millimetres.

Items not listed above would have to be contracted for separately.

HAND DRAWN TUBING TOLERANCES

For Nos. 9, 11 and 40 glasses

Diameter Range mm	Diameter Tolerance mm	Standard Wall Sizes (mm)			
2·0/6·0	± 0·5	0·5/1·0	0·75/1·25		
6·0/12·0	± 0·5	0·75/1·25	1·0/1·5		
12·0/20·0	± 0·75	1·0/1·5	1·25/1·75	1·5/2·0	
20·0/27·0	± 1·0	1·25/1·75	1·5/2·0	1·75/2·25	
27·0/33·0	± 1·25	1·25/2·0	1·5/2·25	1·75/2·5	
33·0/38·0	± 1·5	1·5/2·5	1·75/2·75	2·0/3·0	2·25/3·25
38·0/45·0	± 1·75	1·75/2·75	2·0/3·0	2·25/3·25	2·5/3·5
45·0/50·0	± 2·0	2·0/3·5	2·25/3·75	2·5/4·0	2·75/4·25
Over 50·0	± 4%	2·0/4·0	2·25/4·25	2·5/4·5	

For Nos. 37 and 46 glasses

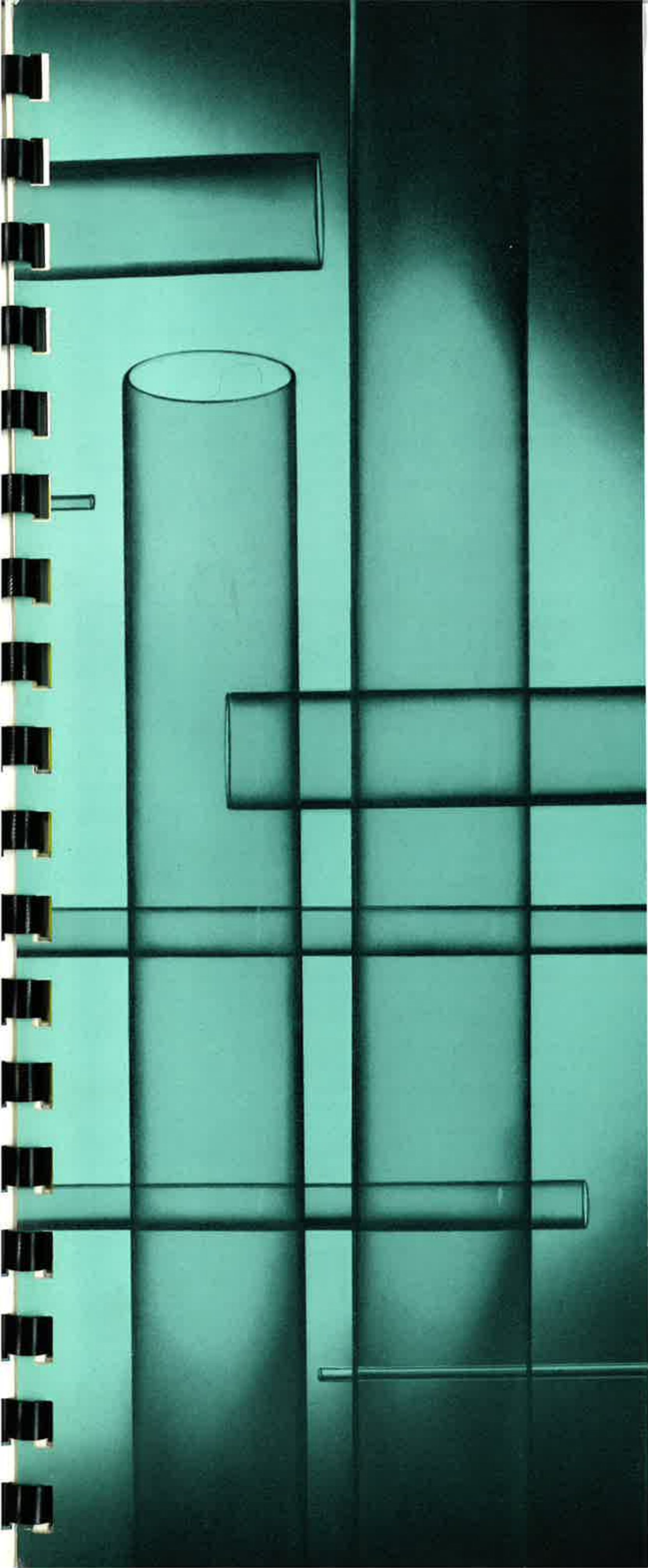
Diameter Range mm	Diameter Tolerance mm	Standard Wall Sizes (mm)		
2·0/10·0	± 0·5	0·5/1·0	0·75/1·25	1·0/1·5
10·0/15·0	± 0·75	0·75/1·25	1·0/1·5	1·25/1·75
15·0/25·0	± 1·0	1·0/1·5	1·25/1·75	1·5/2·0
25·0/30·0	± 1·25	1·25/2·0	1·5/2·25	1·75/2·5
30·0/35·0	± 1·5	1·5/2·5	1·75/2·75	2·0/3·0
35·0/40·0	± 1·75	1·5/2·75	1·75/3·0	2·0/3·25
40·0/45·0	± 2·0	1·75/3·25	2·0/3·5	2·25/3·75
45·0/50·0	± 2·25	1·75/3·5	2·0/3·75	2·25/4·0

N.B. The Glassworks would normally not wish to work to wall thicknesses outside the above standard sizes.
Where different sizes are required for special applications negotiations can be conducted with the Glassworks.

FORMULAE FOR CALCULATING FEET PER LB. & METRES PER KILO OF TUBING AND ROD

When D = Mean O.D. and W = Mean Wall
Both expressed in mm

	Feet per lb.	Metres per kilo
C.9	$\dfrac{210{\cdot}7}{W\,(D-W)}$	$\dfrac{141{\cdot}4}{W\,(D-W)}$
C.11	$\dfrac{206{\cdot}7}{W\,(D-W)}$	$\dfrac{139{\cdot}0}{W\,(D-W)}$
C.12	$\dfrac{155{\cdot}0}{W\,(D-W)}$	$\dfrac{104{\cdot}0}{W\,(D-W)}$
C.19	$\dfrac{191{\cdot}0}{W\,(D-W)}$	$\dfrac{128{\cdot}2}{W\,(D-W)}$
C.37	$\dfrac{186{\cdot}0}{W\,(D-W)}$	$\dfrac{124{\cdot}8}{W\,(D-W)}$
C.40	$\dfrac{196{\cdot}0}{W\,(D-W)}$	$\dfrac{131{\cdot}5}{W\,(D-W)}$
C.46	$\dfrac{181{\cdot}0}{W\,(D-W)}$	$\dfrac{121{\cdot}4}{W\,(D-W)}$
C.94	$\dfrac{189{\cdot}6}{W\,(D-W)}$	$\dfrac{172{\cdot}2}{W\,(D-W)}$



REQUESTS are often made for a single chart of tolerances to cover the whole span of sizes normally manufactured. In view of the great diversity of requirements found in lamp, valve and other assemblies such a chart is not practical and could be misleading. Suffice it to say that we are prepared to consider any requests of a special nature subject to appropriate prices.

The accompanying charts are therefore intended as a rough guide only for normal values of diameter grading, wall thickness, etc. However, the following short descriptions of readily available 'standard' lines do give a fair cross section of our tubing. It is incidental that they carry lamp manufacturing terms.

C 12·30% LEAD GLASS TUBING

Fuse Tubing

This is drawn at the machine in the range 1·7/2·0 mm and is supplied in graded form 1·7/1·9 mm and 1·8/2·0 mm. Wall thickness is closely controlled within 0·30/0·40 mm.

Exhaust Tubing

Two ranges are readily available:

1. O.D. 3·0/3·9 mm } Wall 0·60/0·80 mm
2. O.D. 3·9/4·7 mm }

This tubing supplied in graded form with a guaranteed compliance of 95% to size and 98% at ± 0·05 mm O.D. tolerance. The method of grading is such as to give a high degree of normal distribution without a grade. Customers are normally expected to accept three adjacent grades e.g. 3·2/3·4 mm, 3·3/3·5 mm, 3·4/3·6 mm. The special diameter gauging equipment used for this accurate grading is available only for tubing with the listed wall thicknesses.

Butt Seal Tubing

This is drawn at the machine in the range 5·0/7·0 mm with a wall thickness of 0·70/0·85 mm. Normal diameter grading is in overlapping 0·5 mm steps.

Bulb Blowing Tubing

This is drawn at the machine in the range 5·0/7·0 mm with wall thicknesses of 0·70/0·85 mm and 0·90/1·1 mm. Normal diameter grading is in overlapping 0·5 mm steps.

Standard Flare Tubing

This is drawn at the machine in the range 10·0/12·5 mm with an objective wall thickness of 0·90/1·0 mm. Normal diameter grading is in overlapping 0·5 mm steps.

C.94 SODA TUBING

Generally speaking sizes similar to those of C.12 lead glass can be provided. However, there are many applications particularly in the medical field calling for thin wall tubing at larger diameter sizes and also tighter diameter tolerances. We can satisfactorily meet all requirements and the following list of tubing already supplied to customers well illustrates the scope of our plant.

Outside Diameter	Wall
6·8/ 7·8 mm Graded 0·2 mm steps	0·60/0·70 mm
7·0/ 7·8 mm Graded 0·2 mm steps	0·50/0·60 mm
9·0/10·0 mm 10·5/11·5 mm 11·0/12·0 mm	0·50/0·60 mm
11·5/12·5 mm	1·1 /1·2 mm
16·0/17·0 mm Graded 0·5 mm steps	0·50/0·60 mm
16·5/17·5 mm Graded 0·5 mm steps	0·50/0·60 mm
20·0/21·0 mm Graded 0·5 mm steps	0·90/1·0 mm
21·0/22·0 mm Graded 0·5 mm steps	0·70/0·80 mm

Dimensional Specifications C.12 Lead Glass

C.12 GLASS TUBING

General Guide to Diameter Tolerance

Diameter Range	Normal Grading	
1·7/4·5 mm	0·2 mm	Customers are normally expected to take two overlapping grades.
4·5/6·0 mm	0·25 mm	
6·0/12·0 mm	0·5 mm	
12·0/20·0 mm	1·0 mm	
20·0/30·0 mm	1·5 mm	
30·0/37·0 mm	2·0 mm	

APPROXIMATE FEET PER LB. OF C.12 TUBING AND ROD

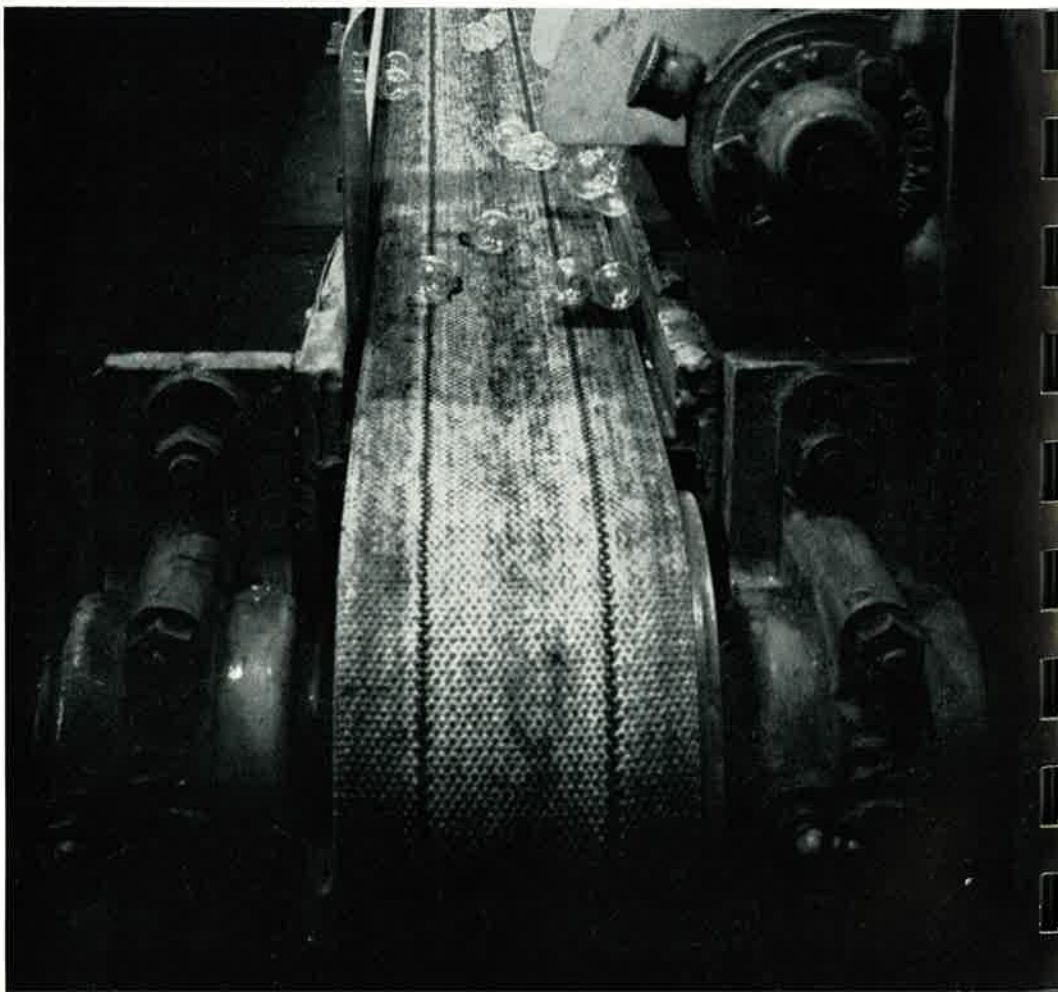
Mean O.D. in mm	Wall ·30/·40	Wall ·40/·60	Wall ·60/·75	Wall ·60/·80	Wall ·70/·85	Wall ·80/1·0	Wall ·90/1·1	Wall 1·0/1·25	Wall 1·25/1·5	Wall 1·5/1·75	2·0 Mean Wall	2·5 Mean Wall	Rod
2	268												155
3	167	124		96									68·7
4		96	69	67									38·7
5		88	61	51·5	47·3								24·8
6		56	43	41·6	38·2	33·7	31						17·2
7		48	36	35·0	32·1	28·2	26						12·6
8		41	30	30·3	27·6	24·2	22·1						9·7
9		36	27	26·6	24·2	21·2	19·4						7·6
10		33	25	23·8	21·6	18·9	17·2						6·2
11			22	21·4	19·5	17·0	15·5	13·9					5·1
12			20	19·6	17·8	15·5	14·1	12·7	10·6				4·3
13			18·5	18·0	16·3	14·2	12·9	11·6	9·9				3·7
14				16·6	15·1	13·1	11·9	10·6	8·9				3·2
15				15·4	14·0	12·2	11·1	9·9	8·25				2·75
16				14·4	13·1	11·4	10·3	9·25	7·7	6·6			2·42
17				13·5	12·3	10·7	9·55	8·65	7·2	6·2			2·14
18					11·6	10·1	9·1	8·15	6·75	5·8			1·91
19					11·0	9·5	8·6	7·7	6·4	5·5			1·71
20					10·4	9·0	8·1	7·3	6·0	5·2	4·3		1·57
21						8·5	7·7	6·9	5·7	4·9	4·1		1·40
22						8·1	7·4	6·6	5·5	4·7	3·9	3·2	1·28
23						7·8	7·0	6·3	5·2	4·5	3·7	3·0	1·17
24						7·5	6·7	6·0	5·0	4·3	3·5	2·88	1·07
25							6·45	5·7	4·8	4·0	3·4	2·75	0·99
26							6·2	5·5	4·6	3·9	3·2	2·63	0·91
27							5·95	5·3	4·4	3·7	3·1	2·53	0·85
28								5·1	4·2	3·6	3·0	2·43	0·79
29								4·9	4·1	3·5	2·9	2·33	0·73
30								4·8	3·9	3·3	2·8	2·25	0·69
31									3·8	3·2	2·7	2·17	
32									3·7	3·1	2·6	2·10	
33									3·6	3·0	2·5	2·04	
34										2·9	2·4	1·97	
35										2·8	2·3	1·90	
36										2·75	2·25	1·84	
37										2·7	2·2	1·79	

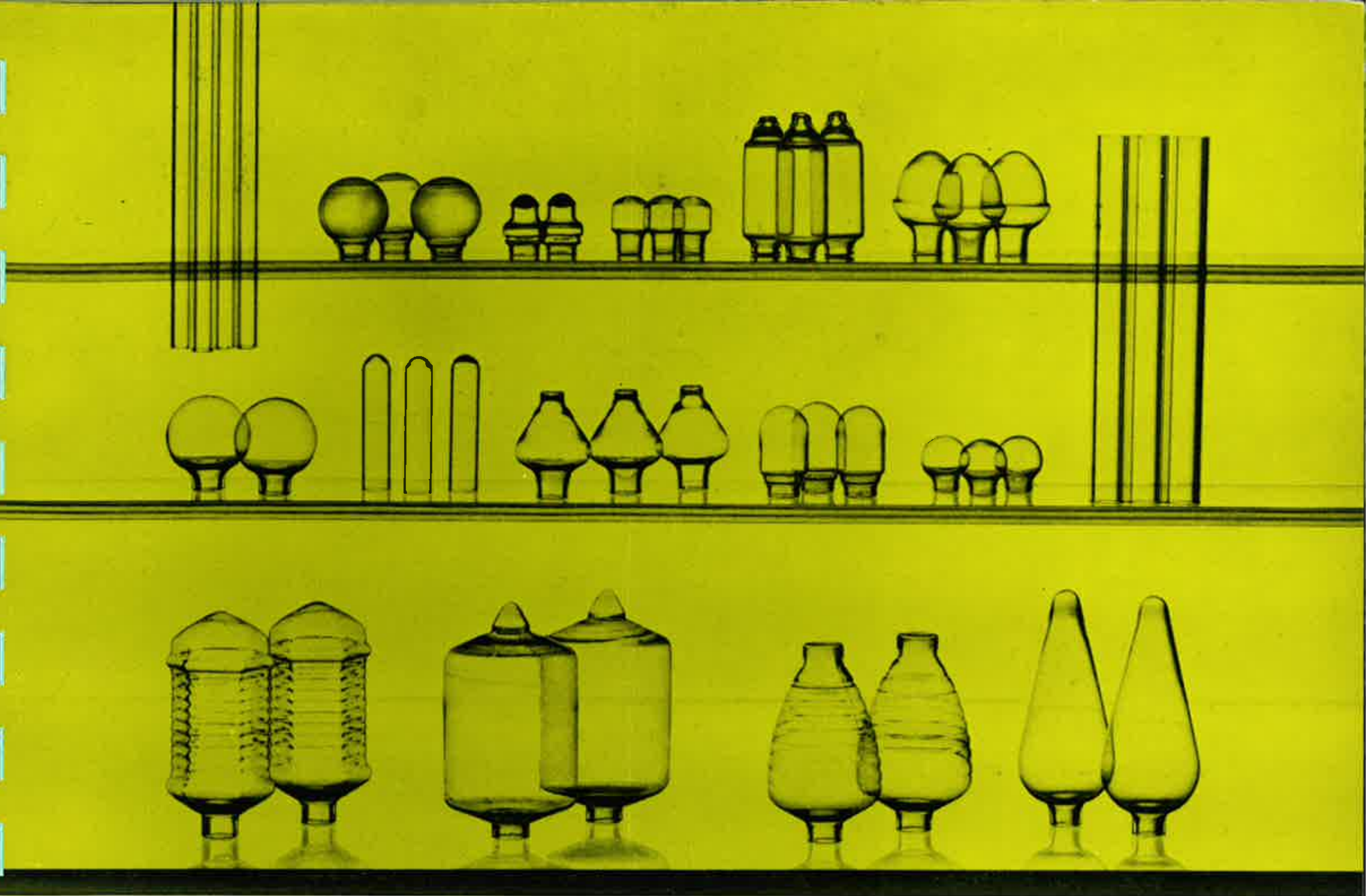
Demand for the miniature bulbs manufactured at Chesterfield—for torches, cars, telephone switchboards, and decoration purposes—has been rising in recent years: in 1957 output was 31 million, and in the following year 40 million.

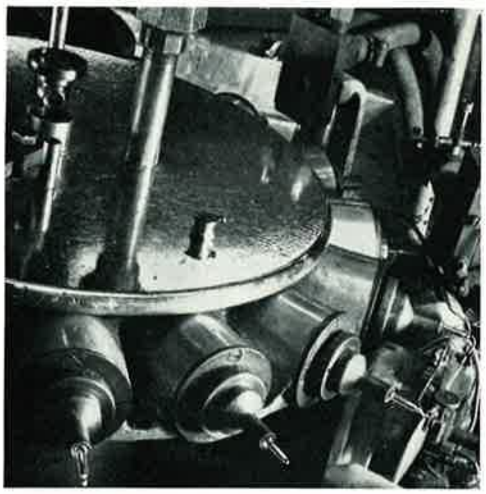
Bulbs Blown from Tubing

The whole process of forming these bulbs from tubing is performed on 16-head machines. When the tubing (usually 46-48 in. long) has been softened by heat, air is blown down it from a central conduit, puffing the end of the tubing to the required shape. The bulb then goes on a conveyor belt to the annealing oven, and from there to another machine for removal of the neck, which is done by thermal shock.

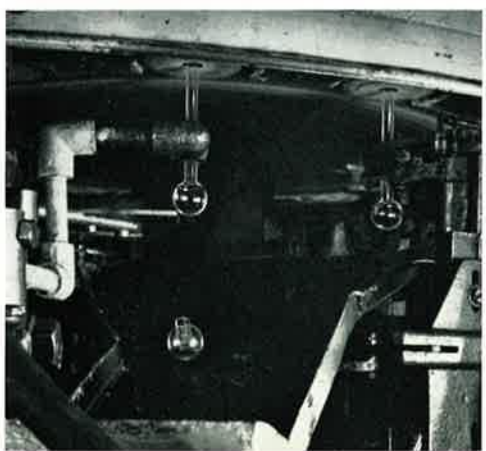
Small variations in the thickness of the tube wall may influence the working of the glass, so the four-foot lengths of tube (already sorted in the Danner department) are graded again, according to weight, before being placed on the bulb-blowing machine.







On this machine the superfluous glass forming the neck of the bulb is removed by thermal shock. The bulb is held in the chuck by a vacuum. (and below) Simple round miniature bulbs can be clearly seen at the delivery stage



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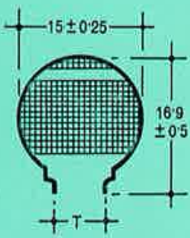
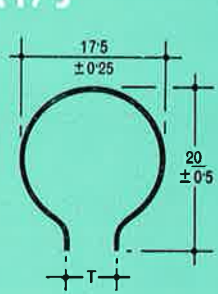


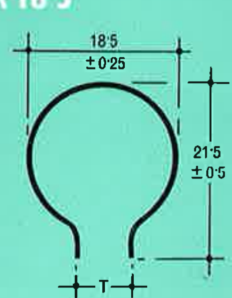
T: TUBING { 6·25 - 6·75 OUTSIDE DIA; 0·9 - 1·1 WALL

R 17·5



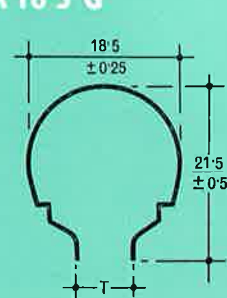
T: TUBING { 6·5 - 7·0 OUTSIDE DIA; 1·1 - 1·3 WALL

R 18·5



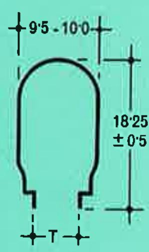
T: TUBING { 6·5 - 7·0 OUTSIDE DIA; 0·9 - 1·1 WALL

R 18·5 G



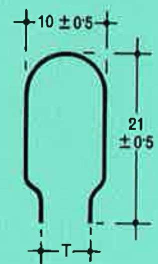
T: TUBING { 6·5 - 7·0 OUTSIDE DIA; 6·75 - 7·25 OUTSIDE DIA; 0·9 - 1·1 WALL

T 10 B



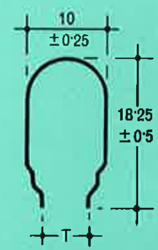
T: TUBING { 5·75 - 6·25 OUTSIDE DIA; 0·7 - 0·8 WALL

T 10 C



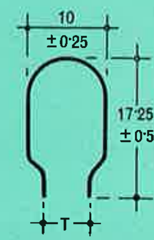
T: TUBING { 5·75 - 6·25 OUTSIDE DIA; 0·7 - 0·85 WALL

T 10 D



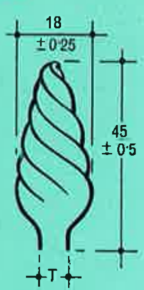
T: TUBING { 5·75 - 6·25 OUTSIDE DIA; 0·7 - 0·8 WALL

T 10 F



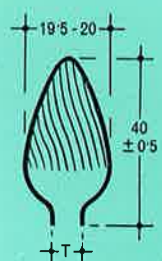
T: TUBING { 5·75 - 6·25 OUTSIDE DIA; 0·7 - 0·8 WALL

TC 18



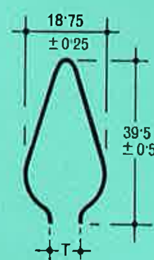
T: TUBING { 6·5 - 7·0 OUTSIDE DIA; 0·9 - 1·1 WALL

TC 20



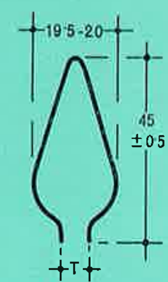
T: TUBING { 6·5 - 7·0 OUTSIDE DIA; 0·9 - 1·1 WALL

CC 19



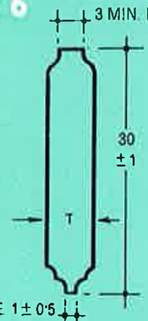
T: TUBING { 6·5 - 7·0 OUTSIDE DIA; 0·9 - 1·1 WALL

CC 20 A



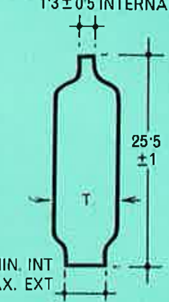
T: TUBING { 6·5 - 7·0 OUTSIDE DIA; 1·2 - 1·3 WALL

DT 6



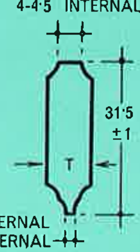
T: TUBING { 5·75 - 6·25 OUTSIDE DIA; 0·5 - 0·6 WALL

DT 8



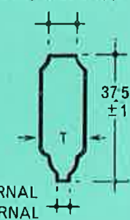
T: TUBING { 7·5 - 8·0 OUTSIDE DIA; 0·8 - 1·0 WALL

DT 11



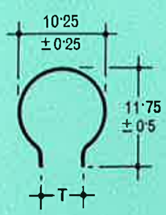
T: TUBING { 10·5 - 11·0 OUTSIDE DIA; 0·5 - 0·6 WALL

DT 11 A



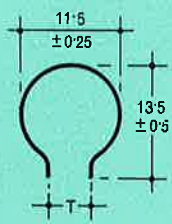
T: TUBING { 10·5 - 11·0 OUTSIDE DIA; 0·5 - 0·6 WALL

R 10·5



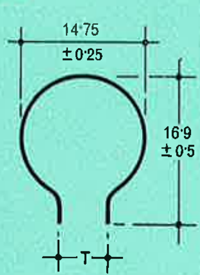
T: TUBING { 5·5-6·0 OUTSIDE DIA; 0·7-0·85 WALL }

R 11·75



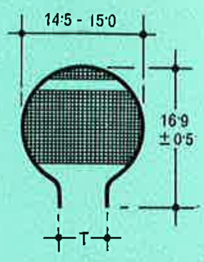
T: TUBING { 5·75-6·25 OUTSIDE DIA; 0·7-0·85 WALL }

R 15



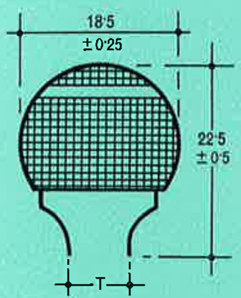
T: TUBING { 6·25-6·75 OUTSIDE DIA; 0·9-1·1 WALL }

R 15 B



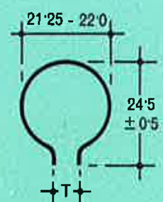
T: TUBING { 6·25-6·75 OUTSIDE DIA; 0·9-1·1 WALL }

R 18·5 H



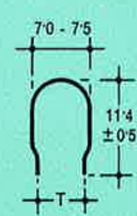
T: TUBING { 6·75-7·25 OUTSIDE DIA; 0·9-1·1 WALL }

R 22 D



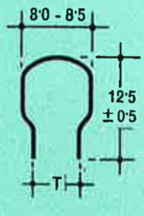
T: TUBING { 7·0-7·5 OUTSIDE DIA; 7·25-7·75 OUTSIDE DIA; 1·1-1·2 WALL }

T 7·5 A



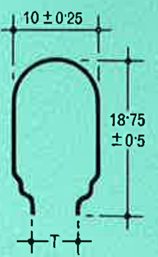
T: TUBING { 6·0-6·5 OUTSIDE DIA; 0·7-0·85 WALL }

T 8·5



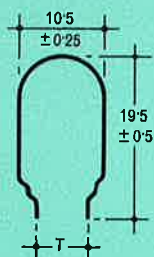
T: TUBING { 5·5-6·0 OUTSIDE DIA; 0·7-0·85 WALL }

T 10 G



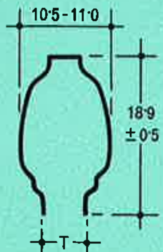
T: TUBING { 6·0-6·5 OUTSIDE DIA; 0·7-0·85 WALL }

T 10 H



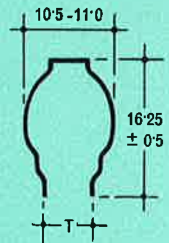
T: TUBING { 6·5-7·0 OUTSIDE DIA; 0·9-1·1 WALL }

OP 11



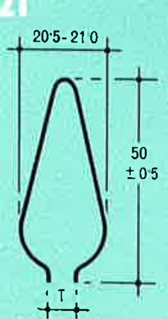
T: TUBING { 6·0-6·5 OUTSIDE DIA; 0·7-0·85 WALL }

OP 11 A



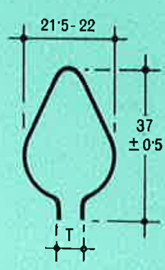
T: TUBING { 6·0-6·5 OUTSIDE DIA; 0·7-0·85 WALL }

CC 21



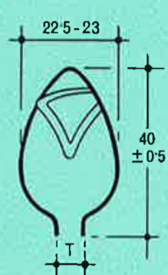
T: TUBING { 6·5-7·0 OUTSIDE DIA; 1·2-1·3 WALL }

OC 22



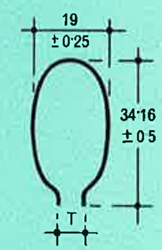
T: TUBING { 6·75-7·25 OUTSIDE DIA; 0·9-1·1 WALL }

X 23



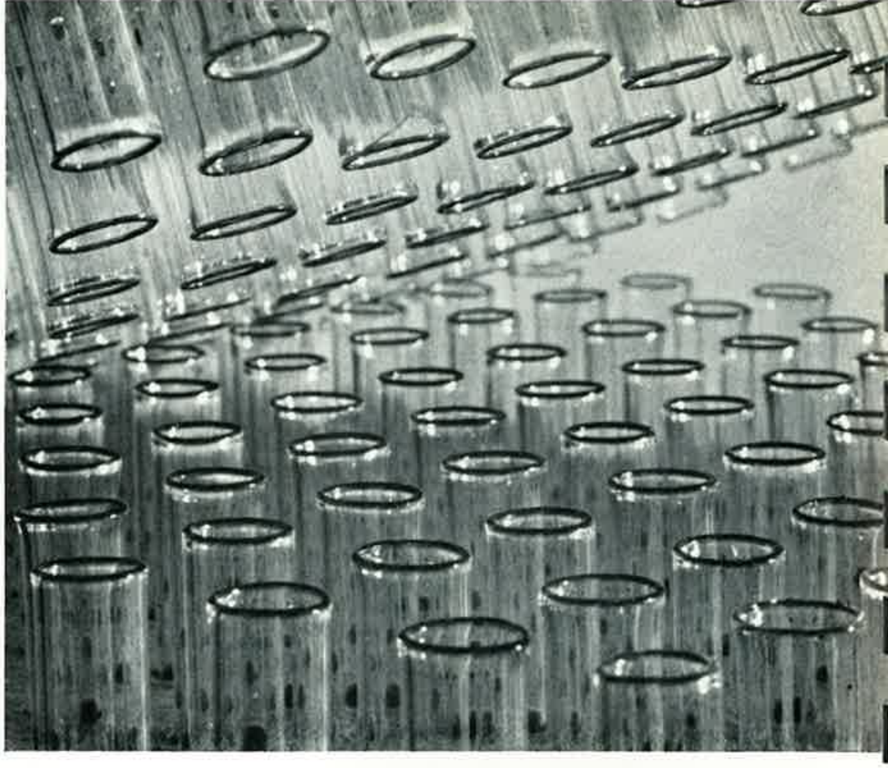
T: TUBING { 6·5-7·0 OUTSIDE DIA; 1·2-1·3 WALL }

E 19



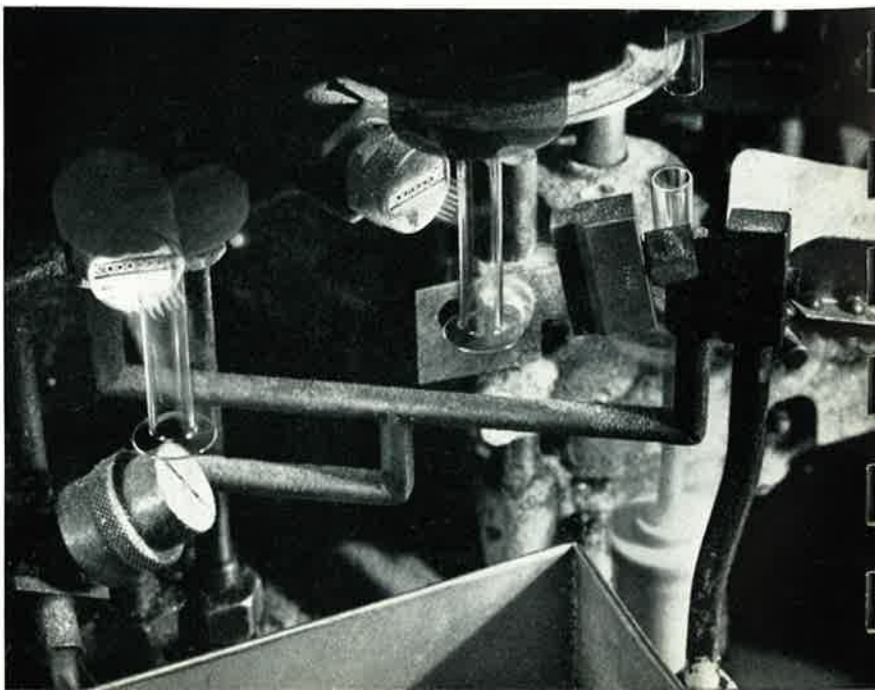
T: TUBING { 6·5-7·0 OUTSIDE DIA; 0·9-1·1 WALL }

All dimensions in millimetres



Flares for Lamps and Valves

The flare, which is common to both incandescent lamps and valves, forms the base of the filament assembly, and is sealed to the neck of the bulb. Production of flares is carried on in the same department as the manufacture of miniature bulbs, and as with miniature bulbs, the raw material is four-foot tubing. The end of the tubing is heated and then forced open by a spindle which revolves at high speed, and all that remains is to sever the stem of the flare from the tubing, according to the length required.



Flares, which are manufactured in the miniature bulb department, are produced by heating one end of a four-foot tube and forming a lip. This operation is performed by a revolving spindle (shown close to the corner of the bin in the lower part of the photograph)

Dimensional Specification *Dimensions in millimetres*

Small Tubing Size Range

Length and Flare Diameter Tolerance ±·5

Diameter Range	6·0/8·5
Wall	·70/·85 and ·80/1·0

Standard Sizes

17 × 11·5, 18 × 11,
18 × 11·5, 19 × 14,
21 × 14·5.

Medium Tubing Size Range

Length and Flare Diameter Tolerance ±·75

Diameter Range	8·5/12·5
Wall	·70/·90 and ·80/1·0

Standard Sizes

20 × 12·25, 20 × 14,
33 × 21, 35 × 21,
38 × 21, 43 × 21,
51 × 21, 54 × 21,
58 × 21.

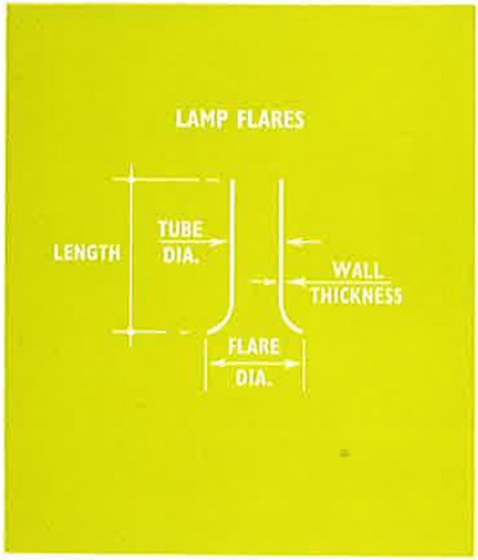
Large Tubing Size Range

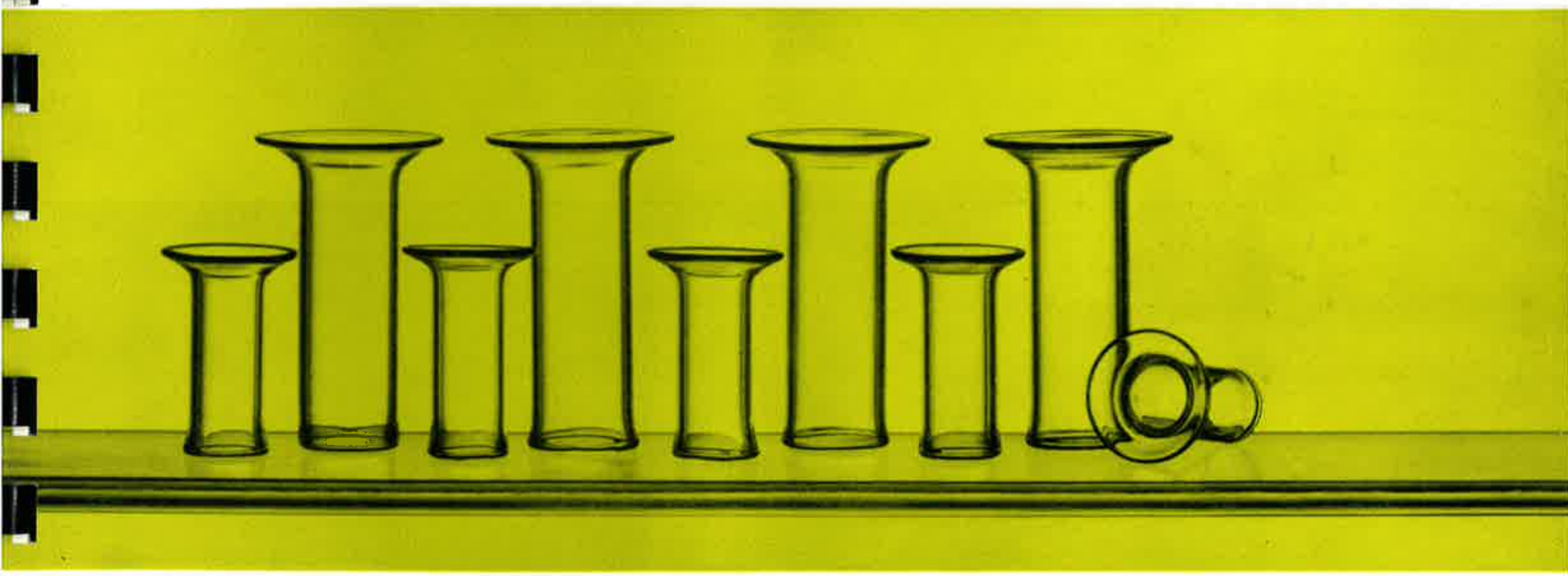
Length and Flare Diameter Tolerance ±1·0

Diameter Range	12·5/16·0
Wall	·80/1·0 and 1·25/1·5

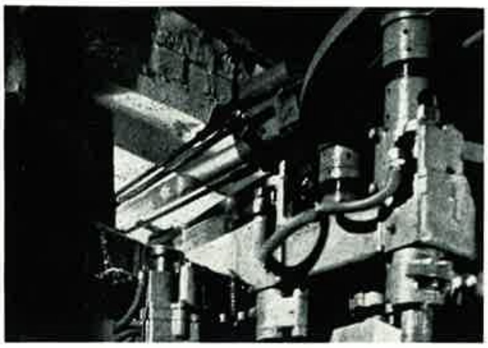
Standard Sizes

28·5 × 22, 65 × 29,
78 × 31.



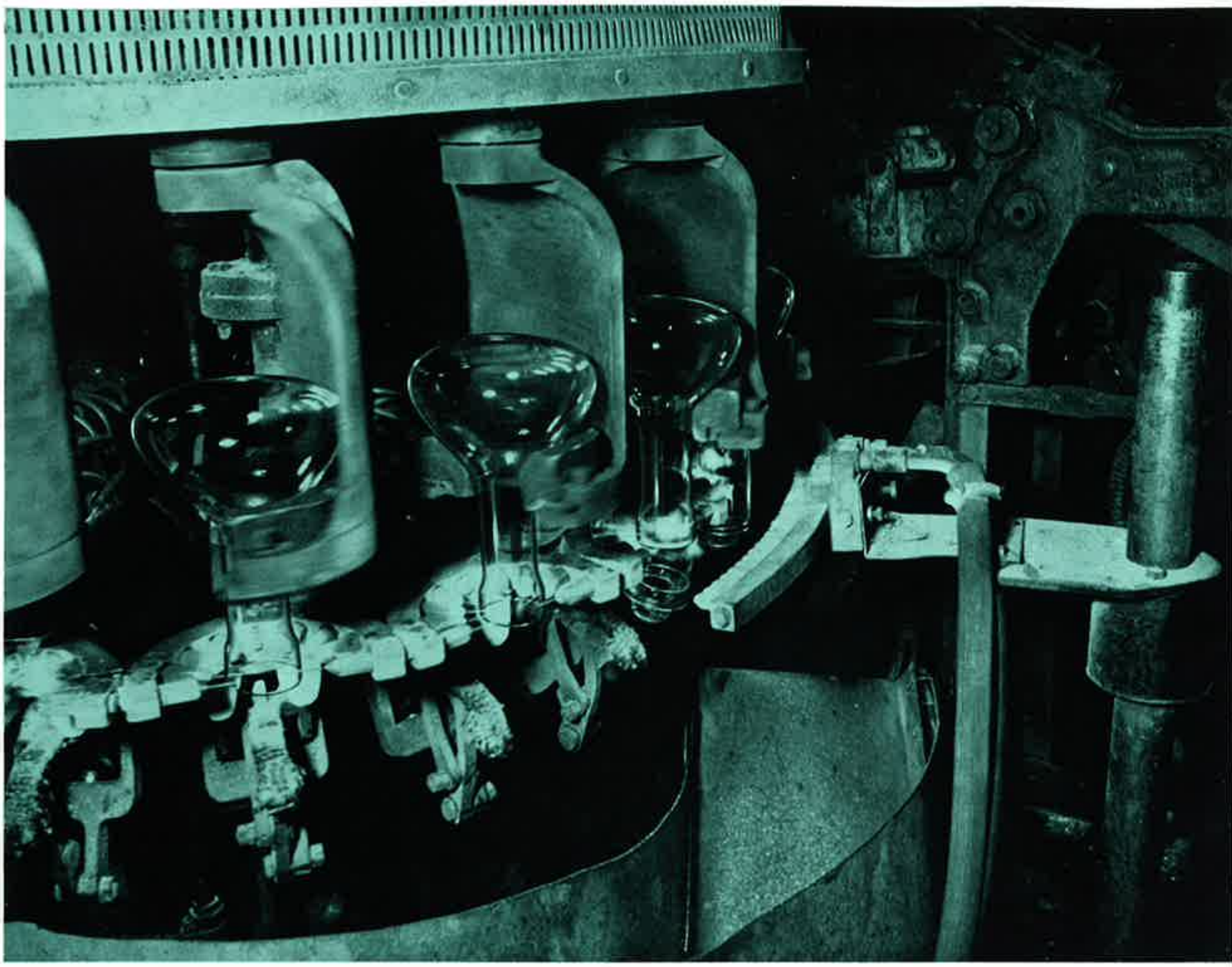


The finished flare is inspected on an illuminated screen as it passes along the conveyor belt



Machine Blown Products

The Westlake machine can be used for the production of glassware for the table, as well as for bulbs, but this catalogue is concerned with the applications of glass in industry or research. It is a circular machine, with twelve working heads, each of which carries two hollow spindles. Two plungers extract glass from the furnace by means of a vacuum, which is released to allow the two blobs of glass to fall into the jaws of the two vertical hollow spindles. The jaws close round the glass, forming an air-tight seal, and a plunger in the spindle makes a cavity in the glass, so that it can be inflated by puffs of air.

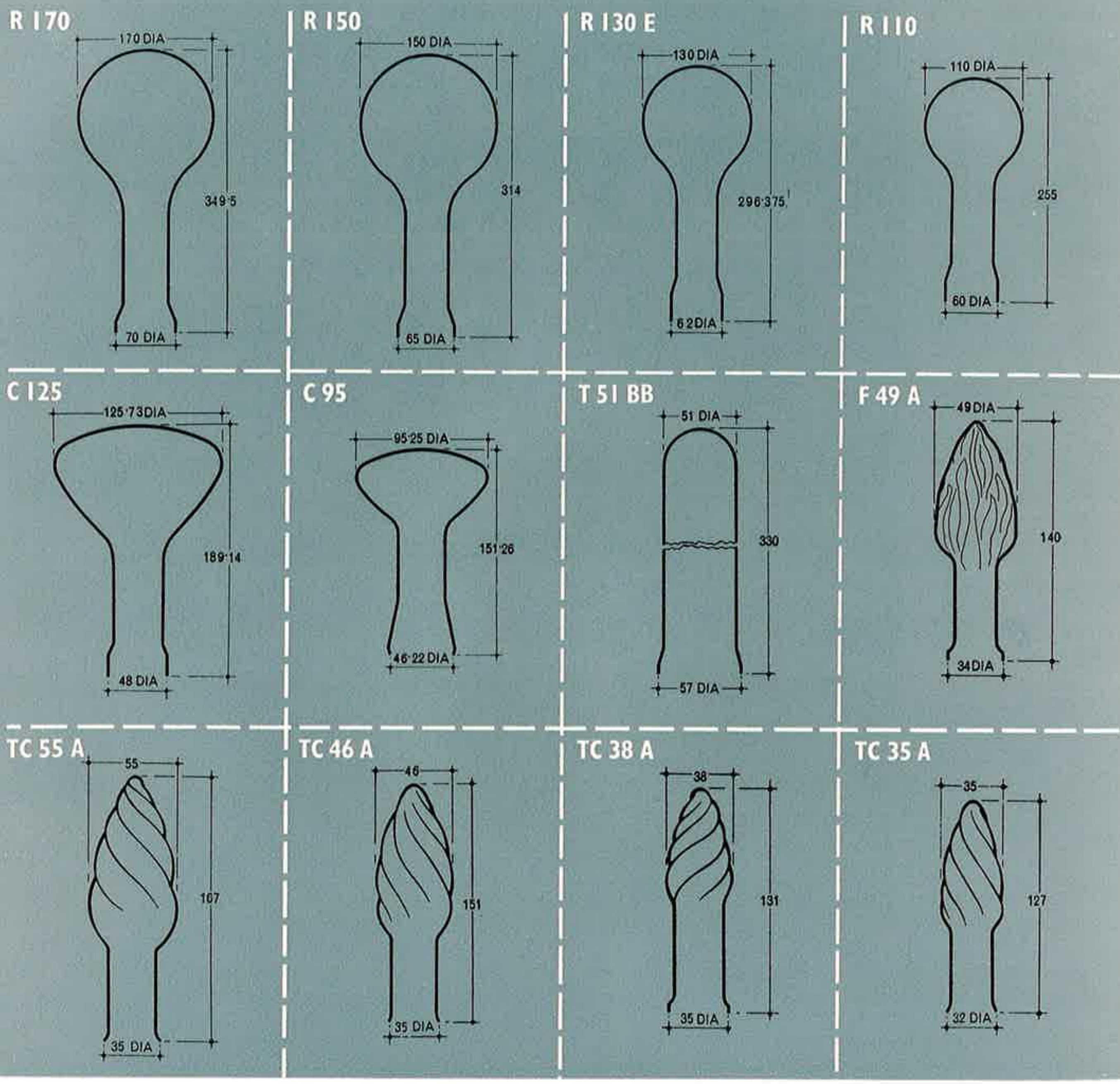


Bulbs for reflector lamps ready for transfer from the Westlake burn off machine to the annealing chamber

Production of bulbs on the Westlake machine. Two arms (seen in the mouth of the furnace) extract molten glass and transfer it to the spindles (shown in two positions). When the spindles have swung into a vertical position the glass is enclosed in a mould and air is puffed into it to form the required shape. (and right) Reflector lamp bulbs about to be released after blowing on the Westlake

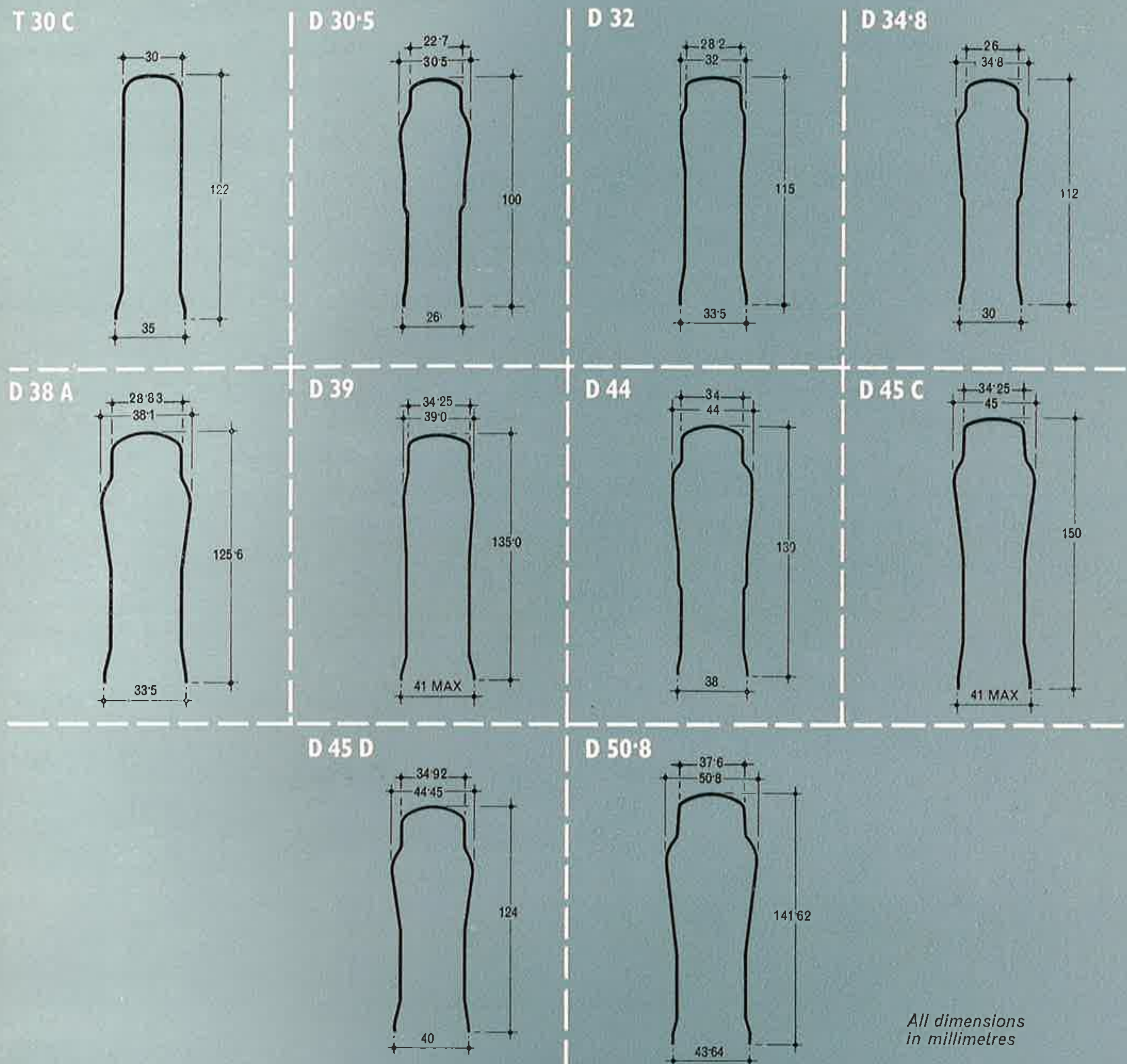
As the spindles move downwards, revolving continuously, air is puffed into the glass, which begins to inflate, until a mould previously dipped into a bath of water closes round it and a final puff forms the required shape. At this stage, when the spindles have almost completed their circuit, the moulds open and the bulbs are deposited on a conveyor belt. The next stage is the burning off of the glass which has keyed the bulbs in the spindle jaws, and they are then transferred to the annealing chamber for stress relieving, and from there to inspection. From the removal of molten glass from the furnace to inspection takes about five minutes.

Vacuum flasks and glass shields for hurricane lamps are manufactured in a similar way on the Westlake.



LAMP BULBS

Bulb Type High Wattage & Miscellaneous	Qty. per Box	Nett lb.	Nett kilos	Gross lb.	Gross kilos	Dimensions of Carton inches
TC 35A	98	5·5	2·5	11	5	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$
TC 38A	98	6	2·7	11	5	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$
TC 46A	98	7	3·2	12	5·4	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$
F 49A	98	8	3·6	13	5·9	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$
T 51BB	36	12	5·5	15	6·8	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$
TC 55A	72	6	2·7	11	5	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$
C 95	50	7	3·2	12	5·4	$17\frac{1}{8} \times 17\frac{1}{8} \times 15\frac{1}{4}$
R 110	32	6·6	3	13	5·9	$17 \times 17 \times 21\frac{1}{2}$
C 125	32	8	3·6	13	5·9	$17\frac{1}{8} \times 17\frac{1}{8} \times 15\frac{1}{4}$
R 130E	20	8·25	3·75	11	5	$24 \times 16 \times 12$
R 150	15	6·6	3	10	4·5	$24 \times 16 \times 12$
R 170	12	8	3·6	12	5·5	$24 \times 16 \times 14$



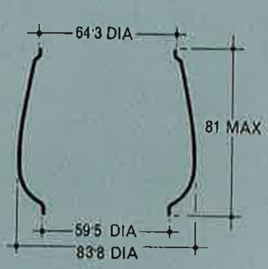
All dimensions in millimetres

VALVE BULBS

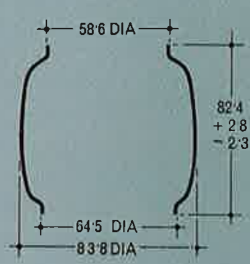
Bulb Type Valve Bulbs	Qty. per Box	Nett lb.	Nett kilos	Gross lb.	Gross kilos	Dimensions of Carton inches
T 30C	144	7	3·2	10	4·5	$14\frac{1}{4} \times 14\frac{1}{4} \times 10\frac{1}{4}$
D 30·5	468	11	5	16	7·2	$13\frac{1}{8} \times 13\frac{1}{8} \times 13\frac{1}{8}$
D 32	200	9	4·1	12	5·4	$12 \times 12 \times 9\frac{1}{2}$
D 34·8	200	8	3·6	11	5	$12 \times 12 \times 9\frac{1}{2}$
D 38A	144	7	3·2	10	4·5	$14\frac{1}{4} \times 14\frac{1}{4} \times 10\frac{1}{4}$
D 39	98	6	2·7	11	5	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$
D 44	98	5	2·3	10	4·5	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$
D 45C	98	8	3·6	13	5·9	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$
D 45D	144	9	4·1	12·5	5·7	$14\frac{1}{4} \times 14\frac{1}{4} \times 10\frac{1}{4}$
D 50·8	72	5	2·3	11	5	$14\frac{1}{8} \times 14\frac{1}{8} \times 14\frac{1}{8}$

HL 101 A

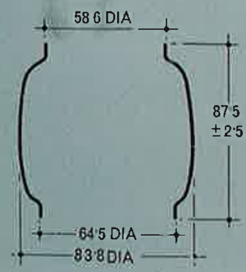
DR 84



DR 84 B



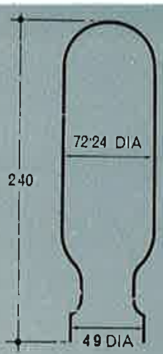
DR 84 C



LANTERN GLOBES

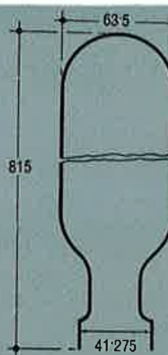
Hurricane Lantern Globes	Qty. per Box	Nett lb.	Nett kilos	Gross lb.	Gross kilos	Dimensions of Carton inches
DR 84	100	11	5·0	17	8·0	$17\frac{1}{8} \times 17\frac{1}{8} \times 15\frac{1}{4}$
DR 84B	96	10	4·5	20	9·0	$17\frac{3}{16} \times 14\frac{1}{8} \times 21\frac{5}{16}$
DR 84C	96	10	4·5	20	9·0	$17\frac{3}{16} \times 14\frac{1}{8} \times 21\frac{5}{16}$
HL 101 A	48	9	3·1	14	6·4	$24 \times 16 \times 12$

T 72 A

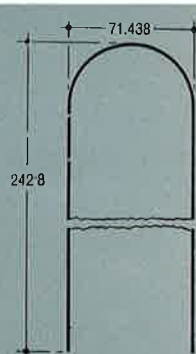


T 81 B

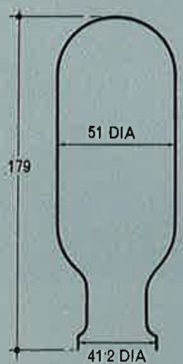
T 63·5



T 71·4 A



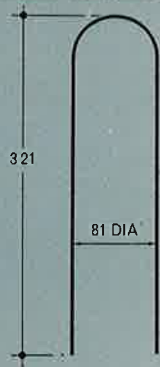
T 51 DD



T 58·5

T 72 B

T 81 A



All dimensions in millimetres

BLANKS FOR VACUUM FLASKS

Glass Blanks for Vacuum Flasks	Qty. per Box	Nett lb.	Nett kilos	Gross lb.	Gross kilos	Dimensions of Carton inches
T 51D	100	10	4·5	15	6·8	$27\frac{1}{2} \times 13\frac{3}{4} \times 18\frac{1}{4}$
T 58·5	100	11	5·0	16	7·3	$27\frac{1}{2} \times 13\frac{3}{4} \times 18\frac{1}{4}$
T 63·5	100	16	7·3	20	9·0	$27\frac{1}{2} \times 13\frac{3}{4} \times 18\frac{1}{4}$
T 71·4A	50	13	5·9	18	8·2	$17\frac{13}{16} \times 17\frac{13}{16} \times 20\frac{1}{2}$
T 72A	50	14	6·4	18	8·2	$15\frac{1}{4} \times 15\frac{1}{4} \times 20\frac{1}{2}$
T 72B	40	11·5	5·2	15	6·8	$24\frac{1}{2} \times 16\frac{1}{2} \times 12$
T 81A	25	10·0	4·5	15	6·8	$17\frac{1}{8} \times 17\frac{1}{8} \times 15\frac{1}{4}$
T 81B	50	18·0	8·2	23	10·4	$17 \times 17 \times 21\frac{1}{2}$

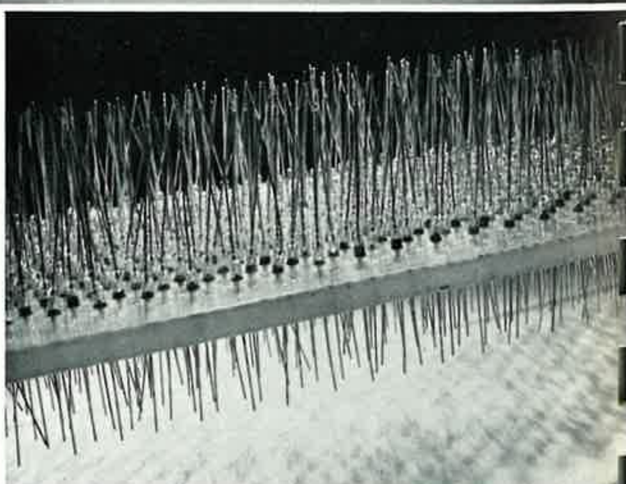
Domestic glassware is an important product of the Chesterfield Works' Westlake plant and over the years the development section has successfully adapted the machine to manufacture a variety of drinking vessels—various shapes of tumblers, lager glasses and, of recent date, the introduction of one piece stemware.

Domestic glassware, with the exception of lamp chimneys and vacuum flasks, is marketed by a single customer, Messrs Dema Glass Ltd., 167 Victoria Street, London, S.W.1. (Telephone: Victoria 4155-Overseas Cables DEMGLAS LONDON*), to whom all enquiries regarding sales, etc., should be directed.*

Glass to Metal and Graded Seals

As the coefficient of expansion of a glass may not be appropriate for sealing directly to the specified metal, it is sometimes necessary to use two or more types of glass to produce the required seal. This is known as a 'graded seal', and several types of Chesterfield glass are suitable for this work—a boro-silicate of the C9 type, for instance; a silicate, such as C19; or a lead glass, such as C12. In a normal combination, as many as five glasses might be used, see page 38.

In the manufacture of filament lamps and valves, a soda-lime-silica glass is used for the bulb and a lead glass for the stem—the soda-lime-silica in the interest of low cost and mass production, and the other to give the necessary electrical resistivity in the stem. Both glasses, of course, must seal to each other, and the lead glass must also seal to Dumet wire. The latter glass (C12) also seals readily to nickel-iron alloys containing about 50 per cent of nickel, provided the alloy has a thin coating of copper to ensure good adhesion.



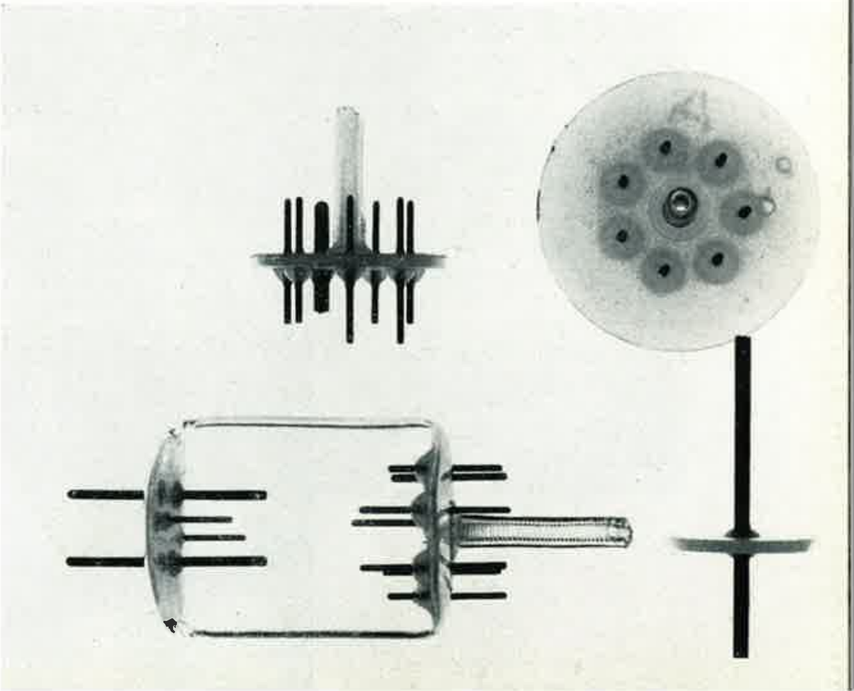
Two examples of a graded seal between C9 and C19 glasses. In order to seal the soft glass (C19) to the boro-silicate C9, a range of other boro-silicates is used

Glass-to-metal seals used in valve manufacture. The dome in the top right-hand corner is sealed to copper

SINTERED GLASS

A technique is being developed for the prefabrication of bases for certain types of valve and lamp, in which glass powder is sintered round an exhaust tube and glassed metal leads in one operation. The finished base has a higher mechanical strength and can withstand thermal shock better than a pressed glass base of orthodox design.

Types now being made range from a 24 mm diameter base, with six wires and exhaust-tube inserted, to a 57 mm diameter base with seven wire inserts and exhaust tube.



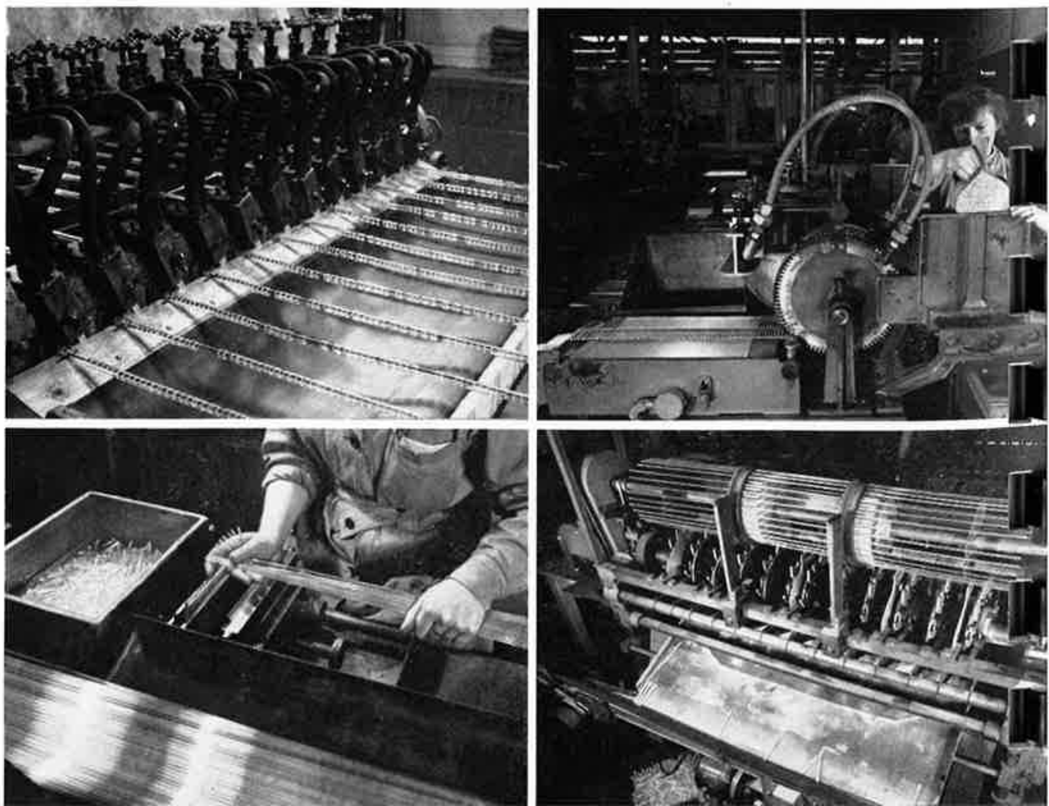
Finishing

By the time glass leaves Chesterfield it has often evolved well beyond the stage of tube drawing, say, and some of the early operations of manufacturing the final product have been completed. A large proportion of the tube produced at Chesterfield is also processed there.

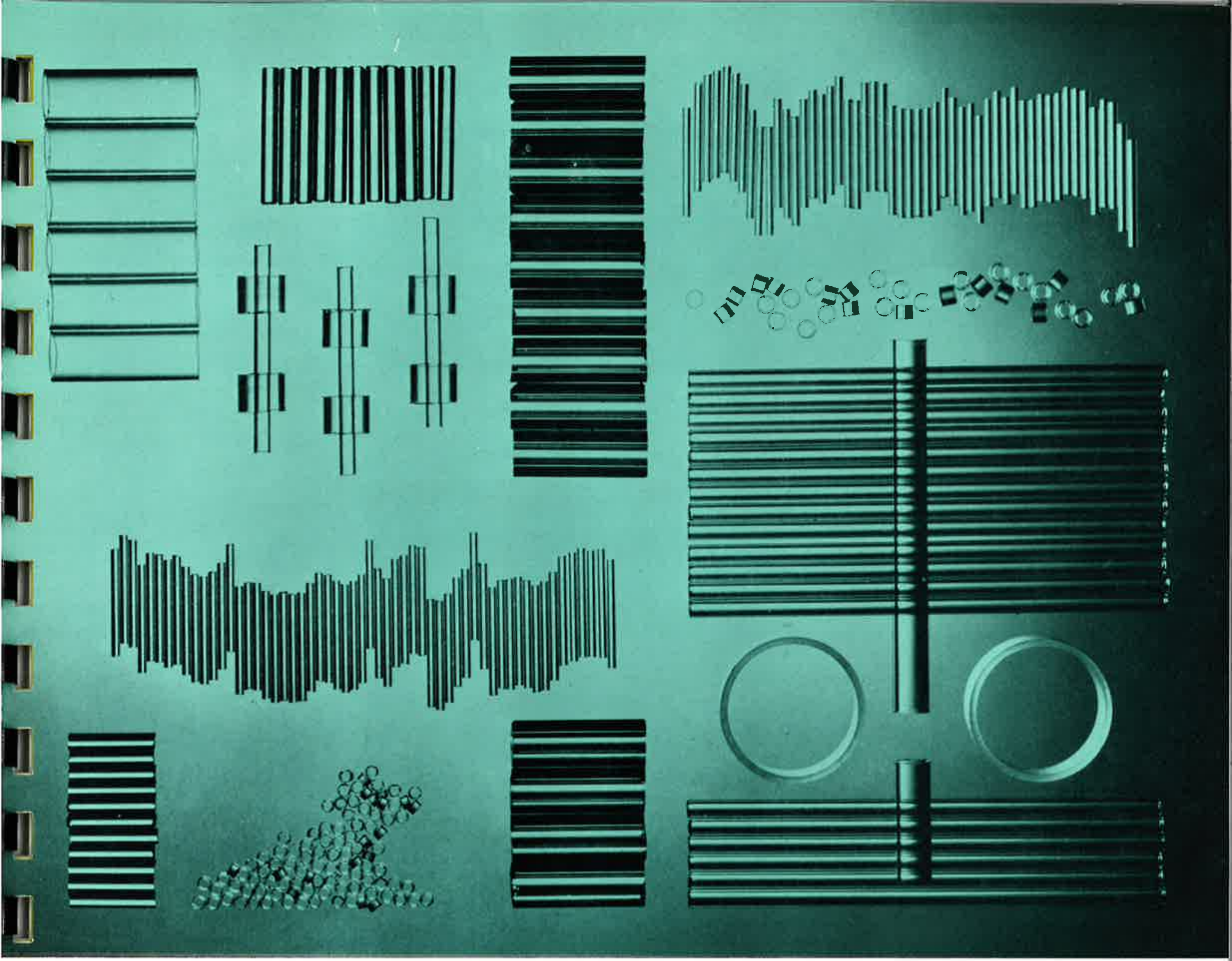
The simplest of the post-Danner operations is to cut the four-foot tube (or whatever other length it is) into the length required by the customer. Where output is sufficiently great this is done by machine; otherwise it is done by hand. In the cutting department a great variety of lengths is prepared—from 18 to 220 millimetres.

A piece of glass tube is the starting point of a variety of components, and in the form of rings it is supplied to valve manufacturers for incorporation in valve bases. The machines employed produce rings in a range of diameters from six to 23 millimetres and lengths between 8 and 120 millimetres, to a tolerance of $\pm$ 5 per cent by weight. Tubular bulbs, including some for cathode ray applications, are produced on the Dichter machine. Pressings, such as those for projector lamp bases, are ground in the finishing department, to give them the required dimensional accuracy.

Another product of the finishing department is beads (small sections of tube) which, among other purposes, are used in transistors. The smallest of these is only $1\frac{1}{2}$ mm long. Others are employed as bushings for the hermetic seal and lead-in to refrigerators.



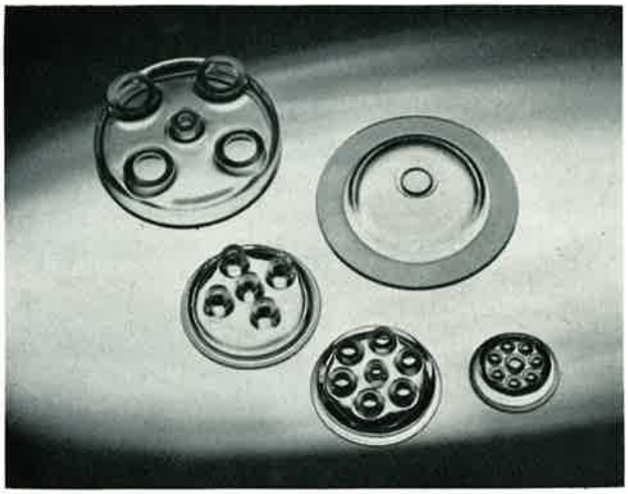
(1) Before the tube is put on this cutting machine it is graded a second time (by weight this time), to guarantee accuracy of the wall thickness. These rings are produced in a great variety of dimensions, for purposes as different as refrigerator bushings and valve bases. (2) Exhaust tube is being fed to this machine for glazing. (3) Cutting exhaust tube by hand. (4) Where the size of the order justified it, exhaust tube is cut on this high-speed machine



PRESSING

Glass of irregular contour can often be obtained by pressing.

With this process, molten glass is dropped into the bottom half of a mould. The plunger comprising the top half of the mould is then forced into the molten glass to form the required shape. Small components such as valve bases are often produced this way but larger pressings such as glass domes of considerable weight can also be obtained.

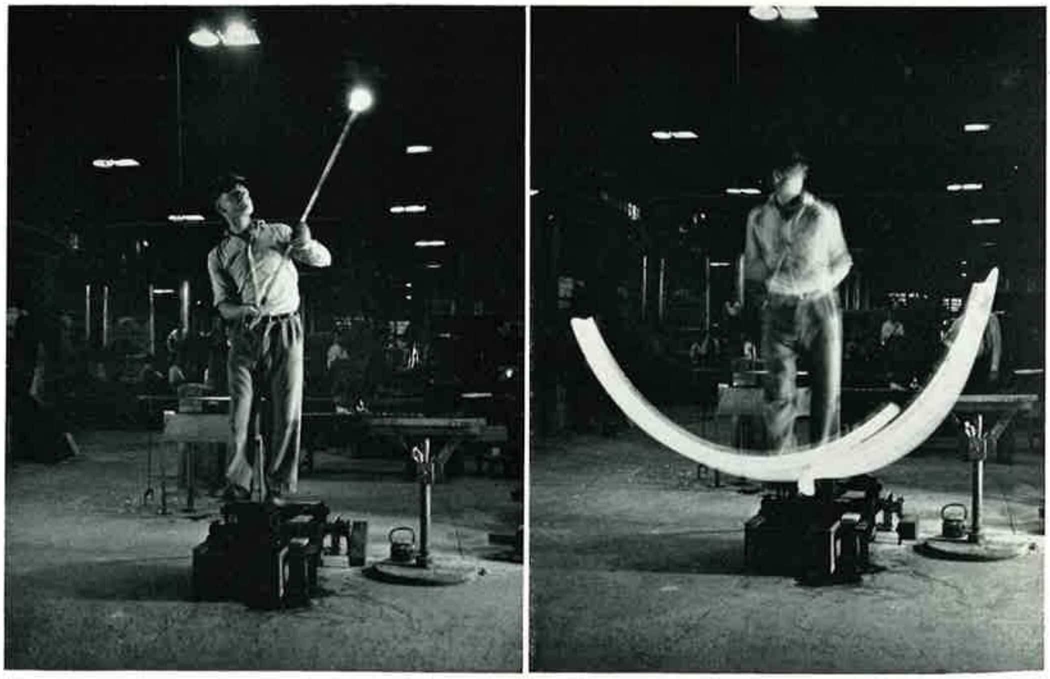


Mouth Blown and Coloured Glass

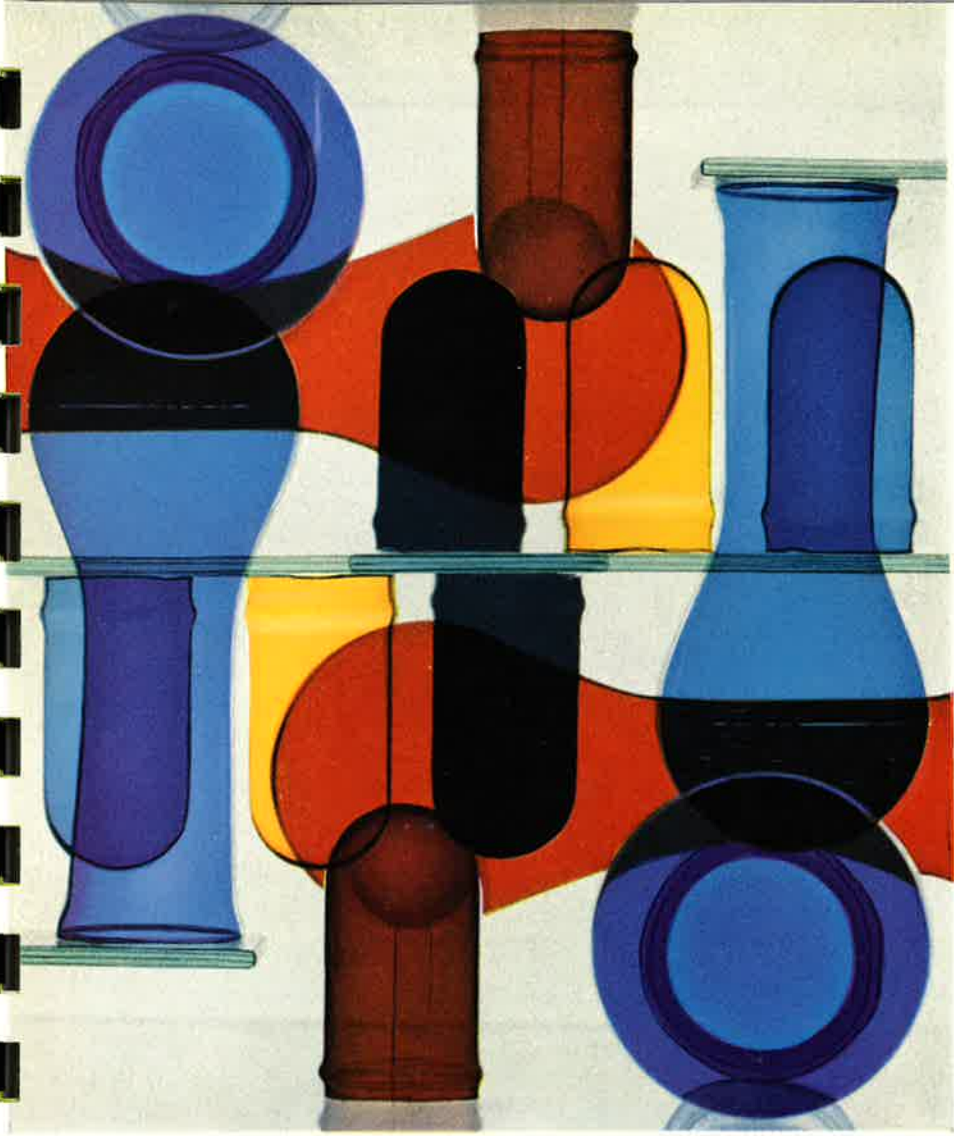
Methods to improve speed of production and quality control are ever present throughout the Chesterfield factory. Some glass products, now flowing continuously from the machines, were a short time ago considered to be suitable only for hand operation.

The artisan—the hand blower—is not disturbed to see mechanization in the industry. He knows that for many years to come his trade is safe and that now he is able to specialize and to employ his skill where it is most needed, in the blowing or drawing of special glasses.

At the A.E.I. glass works we have some of the finest craftsmen in the world; men who are justly proud of their work. Naturally, glass requiring hand operation is frequently more expensive; some special glasses are extremely difficult to work, but in common with all other members of the glass works, the hand blowers constantly aim for fast production and rigid quality control.



The blower, having gathered glass from the furnace, prepares to puff air into it and give it its approximate shape before placing it in the mould at his feet. This bulb is for a mercury-vapour lamp. The other picture shows him swinging the iron



This group of bulbs represents some of the coloured glasses produced at Chesterfield— 'fireglow amber', cadmium yellow (used for motor headlamps), and blue

Among the coloured glasses produced at Chesterfield, 'Fireglow Amber' (C23A, a potash-zinc glass) may be the best-known, because of its association with electric fires, but demand for 'Daylight Blue' (C19B, a soda-lime glass) is at least comparable. Another sodium-lime glass, C19Y, is used in the manufacture of yellow automobile headlamps. Because cadmium sulphide is a constituent, the colour is known as 'cadmium yellow'.

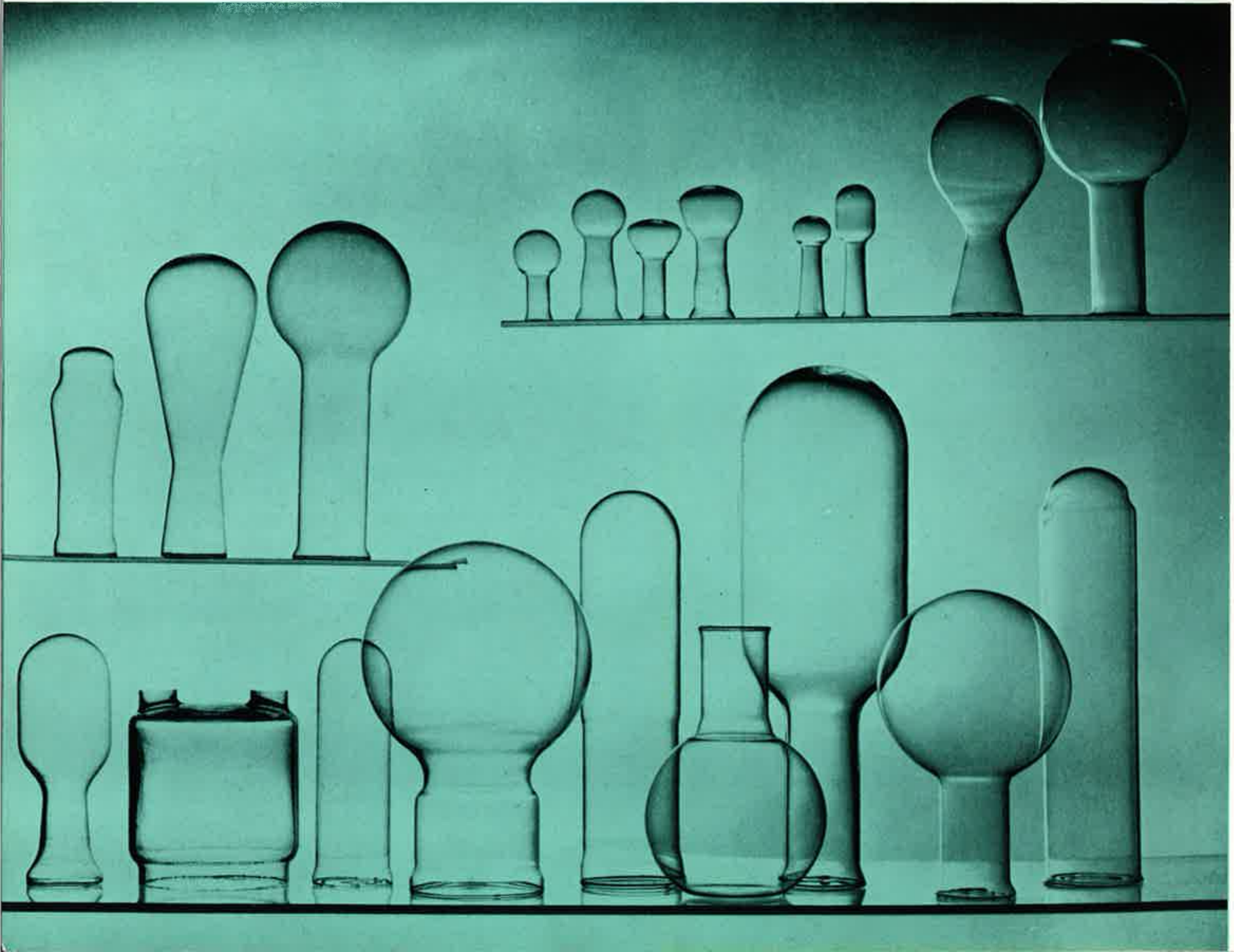
C20BV (an ultra-violet dark blue glass) is used for the mercury vapour discharge ultra-violet lamps employed by laundries to identify customers' garments.

To ensure that colours conform to specification, the manufacturing process is controlled with the help of a spectro-photometer.

Two of the Chesterfield craftsmen employed on blowing borosilicate bulbs

A tilting furnace at Chesterfield with platinum-lined walls to withstand corrosive action of special glasses. The tilting action permits draining and obviates the need for scraping which might damage the walls

A few examples of mouth blown bulbs made by Chesterfield craftsmen



Contents of Glasses Data Section

A·E·I
Lamp and Lighting Co Ltd

The notes and data on the following pages are intended to act as a guide to engineers in the use of glass. Any doubts about the application of the data should be referred back to the A.E.I. Lamp and Lighting Company Limited, Melton Road, Leicester

Chesterfield Glasses

NOTES OF PHYSICAL PROPERTIES OF GLASSES, THEIR MEASUREMENT AND USE.

Thermal Expansion Characteristics

This property is one of the major factors governing suitability of glass for sealing to other glasses or metals, but it should always be remembered that the expansion of glass is dependent on the rate of heating during test and on heat treatment previous to test and markedly so at temperatures approaching within 100-200° of the 'annealing temperature'. In view of this, caution must be used in estimating stresses in seals from published expansion curves; strictly one should consider only the contraction curves with the same cooling rate as the seal being studied or direct measurement may be made of stresses without reference to dilatation measurements.

Thermal expansion is also markedly dependent on chemical composition, and particularly alkali content, so that it is used as a control test. It is measured differentially against fused silica and all figures quoted are the average thermal expansion coefficient per °C measured over the range 50°—400°C. In the case of glasses for Kovar type seals all values should lie within $\pm 1 \times 10^{-7}$ of the quoted coefficient, glasses for sealing to tungsten or molybdenum within $\pm 1{\cdot}5 \times 10^{-7}$ and for soft glasses within $\pm 2 \times 10^{-7}$.

Viscosity

A knowledge of viscosity/temperature characteristics is of value at all stages in the annealing, working and melting of glass although no tolerances are specified for the figures quoted.

In the annealing range (10^{13}—10^{10} poises) the viscosity of glass is determined by measuring the rate of elongation of a fibre of known dimensions under a constant load at a constant temperature. A difficulty arises in that viscosity is another physical property dependent on heat treatment and thermal history so that for each determination a freshly drawn fibre should be used and heated for a time at a constant temperature before measurement, the times being standardized as follows

Viscosity (poises)	10^{10}	10^{11}	10^{12}	10^{13}
Time (min.)	15	20	30	45

In the data sheets which follow the temperatures (°C) are quoted corresponding to viscosities of 10^{13} and 10^{12} poises taken directly from viscosity-temperature curves and for $10^{14{\cdot}6}$ poises by extrapolation of these curves.

The temperature corresponding to 10^{13} poises can be used as a definition of 'annealing temperature' and is approximately that temperature at which a sample will become commercially 'stress free' in 15 minutes. The temperature corresponding to 10^{12} poises may be regarded as an upper annealing temperature which should not be exceeded to avoid deformation of the sample. The temperature corresponding to $10^{14{\cdot}6}$ poises may be regarded as the strain point, below which glass can be cooled as rapidly as possible providing that thermal gradients are not introduced sufficient to crack the glass.

The temperature corresponding to a viscosity of $10^{7{\cdot}6}$ poises is generally known as the softening point or Littleton point and may be taken as the lowest temperature at which sufficient fusion has taken place to enable seals to be made. The $10^{7{\cdot}6}$ point is determined by measuring the temperature at which a fibre of specified dimensions extends under its own weight at a rate of 1 mm per minute when heated in a standard furnace at a standard heating rate.

Annealing

In making use of glass a knowledge of annealing is necessary although it should be emphasized that most seals are not usually stress free; in fact the aim often is definitely to obtain seals with moderately high stress of such a nature that stresses subsequently introduced under working conditions can be withstood. Whatever the aim, however, a knowledge of the way in which stresses in glass change with time and temperature in the annealing range is of fundamental importance. There is no standard definition of annealing temperature, although as mentioned earlier the temperature corresponding to a viscosity of 10^{13} poises is a useful guide. Use can be made of curves developed by Redston and Stanworth which enable annealing schedules to be calculated knowing the expansion coefficient of the glass and the dimensions of the article to be annealed. Typical annealing schedules for varying sizes of each glass are included showing the temperature at which the glass should be held for a given period of time and then the maximum rate at which it should be cooled to the strain point ($10^{14{\cdot}6}$ poises) below which temperature the glass can be cooled at any reasonable rate which can be accomplished without cracking the ware by excessive thermal shock.

Direct Current Resistivity

This property is determined by measuring the time taken for a known capacity to discharge through a sample of known dimensions at a given temperature and varies enormously with composition and temperature but only to a small extent with heat treatment. In the data sheets which follow log. resistivities are quoted for temperatures of 150°C and 300°C and values at other temperatures can be obtained knowing that a graph of log. resistivity and reciprocal absolute temperature is a straight line over a very wide range of temperature.

A·E·I Lamp and Lighting Co Ltd

CHESTERFIELD

C 94 glass

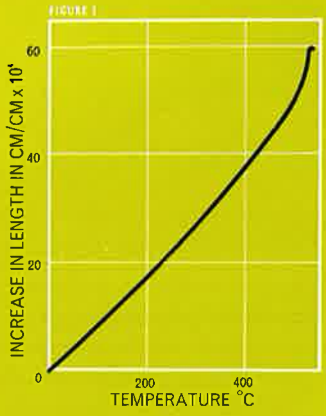


Fig. 1. Typical Thermal Expansion Curve.

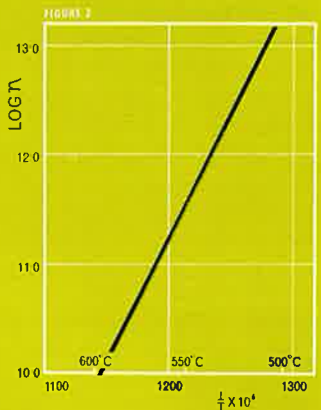


Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature $(\frac{1}{T})$.

Description. Soda-lime-silicate glass.

Applications. Mainly for the production of fluorescent tubes, vials, bench working, etc.

Chemical Composition

SiO_2	71·5	MgO	3·0	Na_2O	14·0
Al_2O_3	2·2	BaO	1·7	K_2O	1·5
CaO	5·7				

Physical Properties

Expansion coefficient . .	95×10^{-7}	(Fig. 1)
Viscosity $10^{14 \cdot 6}$ poises at	475	(Fig. 2)
,, 10^{13} ,, ,,	515	(Fig. 2)
,, 10^{12} ,, ,,	540	(Fig. 2)
,, $10^{7 \cdot 6}$,, ,,	710	(Fig. 2)
,, 10^{5} ,, ,,		(Fig. 2)
Log d.c. resistivity at 150	8·6	
,, ,, ,, ,, 300	5·9	
Specific Gravity	2·50	

Typical Annealing Schedule. A 5 mm thick block of C 94 glass could be annealed by holding at 535°C for 5 minutes, followed by cooling at 3°C per minute to, say, 475°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

A·E·I Lamp and Lighting Co Ltd

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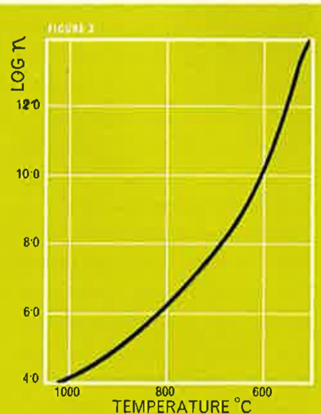
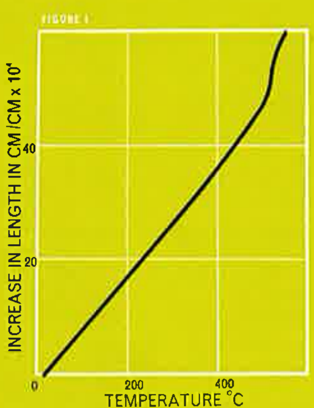
C 19 glass

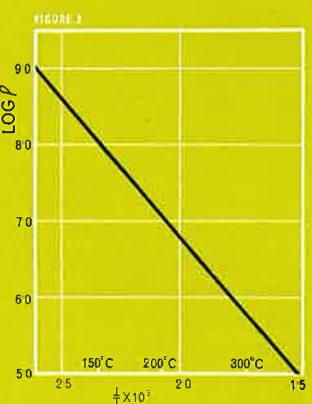
Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Typical Curve of Log. Viscosity (Log η) and Temperature.

Fig. 3. Curve at Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature $(\frac{1}{T})$.







Description. Soda-lime-silicate glass.

Applications. Mainly for the envelopes of lamps and valves.

Chemical Composition

SiO_2	72·5	CaO	6·5	Na_2O, K_2O	16·3
Al_2O_3	1·3	MgO	3·0		

Physical Properties

Expansion coefficient . .	95×10^{-7}	(Fig. 1)
Viscosity $10^{14 \cdot 6}$ poises at	495	(Fig. 2)
,, 10^{13} ,, ,,	530	(Fig. 2)
,, 10^{12} ,, ,,	550	(Fig. 2)
,, $10^{7 \cdot 6}$,, ,,	710	(Fig. 2)
,, 10^{5} ,, ,,	900	(Fig. 2)
Log d.c. resistivity at 150	8·4	(Fig. 3)
,, ,, ,, ,, 300	5·7	(Fig. 3)
Dielectric constant at 1 Mc/sec.	6·8	
Loss angle at 1 Mc/sec.	0·008	
Specific Gravity	2·48	

Typical Annealing Schedule. A 5 mm thick block of C 19 glass could be annealed by holding at 550°C for 5 minutes, followed by cooling at 3°C per minute to, say, 495°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

A·E·I Lamp and Lighting Co Ltd

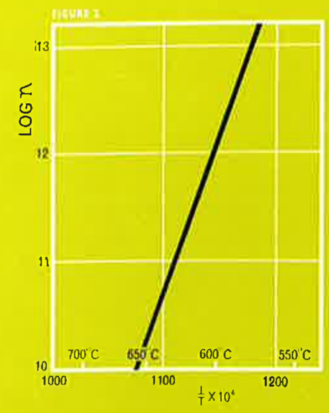
CHESTERFIELD

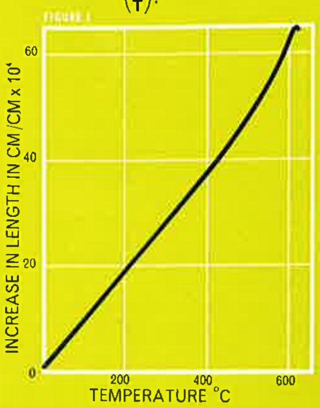
C 66 glass

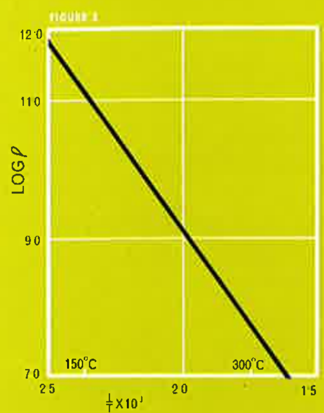
Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature $(\frac{1}{T})$.

Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature $(\frac{1}{T})$.







Description. Potash-barium oxide-silicate.

Applications. Certain types of projector lamps.

Chemical Composition

SiO_2	61·5	B_2O_3	2·4	BaO	15·0
Al_2O_3	3·1	CaO	3·0	K_2O	15·0

Physical Properties

Expansion coefficient	$95{\cdot}0 \times 10^{-7}$	(Fig. 1)
Viscosity $10^{14{\cdot}6}$ poises at	540	(Fig. 2)
,, 10^{13} ,, ,,	580	
,, 10^{12} ,, ,,	605	
,, $10^{7{\cdot}6}$,, ,,		
,, 10^{5} ,, ,,		
Log d.c. resistivity at 150	11·2	(Fig. 3)
,, ,, ,, ,, 300	7·9	
Specific Gravity	2·68	

A·E·I Lamp and Lighting Co Ltd

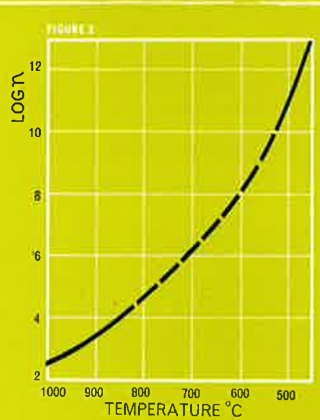
CHESTERFIELD

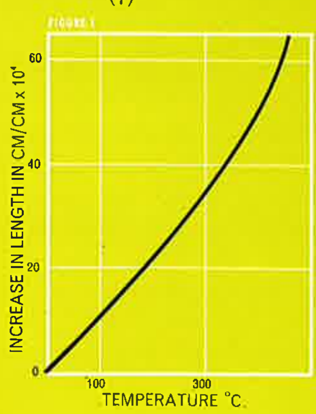
C 41 glass

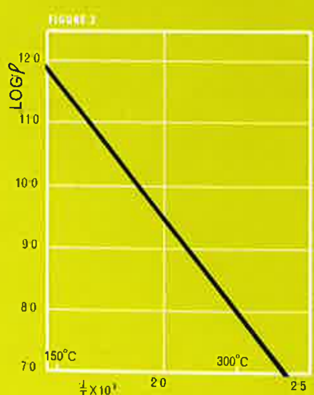
Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Curve of Log. Viscosity (Log η) and Temperature (Broken line by interpolation).

Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature $(\frac{1}{T})$.







Description. Lead free alkali-barium-zinc-silicate.

Applications. Sealing to iron or steel.

Chemical Composition

SiO_2	45·0	ZnO	11·0	Na_2O	6·0
BaO	19·0	K_2O	14·0	CaF_2	5·0

Physical Properties

Expansion coefficient	128×10^{-7}	(Fig. 1)
Viscosity $10^{14{\cdot}6}$ poises at	410	(Fig. 2)
,, 10^{13} ,, ,,	450	
,, 10^{12} ,, ,,	475	
,, $10^{7{\cdot}6}$,, ,,	625	
,, 10^{5} ,, ,,	780	
Log d.c. resistivity at 150	11·7	(Fig. 3)
,, ,, ,, ,, 300	8·1	
Dielectric constant at 1 Mc/sec.	8·2	
Specific Gravity	3·01	

Typical Annealing Schedule. A 5 mm thick block of C 41 glass could be annealed by holding at 465°C for 8 minutes, followed by cooling at 2°C per minute to, say, 410°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

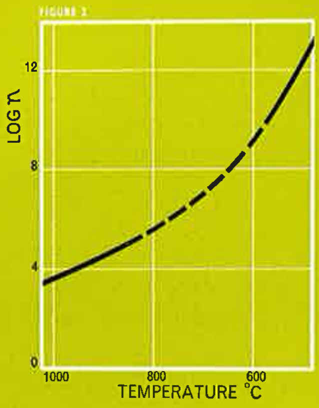
A·E·I Lamp and Lighting Co Ltd CHESTERFIELD

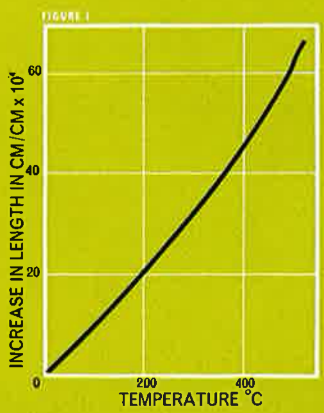
C 76 glass

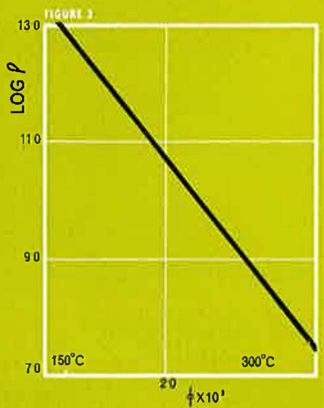
Fig. 1. Thermal Expansion Curve.

Fig. 2. Curve of Log. Viscosity (Log η) and Temperature. (Broken line by interpolation.)

Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature ($\frac{1}{T}$).







Description. Lead-free alkali-barium-zinc-silicate.

Applications. Mainly for Windonuts.

Chemical Composition

SiO_2	48·2	ZnO	11·0	Na_2O	5·0
BaO	19·0	K_2O	11·8	CaF_2	5·0

Physical Properties

Expansion coefficient	115×10^{-7}	(Fig. 1)
Viscosity $10^{14 \cdot 6}$ poises at	445	(Fig. 2)
" 10^{13} " "	480	
" 10^{12} " "	505	
" $10^{7 \cdot 6}$ " "	660	
" 10^{5} " "	835	
Log d.c. resistivity at 150	13·0	(Fig. 3)
" " " " 300	9·0	
Specific Gravity	2·98	

Typical Annealing Schedule. A 5 mm thick block of C 76 glass could be annealed by holding at 500°C for 5 minutes, followed by cooling at 2·5°C per minute to, say, 445°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

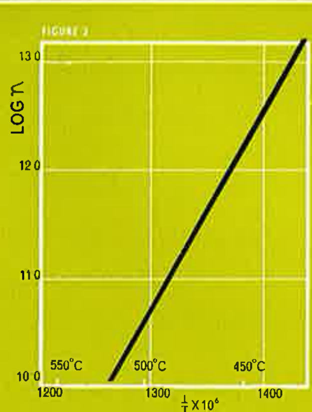
A·E·I Lamp and Lighting Co Ltd CHESTERFIELD

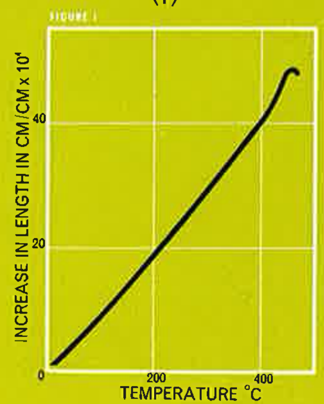
C 55 glass

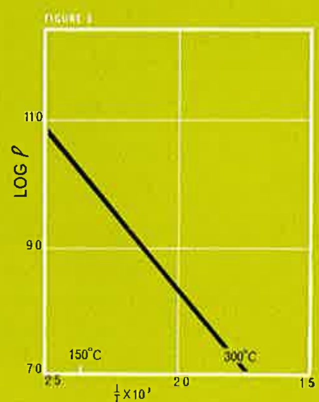
Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature ($\frac{1}{T}$).

Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature ($\frac{1}{T}$).







Description. Lead alkali silicate.

Applications. Glass for beads in lamp manufacture.

Chemical Composition

SiO_2	61·5	PbO	21·6	K_2O	6·5
Al_2O_3	1·4	Na_2O	8·8		

Physical Properties

Expansion coefficient	102×10^{-7}	(Fig. 1)
Viscosity $10^{14 \cdot 6}$ poises at	395	(Fig. 2)
" 10^{13} " "	430	
" 10^{12} " "	460	
" $10^{7 \cdot 6}$ " "	625	
Log d.c. resistivity at 150	10·2	(Fig. 3)
" " " " 300	7·0	
Specific Gravity	2·82	

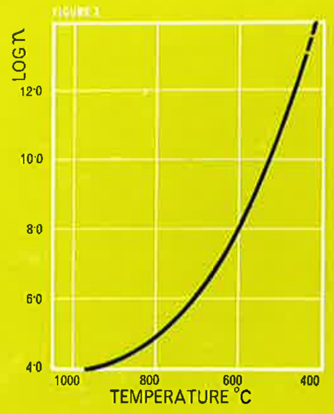
CHESTERFIELD

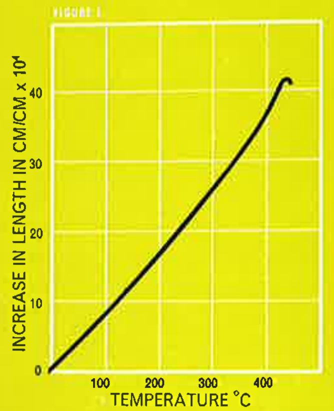
C 12 glass

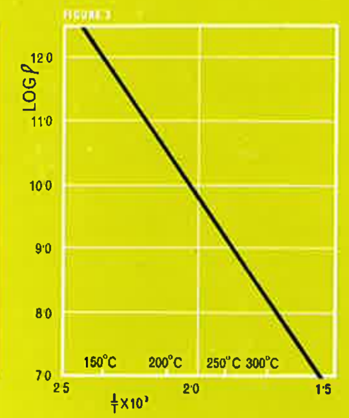
Fig. 1. Thermal Expansion Curve.

Fig. 2. Typical Curve of Log. Viscosity (Log) and Temperature.

Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature ($\frac{1}{T}$).







Description. 30% Lead oxide glass.

Applications. Mainly the internal parts of electric lamps and valves.

Chemical Composition

SiO_2	56·0	PbO	30·0	K_2O	8·0
Al_2O_3	1·3	Na_2O	4·5		

Physical Properties

Expansion coefficient . .	91×10^{-7}	(Fig. 1)
Viscosity $10^{14 \cdot 6}$ poises at	390	(Fig. 2)
,, 10^{13} ,, ,,	435	
,, 10^{12} ,, ,,	465	
,, $10^{7 \cdot 6}$,, ,,	630	
,, 10^{5} ,, ,,	790	
Log d.c. resistivity at 150	12·3	(Fig. 3)
,, ,, ,, ,, 300	8·6	
Dielectric constant at 1 Mc/sec.	6·3	
Loss angle at 1 Mc/sec.	0·0008	
Specific Gravity	3·06	

Typical Annealing Schedule. A 5 mm thick block of C 12 glass could be annealed by holding at 455°C for approximately 5 minutes, followed by cooling at 3°C per minute to, say, 390°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

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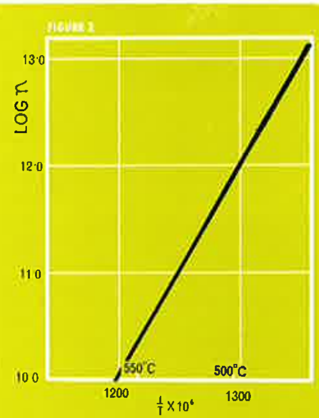
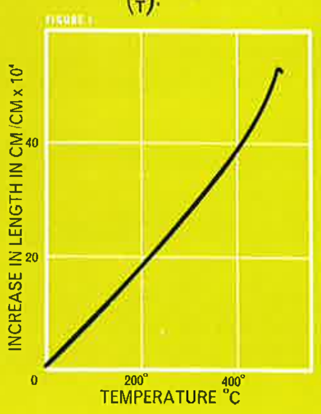
C 73 glass

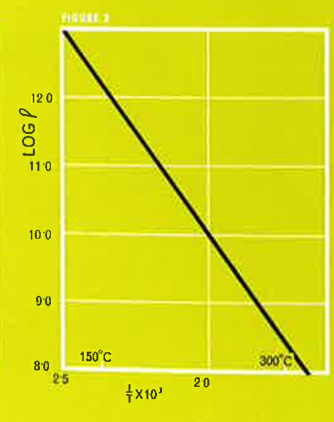
Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature ($\frac{1}{T}$).

Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature ($\frac{1}{T}$).







Description. 20% lead oxide glass (tinted blue).

Applications. Mainly for neck tubing for cathode ray tubes.

Chemical Composition

SiO_2	57·3	CaO	2·4	PbO	20·0	K_2O	9·1
Al_2O_3	0·7	BaO	4·8	MgO	0·7	Na_2O	4·8

Physical Properties

Expansion coefficient . .	$98 \cdot 5 \times 10^{-7}$	(Fig. 1)
Viscosity $10^{14 \cdot 6}$ poises at	425	(Fig. 2)
,, 10^{13} ,, ,,	470	
,, 10^{12} ,, ,,	500	
,, $10^{7 \cdot 6}$,, ,,	670	
,, 10^{5} ,, ,,		
Log d.c. resistivity at 150	12·3	(Fig. 3)
,, ,, ,, ,, 300	8·6	
Specific Gravity	2·95	

Typical Annealing Schedule. A 5 mm thick block of C 73 glass could be annealed by holding at 490°C for 5 minutes followed by cooling at 3°C per minute to, say, 425°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

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C 9 glass

Fig. 1. Typical Thermal Expansion Curve.
Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature.
Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature ($\frac{1}{T}$) for C 9 glass.

FIGURE 2

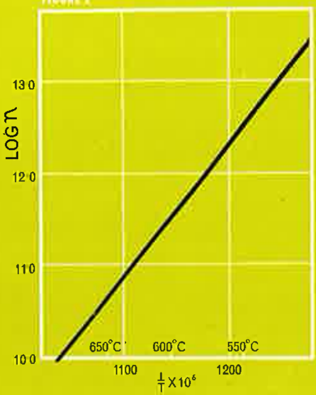


FIGURE 1

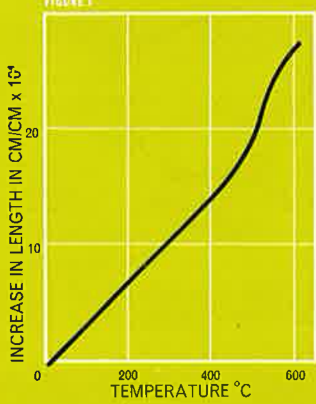
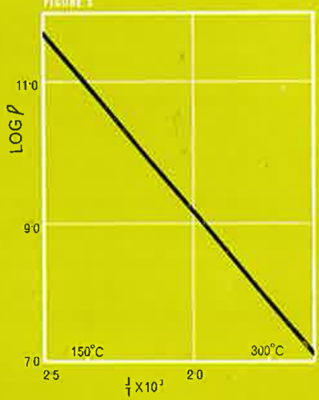


FIGURE 3



Description. Tungsten sealing borosilicate glass.

Applications. Special valves and lamps and other applications which have to withstand high operating temperatures.

Chemical Composition

SiO_2	75·3	Na_2O	4·0	B_2O_3	16·9
Al_2O_3	2·0	K_2O	1·8		

Physical Properties

Expansion coefficient	$37{\cdot}5 \times 10^{-7}$	(Fig. 1)
Viscosity $10^{14{\cdot}6}$ poises at	455	(Fig. 2)
„ 10^{13} „ „	525	
„ 10^{12} „ „	575	
„ $10^{7{\cdot}6}$ „ „	775	
„ 10^{5} „ „		
Log d.c. resistivity at 150	11·0	(Fig. 3)
„ „ „ „ 300	7·8	
Dielectric constant at 1 Mc/sec. ..	4·2	
Loss angle at 1 Mc/sec.	0·0013	
Specific Gravity	2·25	

Typical Annealing Schedule. A 5 mm thick block of C 9 glass could be annealed by holding at 560°C for 2 minutes, followed by cooling at 8°C per minute to, say, 455°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

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C 11 glass

Fig. 1. Typical Thermal Expansion Curve.
Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature.
Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature ($\frac{1}{T}$).

FIGURE 2

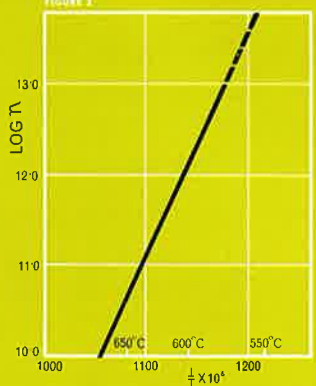


FIGURE 1

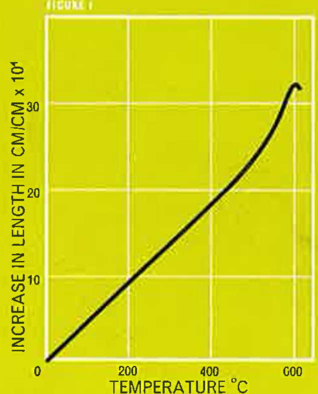
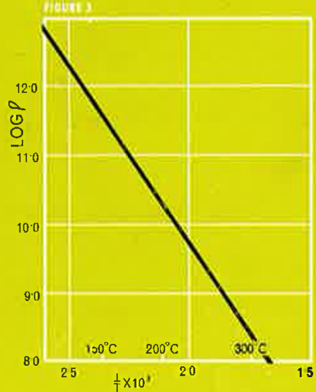


FIGURE 3



Description. Molybdenum sealing borosilicate glass.

Applications. Mainly for mercury arc rectifiers.

Chemical Composition

SiO_2	72·2	B_2O_3	15·0	Na_2O	3·5
Al_2O_3	3·0	CaO	3·0	K_2O	3·0

Physical Properties

Expansion coefficient	$45{\cdot}5 \times 10^{-7}$	(Fig. 1)
Viscosity $10^{14{\cdot}6}$ poises at	525	(Fig. 2)
„ 10^{13} „ „	575	
„ 10^{12} „ „	605	
„ $10^{7{\cdot}6}$ „ „	795	
„ 10^{5} „ „		
Log d.c. resistivity at 150	11·7	(Fig. 3)
„ „ „ „ 300	8·5	
Specific Gravity	2·32	

Typical Annealing Schedule. A 5 mm thick block of C 11 glass could be annealed by holding at 605°C for 3 minutes, followed by cooling at 6°C per minute to, say, 525°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

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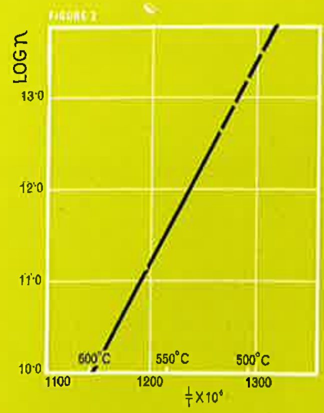
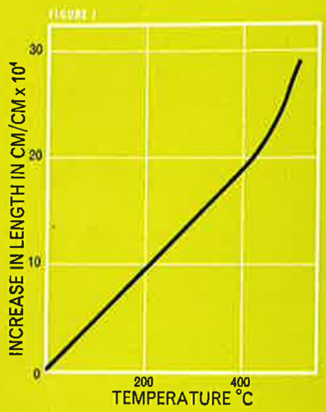
C 40 glass

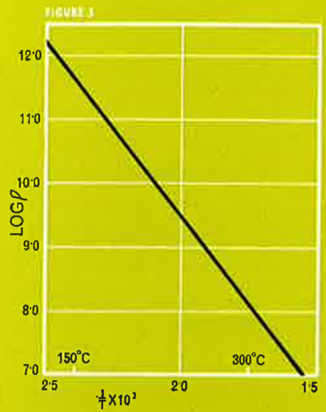
Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature.

Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature.







Description. Kovar sealing borosilicate glass.

Applications. Special valves.

Chemical Composition

SiO_2	65·5	Al_2O_3	2·2	K_2O	4·1
B_2O_3	24·1	Na_2O	4·1		

Physical Properties

Expansion coefficient	$48{\cdot}5 \times 10^{-7}$	(Fig. 1)
Viscosity $10^{14 \cdot 6}$ poises at	460	(Fig. 2)
,, 10^{13} ,, ,,	505	(Fig. 2)
,, 10^{12} ,, ,,	535	(Fig. 2)
,, $10^{7 \cdot 6}$,, ,,	710	(Fig. 2)
,, 10^{5} ,, ,,		(Fig. 2)
Log d.c. resistivity at 150	11·5	(Fig. 3)
,, ,, ,, ,, 300	8·1	(Fig. 3)
Dielectric constant at 1 Mc/sec.	4·5	
Loss angle at 1 Mc/sec.	0·0016	
Specific Gravity	2·25	

Typical Annealing Schedule. A 5 mm thick block of C 40 glass could be annealed by holding at 535°C for 3 minutes, followed by cooling at 5°C per minute to, say, 460°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

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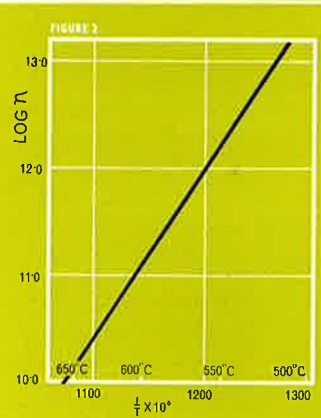
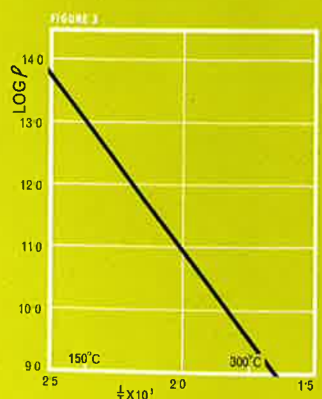
C 38 glass

Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature $(\frac{1}{T})$.

Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature $(\frac{1}{T})$.





Description. Borosilicate glass.

Applications. Electrical applications where low electrical losses are essential.

Chemical Composition

SiO_2	69·5	B_2O_3	27·5	K_2O	1·1
Al_2O_3	0·5	Na_2O	0·3	Li_2O	1·0

Physical Properties

Expansion coefficient	$31{\cdot}0 \times 10^{-7}$	(Fig. 1)
Viscosity $10^{14 \cdot 6}$ poises at	465	(Fig. 2)
,, 10^{13} ,, ,,	515	(Fig. 2)
,, 10^{12} ,, ,,	555	(Fig. 2)
,, $10^{7 \cdot 6}$,, ,,	740	(Fig. 2)
Log d.c. resistivity at 150	13·2	(Fig. 3)
,, ,, ,, ,, 300	9·7	(Fig. 3)
Dielectric constant at 3·2 cm	4·0	
Loss angle at 3·2 cm	0·0027	
Specific Gravity	2·13	

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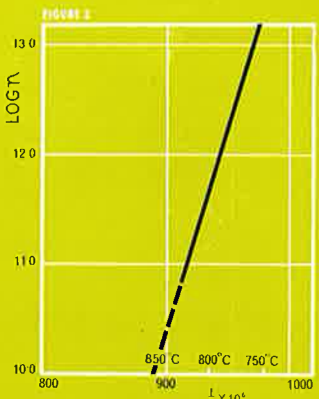
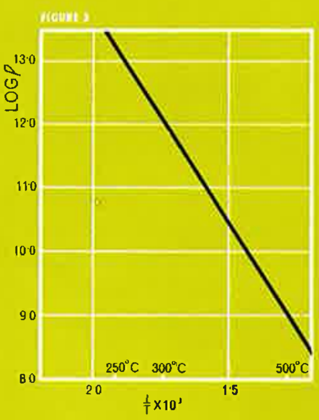
C 37 glass

Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Typical curve of Log. Viscosity (Log μ) and Temperature.

Fig. 3. Typical curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature $\left(\frac{1}{T}\right)$.





Description. Aluminosilicate glass.

Applications. Mainly for the inner jackets of mercury vapour discharge lamps.

Chemical Composition

SiO_2	55·8	B_2O_3	5·1	BaO	3·1
Al_2O_3	23·0	CaO	13·0		

Physical Properties

Expansion coefficient ..	.. 42·5 × 10^{-7}	(Fig. 1)
Viscosity $10^{14.6}$ poises at	 700	(Fig. 2)
,, 10^{13} ,, ,,	 760	
,, 10^{12} ,, ,,	 790	
,, $10^{7.6}$,, ,,		
,, 10^{5} ,, ,,		
Log d.c. resistivity at 150	.. .. 16·2	(Fig. 3)
,, ,, ,, ,, 300	.. .. 12·0	
Specific Gravity	.. .. 2·55	

Typical Annealing Schedule. A 5 mm thick block of C 37 glass could be annealed by holding at 790°C for 3 minutes, followed by cooling at 6°C per minute to, say, 700°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

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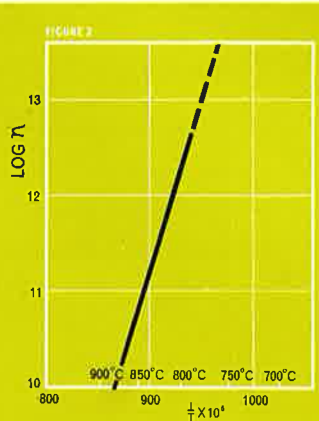
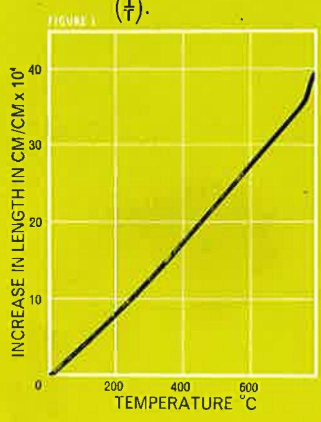
C 46 glass

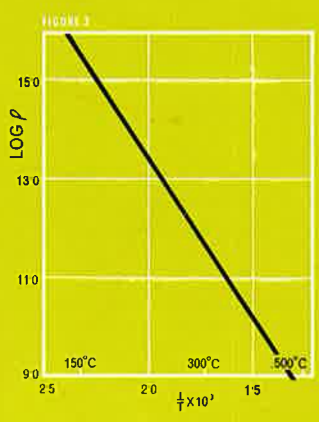
Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature $\left(\frac{1}{T}\right)$ (Broken lines by extrapolation).

Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature $\left(\frac{1}{T}\right)$.







Description. Aluminosilicate glass.

Applications. Mercury vapour lamps and chemical combustion tubing.

Chemical Composition

SiO_2	54·5	P_2O_5	3·8	BaO	6·3
Al_2O_3	23·5	CaO	11·3	MgO	0·5

Physical Properties

Expansion coefficient ..	.. 43·0 × 10^{-7}	(Fig. 1)
Viscosity $10^{14.6}$ poises at	 725	(Fig. 2)
,, 10^{13} ,, ,,	 775	
,, 10^{12} ,, ,,	 805	
,, $10^{7.6}$,, ,,		
,, 10^{5} ,, ,,		
Log d.c. resistivity at 150	.. .. 15·9	(Fig. 3)
,, ,, ,, ,, 300	.. .. 11·9	
Dielectric constant at 1 Mc/sec.	.. 5·9	
Loss angle at 1 Mc/sec.	.. .. 0·0019	
Specific Gravity ..	.. .. 2·62	

Typical Annealing Schedule. A 5 mm thick block of C 46 glass could be annealed by holding at 805°C for 3 minutes, followed by cooling at 6°C per minute to, say, 725°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

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C 57BK glass

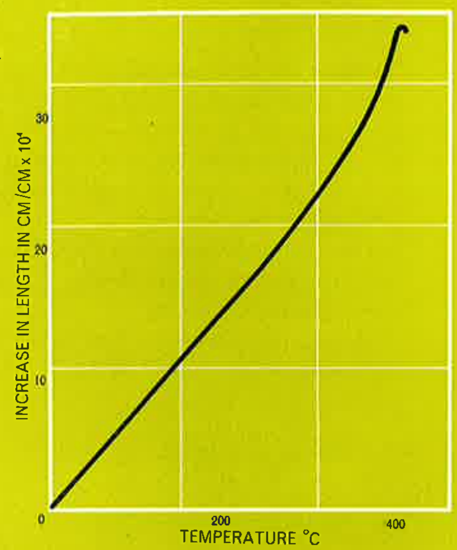

Fig. 1. Typical Thermal Expansion Curve.

Description. Zinc-vanadium-borate.

Applications. Solder seals to C 40 glass or Kovar type alloys.

Chemical Composition

B_2O_3	28·5	ZnO	57·0
Al_2O_3	5·0	V_2O_5	9·5

Physical Properties

Expansion coefficient ..	.. $49{\cdot}0 \times 10^{-7}$	(Fig. 1)
Viscosity $10^{14\cdot6}$ poises at ..	.. 480	
,, 10^{13} ,, ,, ..	.. 500	
,, 10^{12} ,, ,, ..	.. 515	
Log d.c. resistivity at 150 ..	.. 13·8	
,, ,, ,, ,, 300 ..	.. 10·2	

Note. This glass is supplied in powder form for making seals between glasses of expansion coefficient approximately 50×10^{-7} and/or metals or alloys of similar expansion coefficient. It enables seals to be made at a temperature of approximately 610°C without the necessity for fusion.

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C 93 glass

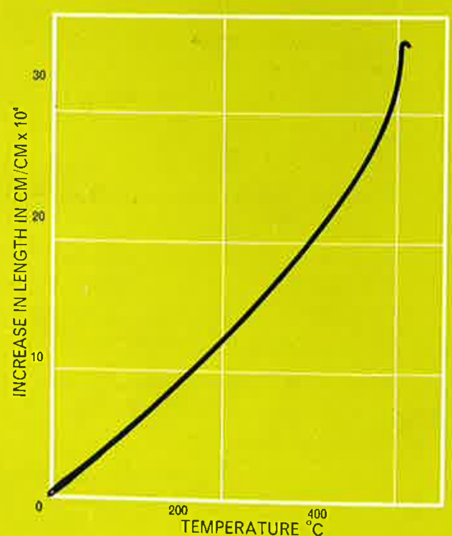

Fig. 1. Typical Thermal Expansion Curve.

Description. Modified lead-zinc-borate.

Applications. Solder seals between C 19, C 12 etc.

Chemical Composition

B_2O_3	17·0	ZnO	14·0
PbO	64·0	SiO_2	5·0

Physical Properties

Expansion coefficient (50-200°C) ..	76×10^{-7}
Viscosity $10^{14\cdot6}$ poises at	
,, 10^{13} ,, ,,	
,, 10^{12} ,, ,,	
,, $10^{7\cdot6}$,, ,,	
,, 10^{5} ,, ,,	
Log d.c. resistivity at 150 ..	.. 12·8
,, ,, ,, ,, 300 ..	.. 8·9

Note. This glass is supplied in powder form for making seals between glasses of expansion coefficient approximately 90×10^{-7} and/or metals or alloys of similar expansion coefficient. It enables seals to be made at a temperature of approx. 550°C without the necessity for fusion.

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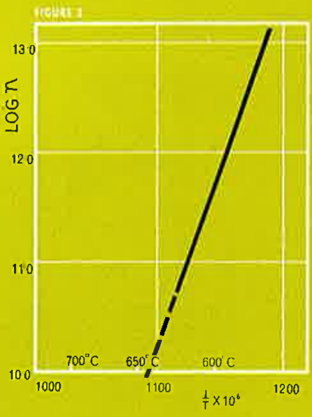
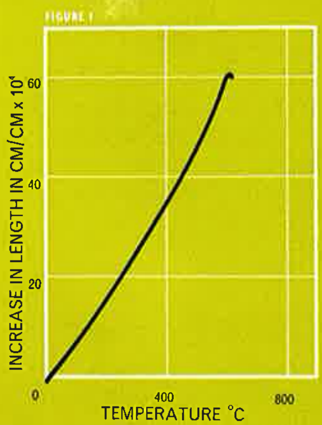
C 87 glass

Fig. 1. Typical Thermal Expansion Curve.

Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature $\left(\frac{1}{T}\right)$. (Broken line by extrapolation.)

Fig. 3. Typical Infra-red Transmission Curve.





Description. Soda-zinc-silicate glass.

Applications. Infra-red transmission.

Chemical Composition

SiO_2	45·8	BaO	2·0	TiO_2	1·2
Al_2O_3	7·2	ZnO	29·8	Na_2O	14·0

Physical Properties

Expansion coefficient . . . . $93{\cdot}0 \times 10^{-7}$ (Fig. 1)

Viscosity $10^{14.6}$ poises at . . . . 535 (Fig. 2)

" 10^{13} " " . . . . 575 (Fig. 2)

" 10^{12} " " . . . . 600 (Fig. 2)

Typical Annealing Schedule for C 87 Glass. A 5 mm thick block of C 87 glass could be annealed by holding at 595°C for 5 minutes, followed by cooling at 3°C per minute to, say, 535°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

Infra-red Transmission. Typical transmission curve for C 87 glass is shown in Fig. 3. Values taken from this curve are as follows.

Wavelength: 1 micron —, 2 microns 89, 3 microns 67·5
4 " 70, 5 " —.

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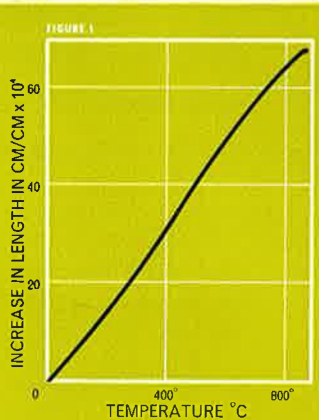
C 97 glass

Fig. 1. Typical Thermal Expansion Curve.



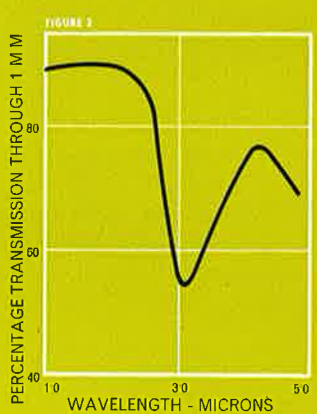


Fig. 2. Typical Infra-red Transmission Curve.

Description. Calcium aluminate glass.

Applications. Infra-red transmission.

Chemical Composition

SiO_2	6·8	CaO	48·9
Al_2O_3	39·3	MgO	5·0

Physical Properties

Expansion coefficient . . . . $84{\cdot}0 \times 10^{-7}$ (Fig. 1)

No measurements have been made of the viscosity but the top point of the expansion curve corresponding to a viscosity of approximately 10^{12} poises is 850°C.

Refractive Index . . . . . . 1·67005

Specific Gravity . . . . . . 2·94

Typical Annealing Schedule for C 97 Glass. A 5 mm thick block of C 97 glass could be annealed by holding at 865°C for 4 minutes, followed by cooling at 4°C per minute to, say, 740°C, below which temperature the glass could be cooled as rapidly as possible without causing fracture.

Infra-red Transmission. Typical transmission curve for C 97 glass is shown in Fig. 2. Values taken from this curve are as follows.

Wavelength	*C 97*	
1 micron 90,	2 microns 89,	3 microns 57,
	4 " 75,	5 " 65.

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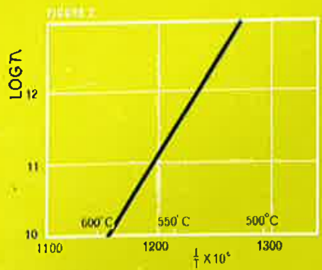
C 43 glass

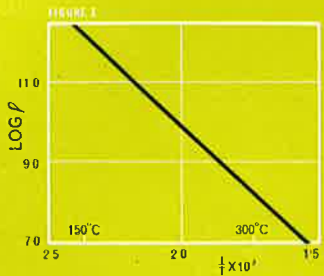
Fig. 1. Typical Thermal Expansion Curve.

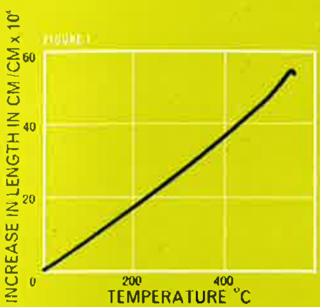
Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature ($\frac{1}{T}$).

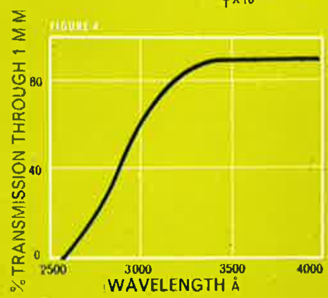
Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature ($\frac{1}{T}$).

Fig. 4. Curve of u.v. Transmission.









Description. Alkali-barium oxide-silicate glass.

Applications. Any devices requiring transmission at 3000Å, for example, certain photomultiplier cells.

Chemical Composition

SiO_2	65·0	BaO	18·0	Na_2O	5·7
B_2O_3	2·0	K_2O	9·3		

Physical Properties

Expansion coefficient	$95{\cdot}0 \times 10^{-7}$	(Fig. 1)
Viscosity $10^{14{\cdot}6}$ poises at	465	(Fig. 2)
,, 10^{13} ,, ,,	510	(Fig. 2)
,, 10^{12} ,, ,,	540	(Fig. 2)
Log d.c. resistivity at 150	12·3	(Fig. 3)
,, ,, ,, ,, 300	8·2	(Fig. 3)
Specific Gravity	2·71	

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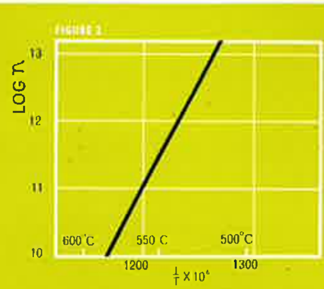
C85 glass

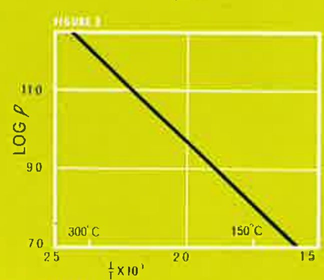
Fig. 1. Typical Thermal Expansion Curve.

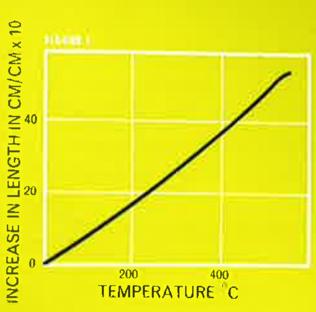
Fig. 2. Curve of Log. Viscosity (Log η) and Reciprocal Absolute Temperature ($\frac{1}{T}$).

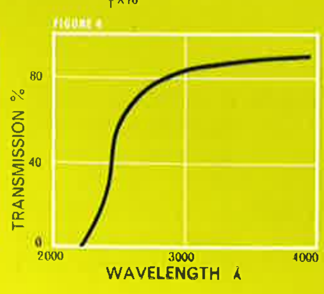
Fig. 3. Curve of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature ($\frac{1}{T}$).

Fig. 4. Typical Transmission Curve through a 2 mm thickness of C 85 glass.









Description. Alkali-barium oxide-silicate glass.

Applications. Germicidal uses.

Chemical Composition

SiO_2	65·0	BaO	18·0	Na_2O	5·7
B_2O_3	2·0	K_2O	9·3		

Physical Properties

Expansion coefficient	$99{\cdot}0 \times 10^{-7}$	(Fig. 1)
Viscosity $10^{14{\cdot}6}$ poises at	470	(Fig. 2)
,, 10^{13} ,, ,,	510	(Fig. 2)
,, 10^{12} ,, ,,	535	(Fig. 2)
,, $10^{7{\cdot}6}$,, ,,		(Fig. 2)
,, 10^{5} ,, ,,		(Fig. 2)
Log d.c. resistivity at 150	12·3	(Fig. 3)
,, ,, ,, ,, 300	8·2	(Fig. 3)
Specific Gravity	2·71	

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Graded Seal Borosilicate Glasses

C 39 C 77 C 78 C 79 C 80

Fig. 1. Typical Thermal Expansion Curves of some graded seal glasses.
Fig. 2. Curves of Log. Viscosity (Log η) and Reciprocal Absolute Temperature $\left(\frac{1}{T}\right)$ for some graded seal glasses.
Fig. 3. Curves of Log. Resistivity (Log ρ) and Reciprocal Absolute Temperature for some graded seal glasses.

FIGURE 2

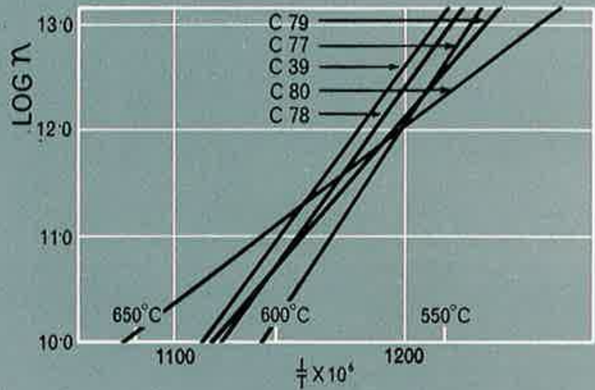


FIGURE 1

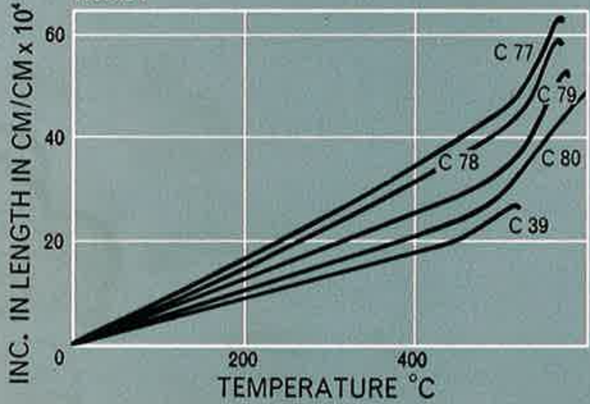
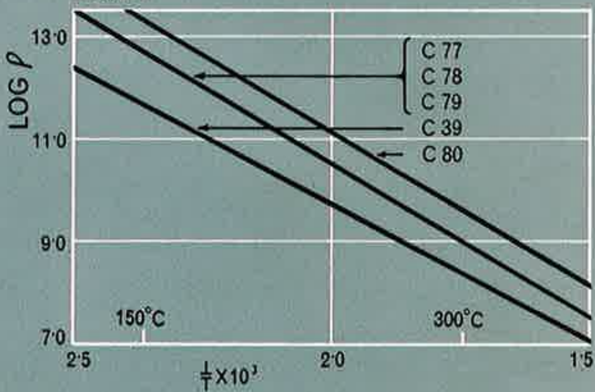


FIGURE 3



	C 39	C 77	C 78	C 79	C 80
Chemical Properties	SiO_2 70·0, Na_2O 3·5, Al_2O_3 1·4, K_2O 3·2, B_2O_3 21·7, CaO 0·2	SiO_2 55·0, CaF_2 3·2, B_2O_3 9·6, Na_2O 3·8, BaO 12·4, K_2O 8·8, ZnO 7·2	SiO_2 57·3, CaF_2 2·7, B_2O_3 13·0, Na_2O 3·2, BaO 10·4, K_2O 7·4, ZnO 6·0	SiO_2 59·6, CaF_2 2·2, B_2O_3 16·4, Na_2O 2·6, BaO 8·4, K_2O 6·0, ZnO 4·8	SiO_2 61·9, CaF_2 1·7, B_2O_3 19·8, Na_2O 2·0, BaO 6·4, K_2O 4·6, ZnO 3·6
Used for making seals between these glasses or materials of similar expansion coefficients.	C 9—C 40 C 9—C 80	C 19—C 78	C 77—C 79	C 78—C 80	C 79—C 39
Expansion Coefficient	$42·5 \times 10^{-7}$	$85·0 \times 10^{-7}$	$77·0 \times 10^{-7}$	$65·0 \times 10^{-7}$	$50·0 \times 10^{-7}$
Viscosity $10^{14·6}$ Poises at	510	490	510	490	460
10^{13} " "	550	540	550	535	520
10^{12} " "	575	560	570	565	560
$10^{7·6}$ " "					
10^{5} " "					
Log d.c. Resistivity at 150	11·7	12·9	12·7	12·7	13·3
at 300	8·1	9·1	9·0	9·0	9·6
Specific Gravity	2·24	2·73	2·68	2·58	2·45

COLOURED GLASSES

C 6W A white opal glass, used for decorative lamps, of expansion coefficient approximately 92×10^{-7} and upper annealing temperature 550°C.

C 19B A range of blue soda-lime silicate glasses.

C 19G A range of green soda-lime silicate lamp glasses.

C 19Y A cadmium yellow silicate glass of expansion coefficient approximately 103×10^{-7} and upper annealing temperature 510°C.

C 23R A straight blown ruby glass, used for filters, of expansion coefficient 106×10^{-7} and upper annealing point 530°C.

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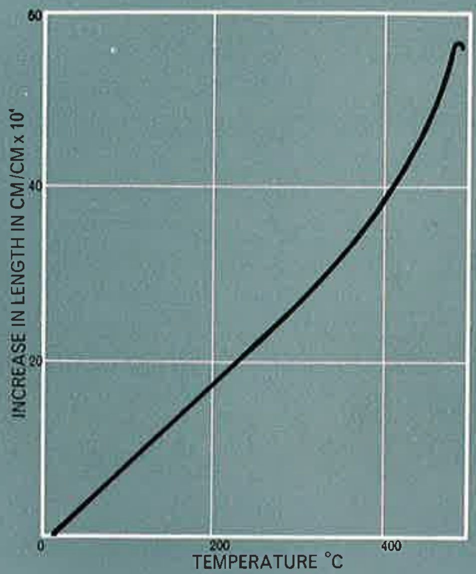
Special Glasses

Fig. 1. Thermal Expansion Curve of C 44 BK glass.



No. 44BK GLASS

Description
Black silicate glass.

Applications
Glass-metal seals of the Fusite type.

Chemical Composition

SiO_2	56·0	B_2O_3	7·5	K_2O	8·5	CaO	4·5
Al_2O_3	8·0	Na_2O	8·5	Li_2O	1·0	F_2	2·0
		MnO_2	7·0				
		CoO	0·6				

Physical Properties
Expansion coefficient . . . . 101×10^{-7} (Fig. 1)

No measurements have been made of viscosity in the annealing range but the top point on the expansion curve corresponding to a viscosity of approximately 10^{12} poises is 490°C.

Viscosity $10^{7 \cdot 6}$ poises at 625
Log d.c. resistivity at 150 . . . . 11·0
„ „ „ „ 300 . . . . 7·5
Dielectric constant at 1 Mc/sec.
Loss angle at 1 Mc/sec.
Specific Gravity . . . . . . 2·56

No. 20BV GLASS

Description
A dark ultra-violet transmitting glass.

Applications
In conjunction with fluorescent marking ink.

Chemical Composition

SiO_2	64·8	CaO	5·1	Na_2O	12·6	NiO	7·0
Al_2O_3	0·7	B_2O_3	5·6	K_2O	3·2	CoO	0·9

Physical Properties
Expansion coefficient . . . . . . $92{\cdot}0 \times 10^{-7}$

No measurements have been made of the viscosity but the top point on the expansion curve corresponding to a viscosity of 10^{12} poises is 570°C.

The transmission at 3650Å is greater than 40% and at 3200Å is less than 4%.

Annealing Pt. 10^{13} Poises 545 °C.

No. 23A GLASS

Description
Alkali-zinc-silicate.

Applications
'Fireglow amber' type lamps.

Chemical Composition

SiO_2	64·2	ZnO	11·9	K_2O	7·7	CdSe	2·5
Al_2O_3	0·3	Na_2O	10·0	CdS	3·1	S	0·4

Physical Properties
Expansion coefficient . . . . . . 104×10^{-7}
Specific Gravity . . . . . . 2·62

No measurements of viscosity have been made but the top point on the expansion curve corresponding to a viscosity of 10^{12} poises is 530°C.

No. 86 GLASS

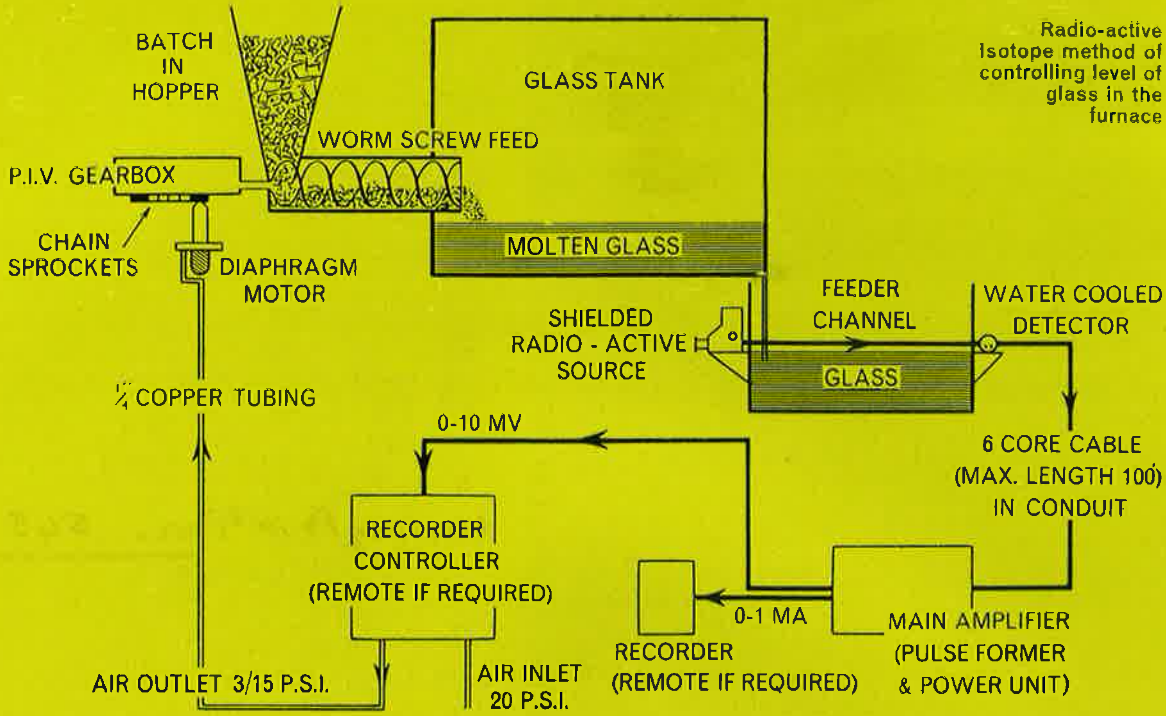
Description
Phosphate glass.

Applications
Fluoride resistant.

Chemical Composition

P_2O_5	72·0	ZnO	7·5
Al_2O_3	18·0	CdO	2·5

Physical Properties
Expansion coefficient . . . . $60{\cdot}0 \times 10^{-7}$
Viscosity $10^{14 \cdot 6}$ poises at . . . .
„ 10^{13} „ „ . . . .
„ 10^{12} „ „ . . . . } 555
„ $10^{7 \cdot 6}$ „ „ . . . .
„ 10^{5} „ „ . . . .
Log d.c. resistivity at 150 . . . .
„ „ „ „ 300 . . . . } 10·3
Dielectric constant at 1 Mc/sec.
Loss angle at 1 Mc/sec.
Specific Gravity . . . . . . 2·7



Radio-active Isotope method of controlling level of glass in the furnace

Examples of technical development

The higher melting temperatures which have become a practice since the war, have produced refractory problems. Because the molten glass attacks the tank lining, more and more expensive refractory materials are being used; but by itself, the use of high-quality refractories in contact with the glass is not sufficient to solve the problem. While the tank lining may now be serviceable for 4-5 years instead of perhaps one year, the failure of the refractories in auxiliary parts of the furnace means that it must be taken out of production while the lining is still serviceable, at the cost of losing a month's output, or possibly more.

Chesterfield's technologists, therefore, are studying the properties of refractories in a laboratory which was opened shortly before this catalogue was compiled. Until recently, the performance of a refractory sample could be determined only in a furnace used for production ; but facilities are now available in the laboratory for this type of work.

Tests of the properties of a refractory and its performance when subjected simultaneously to heat and pressure are also carried out in the laboratory, and comparisons are being made of the results of these tests with similar ones conducted under production conditions.

Parallel with its effort to increase output, the factory has had to satisfy its customers' demand for increasingly close tolerances. The up-draw tube machine (which works in conjunction with the electric furnace already mentioned) is an example of the effort Chesterfield is making to supply this need. Close tolerances, however, are only one aspect of the improvement of quality. In the chemistry laboratory is a flame photometer used for controlling the content of alkali in the glass. With this apparatus variations of alkali content of more than one-half of one per cent of the alkali can be quickly detected and corrected.

Chesterfield is also proud of the distinction of being the first glassworks in the country to control automatically the level of glass in the furnace by means of a radio-isotope. In the melting of soda glass for tubing, a small variation in the level of the molten glass in the tank is sufficient to impair its quality. By means of a combination of an electronic device with radiation from an isotope, Chesterfield has succeeded in controlling this level to within a few thousandths of an inch.

Radiation from a pellet of Cobalt 60 penetrates the wall of the tank and is registered by a detector device on the opposite side of the feeder channel. As the glass level rises, the radiation is reduced, and, conversely, it increases as the level falls. By transforming these signals into terms of electrical energy and then changes in air pressure, it is possible to control automatically the supply of raw material to the tank.

In the manufacture of small bulbs, a reduction in the length of the gas flame may mean that the glass is not sufficiently soft for satisfactory working. These variations in length of the gas flame (caused by changes in the gravity of the gas) are now being automatically corrected by an instrument which detects the change and introduces more air into the gas supply. These are a few examples of methods designed to improve the consistency of the glass.

Further advice or
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