THE CHOICE OF GLASS BATCHES CONTAINING LIME¹

BY W. E. S. TURNER

Through the kindness of Dr. Tillotson, the writer has just received a copy of the very interesting and useful report by Dr. Fettke entitled "Glass Manufacture and the Glass Sand Industry of Pennsylvania." In it there is a reference which has suggested this communication in regard to the choice of glass batches, the chief constituents of which are silica (sand), lime and alkali.

On pages 90-95 are quoted a number of batches for various purposes, including table ware, plate glass, lime, flint, and bottle glasses. For the production of the last-named type, the following are quoted:

	American (3)	American (4)	American (4)	American (4)	American (4)
Sand.....	100	100	100	100	100
Limestone.....	30	36	32	34	36
Soda ash.....	27 ¹ / ₂	38	35	...	...
Salt cake.....	...	...	...	38	42
Salt.....	3 ¹ / ₈	...	...	...	...
Carbon.....	...	...	...	5	8

It is not easy, unless one is fairly closely in touch with the industry, to know what batches are in common use, and the author of this excellent report was obliged to have recourse for them to early publications as far back as 1883² and 1899.³

The writer is of the opinion, however, that bottle batches of the type quoted have almost, if not entirely, disappeared from American factories, certainly from those employing automatic or semi-automatic machines. The batches with high lime content are still to be found in use in Europe, since they are eminently

¹ Received Feb. 27, 1920.

² Report on the manufacture of glass, by Jos. D. Weeks, 1883, Census Report.

³ Glass, Robert Linton, "The Mineral Industry for 1889," Vol. 9, pp. 234-263.

suitable for hand-working and are used also in certain types of semi-automatic machines (such as the Horne, the Simpson and the Johnny Bull), which are less highly productive than the modern types. The introduction of machines like the Owens, the Hartford-Fairmont, O'Neill, Millar, Lynch and other types, whether hand fed (in the last three cases), or automatically fed, has not only revolutionized production but has changed markedly the composition of the batch, leading to the introduction of a type similar to that described by Fettke under the term "lime-flint," namely, one similar to the following:

	American (3)
Sand.....	100
Lime.....	10
Soda ash.....	$33\frac{1}{3}$
Chili saltpeter.....	$13\frac{1}{3}$

The choice of a glass batch, and in particular of the lime-soda batches, is affected very largely by the mode of working the glass. A glass with a high lime content sets quickly and is, for this reason, suitable for hand-working as the blower does not have to wait unnecessarily after gathering and marvering the metal. Glasses even with higher lime content than numbers 12 and 13 (p. 382) have been used for hand-blowing. Where, however, the glass comes into contact with a mass of iron work which would chill it fairly rapidly, as in machines where the bottle passes through several stations on each of two tables, or on two tiers around a central body, the use of a high lime glass would be either impossible or be attended with difficulty. Moreover, if the machine be fed by an automatic flowing or feed-device, the orifice of the flow would probably tend to become choked as the result of devitrification, a phenomenon which the moderately high lime glasses often exhibit.

For the sake of the mechanical devices, therefore, bottle batches are now much softer, a condition obtained by reducing the lime content very considerably and raising, correspondingly, the alkali content. There are quite a number of advantages. In the first place the high soda, low lime glass melts much more readily than the older batches for hand operation, and production of glass can be speeded up in consequence. Next the glass is softer, and the

bottle can be readily blown up or pressed to its normal shape, whereas when a high lime batch has been used, trouble has frequently been found, especially with narrow-mouth ware, in that the neck near the mouth has not been fully blown up owing to setting too quickly; several bottles and jars can be collected before conveying them to the lehr, whereas the high lime glass must be transferred to the annealing oven much more quickly. For the same reason, the high lime glass could not be so successfully transferred to the lehr by an automatic conveyor because of its rapid setting. Fourthly, the "limeflint" glass requires a distinctly lower annealing temperature than the high lime glass¹ and can therefore be annealed more quickly. A high lime glass has the virtue of smaller expansion for heat than the lime flint glass, but on the other hand has a higher conductivity for heat which causes it to cool rapidly, so that if its temperature falls distinctly below the required annealing temperatures before it is placed in the lehr, strains may be set up which result in cracking. The disadvantage attending the higher coefficient of expansion of the high soda glass is readily avoided by preventing entrance of draught in the lehr.

This account does not quite complete the comparison of the relative merits of the high lime and the lime flint glasses, but it will at any rate serve to indicate the reason why the latter have come into general employment in the bottle industry.

But while the lime flint glass has so many advantages for machine use, it must be borne in mind that the resistance which glass shows toward the atmosphere and to liquids it contains is reduced stage by stage as the amount of alkali is increased. Lime in a well-annealed glass makes very strongly for durability.

The question therefore arises as to how far the softening process can, with safety, proceed, and this question is of importance, not only for bottle glass, but for all other types of lime-soda glass. In order to answer this question, a series of glasses, numbers 1 to 13 (p. 382), were prepared on a semi-commercial scale in the writer's department and were subjected to treatment by boiling water and boiling solutions of strong caustic alkali, sodium carbonate

¹ See English, S. and Turner, W. E. S., *J. Soc. Glass Tech. Trans.*, 3, 125 (1919).

and hydrochloric acid, for six hours with water and hydrochloric acid, three hours with caustic soda (2N.-NaOH) and sodium carbonate (2N.-Na₂CO₃).

The batch composition of the glass as shown in table 1, numbers 12 and 13, as already stated, being typical bottle batches for hand-working.

TABLE 1

No. of glass	1	2	3	4	5	6	7	8	9	10	11	12	13
Sand	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Soda ash	590	560	530	501	471	441	412	383	353	324	295	365	285
Limespar	.....	28	55	83	111	139	166	194	222	250	278	500	450
Arsenic	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	7

Since ordinary commercial materials were employed in the preparation it is desirable to state the actual compositions of the finished glasses. These are shown in table 2.

TABLE 2—COMPOSITION OF THE LIME-SODA SERIES OF GLASSES

Glass	SiO ₂	Na ₂ O	CaO	MgO	Al ₂ O ₃	Fe ₂ O ₃	As ₂ O ₃	Total
1.....	74.05	25.34	0.21	Trace	0.24	0.14	..	99.98
2.....	73.92	23.80	1.50	Trace	.20	.14	..	99.56
3.....	74.08	23.00	2.61	Trace	.21	.15	..	100.05
4.....	74.07	21.50	3.81	Trace	.28	.15	..	99.80
5.....	73.78	20.78	4.50	0.15	.38	.19	..	99.78
6.....	73.18	19.38	6.26	.21	.58	.61	..	100.22
7.....	74.41	17.20	7.45	.24	.30	.40	..	100.00
8.....	74.99	16.00	8.16	.26	.31	.09	..	99.81
9.....	74.96	14.88	9.36	.28	.42	.16	..	100.08
10.....	74.59	14.22	10.38	.30	.45	.21	..	100.15
11.....	74.93	13.02	11.68	.31	.38	.17	..	100.49
12.....	66.71	12.72	18.17	.85	1.41	.31	0.30	100.47
13.....	69.73	11.22	17.38	.55	0.50	.25	.47	100.10

The results of the tests are recorded in table 3, in which the effect of the several reagents is measured by the loss in weight suffered by each 100 square centimeters of the surface.

It will be noted that water is the most corrosive liquid when either no lime or very little lime is present, while strange as it may seem, the strong caustic alkali has least effect.

It will be noted, further, that as the amount of lime is increased, the corrosive action very rapidly falls off. At glass 6, we reach the border line of what may, for ordinary commercial purposes,

TABLE 3—SUMMARY OF RESULTS
(Expressed in mg. per 100 sq. cm.)

Glass	Boiling water Loss in wt.	2N.NaOH Loss in wt.	2N.Na ₂ CO ₃ Loss in wt.	20.24% HCl Loss in wt.
1.....	24000.0	65.2	4618.5	158.4
2.....	335.4	61.1	234.0	71.4
3.....	157.9	60.6	83.8	18.0
4.....	20.9	58.8	45.5	10.2
5.....	10.5	56.0	35.5	6.2
6.....	2.5	53.6	32.3	4.6
7.....	1.9	51.2	30.3	3.5
8.....	1.4	49.4	27.8	2.5
9.....	0.62	46.9	26.7	1.5
10.....	.57	44.6	26.0	1.0
11.....	.53	42.1	25.1	0.85
12.....	.70	46.3	32.7	1.7
13.....	.60	49.8	25.0	1.1

be used with safety. Glass 6 is not quite satisfactory, however. When powdered finely it was found to attract moisture slowly but quite appreciably so that even in article form the same trouble will eventually be discovered.

For general machine use, as well as for hand lime flint operations, glasses 7 to 9 are most satisfactory, 7 containing the lowest limit of lime which is consistent with safety in the above batches. Glasses of this type are commonly in use for Owens machines and for semi-automatic machine with or without automatic feeding devices. On various occasions, however, the writer has found glasses in use made from batches below the lime content of glass 7. Such batches should be avoided.

THE DEPARTMENT OF GLASS TECHNOLOGY
UNIVERSITY, SHEFFIELD, ENGLAND

NOTICE.—Further discussion of this general subject is solicited. All communications should be sent to the Editor.