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(54) Multi-stage method for filling containers with carbonated liquids.

(57) In a method for filling containers with carbonated liquids the container is filled in several stages. In the last stage, filling is completed under isobaric conditions with a liquid carbonated to a pressure sufficient to obtain the desired final carbonation level of the liquid in the container, the preceding stages involving filling with liquid which is uncarbonated or only weakly carbonated.

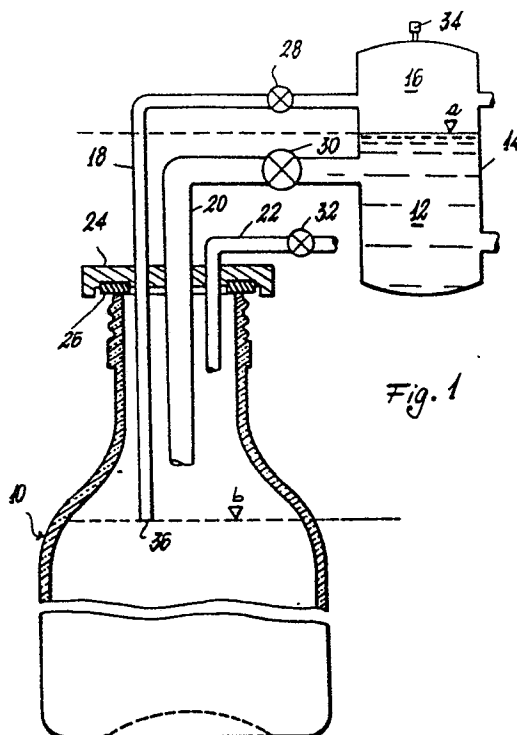


Fig. 1

MULTI-STAGE METHOD FOR FILLING CONTAINERS WITH CARBONATED LIQUIDS

This invention relates to a method for filling containers with carbonated liquids.

Carbonated liquids (mineral water, soft drinks, beer and the like) are currently bottled in containers such as glass bottles, plastic bottles, cans and the like, using continuous rotary machines or reciprocating linear machines, provided with a number of filling cocks directly proportional to the machine production capacity
 5 (number of containers filled per unit of time). Common to all machines is a filling process using the so-called isobaric method, which is described briefly hereinafter with reference to Figure 1 of the accompanying drawings.

Said figure shows a bottle 10 to be filled with a carbonated liquid 12 contained in a vessel 14.

The liquid 12 has been previously saturated with CO₂ and is maintained at a determined level a by an
 10 appropriate control device (not shown). That part of the inner volume of the vessel 14 above the level a of the liquid 12 is kept filled with CO₂ at a pressure p equal to the liquid saturation pressure at the vessel temperature. There is thus a CO₂-saturated liquid phase (12) in equilibrium with the overlying gaseous phase.

To fill the bottle 10, the bottle interior is put into communication with the vessel 14 via two pipes, a first
 15 18 of which opens into the upper part of the vessel above the level a of the liquid 12, whereas the second pipe or filling pipe 20 opens into the vessel 14 below said level a.

A third pipe 22 connects the bottle interior to atmosphere. An appropriate closure device 24 provided with a seal gasket 26 seals the mouth of the bottle 10 during filling, while allowing passage of the three said
 20 pipes. In each of said pipes (18, 20 and 22) a shut-off valve (28, 30 and 32 respectively) is provided to close the relative pipe.

In reality the assembly of pipes 18, 20, 22 and respective valves 28, 30, 32 is provided within a single member, namely the filling cock, which must necessarily be of small dimensions, particularly in the case of bottles which have a rather narrow neck.

To fill the bottle 10, the mouth of this latter is pressed to form a seal against the gasket 26 of the
 25 closure device 24. The valve 32 in the pipe 22 is kept closed. The valve 28 is then opened so that the CO₂ contained in the vessel 14 flows into the container until it is pressurized to the pressure p.

While keeping the valve 28 open, the valve 30 is opened so that the liquid 12 contained in the vessel 14 begins to fall by gravity into the bottle 10, while the corresponding volume of gas (air already present in the bottle + CO₂ introduced) flows through the pipe 18 into the upper part 16 of the vessel 14. The air,
 30 being lighter than the CO₂, collects in the top part of the vessel 14 and is bled off to atmosphere at regular intervals through the valve 34. In this manner the bottle 10 continues to fill until the filling level b is reached, corresponding to the lower mouth 36 of the pipe 18. On reaching this level the liquid can do nothing other than rise in the pipe 18 until it reaches the hydrostatic level a at which it stops, the system comprising the vessel 14 and bottle 10 then being in equilibrium. The valves 28 and 30 are closed and the valve 32 then
 35 opened to discharge to atmosphere the pressure in that space of the bottle 10 which has not been filled with liquid. The residual liquid contained in the pipe 18 then falls into the bottle 10, but its quantity is so small as to not significantly change the filling level b. This quantity can in any case be taken into account. The filling is now complete and the bottle 10 can be removed from the filling cock and conveyed to the subsequent closing operation.

40 It has already been stated that the filling cock must be of small dimensions especially in the case of bottles. The cross-sections of the pipes 18, 20 and 22, and in particular that of the pipe 20, are therefore necessarily small, and in fact the more so the smaller the diameter of the bottle mouth.

On the other hand the cross-section of the pipe 20 determines the speed with which the bottle 10 can be filled. It is apparent that the higher the filling speed the smaller the number of filling cocks required to
 45 obtain a given filling machine production capacity.

The object of the present invention is to provide a method for filling containers with carbonated liquids in which the overall filling time is significantly less than the filling time provided by the aforesaid known filling method.

To increase the filling rate the inventor of the present invention conceived the idea of effecting a pre-
 50 filling of the containers with a determined volume of uncarbonated liquid, and then completing the container filling with liquid carbonated to a greater level than the final desired value. The purpose of this was to reduce the filling time by virtue of the fact that during the first stage (partial filling with uncarbonated liquid), the container is filled with a filling cock comprising only the filling pipe, this latter therefore having a cross-section considerably greater than that of the pipe 20 and in the limit having a size close to the size of the container mouth. For example, if the final product in the container is to be carbonated water containing 5 g/l

of CO₂, then by pre-filling one half of the container with uncarbonated water (0 g/l of CO₂) followed by completion of filling of the other half of the container with carbonated water containing 10 g/l of CO₂ a significant saving in the overall filling time of the container should be achieved.

It was however surprisingly found that the expected results based on the obvious proportionality law are not achieved in reality, in the sense that using the aforesaid two-stage filling method the final CO₂ content is significantly and surprisingly higher than that which would be expected on the basis of pure proportionality. Thus, again considering the preceding example, on pre-filling one half of the container with water containing 0 g/l of CO₂ followed by isobaric completion of the filling of the remaining half of the volume with water containing 10 g/l of CO₂, the final result is not water carbonated with 5 g/l of CO₂, but instead water carbonated to a significantly greater level (as much as 25-30%). This surprising result can only be attributed to unexpected mechanisms involved in the transfer of CO₂ to the pre-filling liquid during the effecting of the subsequent isobaric stage. In other words, it has been found that when a container partly filled with an uncarbonated liquid is then filled to the required level by adding carbonated liquid under isobaric filling conditions in which the liquid has a proportionally increased level of carbonation, the final carbonation level of the mixture is greater than that which would have been expected by a proportionality calculation on the basis of the pre-fill volume. Some examples are given hereinafter to better illustrate this point.

EXAMPLE 1

Seven identical plastics containers with an effective volume of 1520 ml at the required filling level were used.

A different quantity of water without CO₂ addition was poured into each container (pre-fill). The filling of the containers was then completed by isobaric filling using the same water as before, but carbonated to a level of 4.25 vol/vol. The temperature of both the water fillings was 10.5 °C.

When filling was complete, the containers were left at rest for about 2 hours after which the carbonation level of each container was measured by one of the standard methods well known to the expert of the art.

The experimental results compared with the "expected" results (ie those calculated on the basis of simple proportionality) are shown in Table 1, in which D is the vol/vol difference between the "expected" carbonation level and the measured carbonation level, and S is the percentage difference between the measured and expected values.

TABLE 1

35	Container No.	PRE-FILL (uncarbonated water)		FINAL VOLUME (ml)	FINAL CARBONATION LEVEL (vol/vol) "Expected" Measured		D	S
		ml % of final volume						
40	(a)	(b)	(c)	(d)	(e)	(f)	(g)*	(h)*
	1	0	0	1520	4.25	4.25	-	-
45	2	304	20	1520	3.40	3.70	0.30	9
	3	700	46	1520	2.29	2.80	0.51	22
	4	760	50	1520	2.12	2.65	0.53	25
	5	800	52	1520	2.04	2.55	0.51	25
	6	850	56	1520	1.87	2.45	0.58	31
	7	1216	80	1520	0.85	1.65	0.8	94

$$* (g) = (f)-(e); (h) = 100 \times (g)/(e)$$

In the graph of Figure 2 the horizontal axis represents the percentage V of pre-filling of the container with uncarbonated liquid and the vertical axis represents the final CO₂ content C in vol/vol.

By showing on the graph the "expected" carbonation levels and those effectively found, it can be seen that the measured values, indicated by small circles, practically lie on a straight line (shown as a continuous line) located always above the straight line corresponding to the "expected" results (shown as a dashed and dotted line) but having a different slope from this latter. The percentage difference between the

measured values and the expected values therefore increases as the volume occupied by the pre-fill with uncarbonated water increases.

EXAMPLE 2

Repeating the procedure of Example 1, five containers with a capacity (to the required filling level) of 14 ml were used.

The results obtained are given in Table 2.

TABLE 2

Container No.	PRE-FILL (uncarbonated water)		FINAL VOLUME (ml)	FINAL CARBONATION LEVEL (vol/vol) "Expected" Measured		D	S
	ml % of final volume						
(a)	(b)	(c)	(d)	(e)	(f)	(g)*	(h)*
1	0	0	514	4.20	4.20	-	-
2	236	46	514	2.27	2.90	0.63	29
3	257	50	514	2.10	2.75	0.65	31
4	267	52	514	2.02	2.60	0.58	29
5	288	56	514	1.85	2.55	0.70	38

* (g) = (f)-(e); (h) = 100x(g)/(e)

The graph of Figure 3 was obtained as in Example 1. The conclusions and comments of Example 1 are also valid in this case.

EXAMPLE 3

Two series (identified by the apices ' and " respectively) each of three containers were prepared for a double test. Two containers of each series were partially filled with uncarbonated water at a temperature of 8 °C. The three containers were then filled to the required level, using an isobaric cock, with water carbonated to 4.6 vol/vol of CO₂ and having a temperature of 17 °C. The results are shown in Table 3.

TABLE 3

Container No.	PRE-FILL (uncarbonated water)		FINAL VOLUME (ml)	FINAL TEMP ° C	FINAL CARBONATION LEVEL (vol/vol) "Expected" Measured		D	S
	ml % of final volume							
1'	0	0	1520	17	4.6	4.6	-	-
2'	760	50	1520	12	2.3	2.8	0.6	26
3'	760	50	1520	12	2.3	2.8	0.6	26
1"	0	0	1520	17	4.6	4.6	-	-
2"	760	50	1520	12	2.3	2.8	0.6	26
3"	760	50	1520	12	2.3	2.8	0.6	26

EXAMPLE 4

The filling machine of a line for bottling mineral water carbonated to 2.5 vol/vol into plastic bottles of a rated volume of 1.5 litres was fed not with empty bottles but with bottles already 50%-filled with the same water but free of CO₂. The temperature both of the carbonated water and of the uncarbonated water was 13 °C. After completion of filling, the bottles which had been 50% pre-filled with uncarbonated water were found to have a carbonation level (the average of several measurements) of 1.65 vol/vol, ie 32% higher than the "expected" carbonation level based on simple proportionality criteria (1.25 vol/vol).

EXAMPLE 5

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The filling machine of a bottling line for carbonated drinks, intended for bottling a drink carbonated to 4.1 vol/vol into plastic containers of rated volume 1.5 litres, was fed with bottles pre-filled to 760 mm, ie 50%, with the same drink but free of dissolved CO₂.

The temperature both of the carbonated drink and of the uncarbonated drink was 12 °C.

15

After completion of filling, the bottles which had been 50% filled with uncarbonated drink were found to have a measured carbonation level of 2.6 vol/vol, ie 27% higher than the "expected" carbonation level based on simple proportionality criteria (2.05 vol/vol).

EXAMPLE 6

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A citrus drink containing about 85% of water by volume was obtained in the following manner using the containers of Example 5:

- 1) - The bottles were pre-filled to 50% of their final volume with a drink in which all the ingredients were of double the required final concentration but without CO₂ addition. The solution temperature was 13 °C.
- 2) - Using an isobaric system the filling of the containers was completed using only water carbonated to 5.30 vol/vol, at a temperature of 13 °C. The final drink obtained in this manner showed a carbonation level (the average of several measurements) of 3.5 vol/vol, ie 32% higher than the "expected" carbonation level based on simple proportionality criteria (2.65 vol/vol). The difference between the "expected" and measured carbonation levels, which is very significant and surprising in the above examples, is reduced although still apparent if the partial pre-filling is done not with liquid totally free of CO₂ but with liquid with a slight carbonation level (such as 1-2 vol/vol), as shown by the following example.

EXAMPLE 7

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A number of containers identical to those described in Example 3 were pre-filled to 50% of the final volume with water carbonated to 1.4 vol/vol at a temperature of 13 °C. Filling was then completed by an isobaric system using water at 13 °C carbonated to 4.3 vol/vol. The final carbonation level (the average of several measurements) was 3.15 vol/vol against an "expected" carbonation level of $0.5 \times 4.3 + 0.5 \times 1.4 = 2.85$ vol/vol, and thus 10% greater than this latter.

All the described examples confirm that filling a container in several stages, the last of which is isobaric, results in a final carbonation level greater than that which would have been expected on the basis of pure proportionality criteria.

45

This result is of considerable practical importance.

As already stated, with the currently used isobaric filling method the speed with which a container can be filled depends only on the quantity of liquid which the filling cock can deliver in unit time (cock throughput). The saturation pressure p does not influence this throughput (see Figure 1). Thus for a given container the capacity of a filling machine (ie the number of containers filled in unit time) is directly proportional to the number of cocks fitted to the machine.

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It is precisely for this reason that if the filling machine instead of completely filling a given container by an isobaric system has to use isobaric filling only to complete the filling of the partially filled container, the capacity of the filling machine obviously increases. Pre-filling with uncarbonated liquid at atmospheric pressure is a very simple operation, requiring much less time than isobaric filling.

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The cocks for use during the pre-filling stage or stages (which can be of the volumetric, weight or level type) are extremely simple and enable filling rates to be used which exceed even double those of the cocks used for the final isobaric filling completion stage.

As a conclusion to the described tests it can be stated that the previously defined object is attained by

the filling method according to the invention, characterised in that the container is filled in several filling stages, in the last of said filling stages the filling being completed under isobaric conditions with a liquid carbonated to a pressure sufficient to obtain the desired final carbonation level of the liquid in the container, in the stages preceding the last there being fed into the container liquid which is uncarbonated or only

5 weakly carbonated.

Obviously, to obtain a given final carbonation level, the container must be pressurized during the final isobaric stage to a pressure which is higher the larger the volume pre-filled prior to the final isobaric stage. Consequently, the limit placed on the pre-fill volume is finally determined by the strength of the container which has to withstand the pressurization during the final stage.

10 With the known single stage isobaric filling process, normally (especially when using glass bottles) the internal pressure during filling is much less than the pressure which the container can withstand, the wall thickness of this latter being determined more by the fact that it must not break during handling and transport. In contrast, the multi-stage method according to the invention enables this particular container strength determined by the aforesaid considerations to be fully utilized.

15 The fact that in multi-stage filling, the final stage (ie the isobaric stage) results in a final product having a carbonation level considerably greater than that which the liquid quantity added during the final stage should proportionally have provided, is in this light therefore of considerable importance. It thus becomes possible to pre-fill with large volumes and, as is apparent from the preceding examples, the larger these volumes are, the greater is the positive effect of the difference between the final carbonation level and the

20 carbonation level which would be expected on the basis of the ratios of the volumes added in the various stages.

In the most simple case in which, as the final result, it is required to obtain containers filled with carbonated water, there need be only two stages in the filling procedure, namely:

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1st stage:

partial filling of a container with uncarbonated (or slightly carbonated) liquid by a volumetric, weight or level system. The liquid volume introduced in this stage should be as high as possible, compatible with the

30 next stage, but without compromising the strength of the container.

2nd stage:

35 isobaric completion of filling in the manner described with reference to Figure 1.

In the case of soft drinks (orangeade, lemonade, aperitifs and the like), the filling can also be done in more than two stages. For example, in the first stage the suitably diluted syrup which determines the taste of the drink can be introduced, in the second stage uncarbonated water is added to the maximum level allowed by the next stage, and in the third isobaric stage suitably carbonated water only is added to the

40 required level. However there is no reason why the filling of these drinks cannot also be done in only two stages, using in both stages a liquid of the same composition but with the only difference that in the second (isobaric) stage the liquid is suitably carbonated.

The choice of the number of stages, the relative filling volumes and the liquid composition in the various stages is only a question of convenience.

45 It can however be stated that normally the volume of carbonated liquid introduced into the container during the final stage should conveniently be as small as possible, compatible with the strength of the container.

In practice a two-stage filling process can be implemented with two successive filling machines, which can be mutually synchronized.

50 It can be more usefully implemented with rotary filling machines of the type currently used, but provided with as many filling turntables as the stages into which the filling process is to be divided, and with the obvious condition that the last turntable is equipped for isobaric filling.

Likewise, and still more usefully, in a linear filling plant it is sufficient to precede the isobaric filling cock with as many other cocks as the chosen number of filling stages minus one, to equalize the times required

55 for completing each stage.

Because of the fact that, as stated, it is advantageous for the final stage to feed the least possible liquid quantity compatible with the final required carbonation level, the filling temperature and the container strength, it could happen in particular cases (such as in rotary filling) that the final stage requires a much

smaller number of filling cocks than the preceding stage. In such cases the first stage could itself be divided into two or more stages with the advantage of making the number of cocks in each of the subsequent stages equal, without any difference in the final result compared with that obtained with a plant using two-stage filling.

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Claims

1. A method for filling containers with carbonated liquids, characterised in that the container is filled in
10 several filling stages, in the last of said filling stages the filling being completed under isobaric conditions with a liquid carbonated to a pressure sufficient to obtain the desired final carbonation level of the liquid in the container, in the stages preceding the last there being fed into the container liquid which is uncarbonated or only weakly carbonated.

2. A method as claimed in claim 1, characterised in that during the various stages, liquids of different
15 type or composition are fed into the container.

3. A method as claimed in any one of the preceding claims, characterised in that the liquids fed into the container during the various stages are of different temperature.

4. A method as claimed in any one of the preceding claims, characterised in that the filling stags are two in number.

20 5. A method as claimed in any one of the preceding claims, characterised in that the container is intended to contain carbonated drinks consisting of a syrup diluted with water.

6. A method as claimed in claim 5, characterised in that in the first stage the container is partially filled with syrup diluted to a concentration proportionally greater than the final concentration, and in the second and final isobaric stage the filling of the container is completed with carbonated water.

25 7. A method as claimed in claim 6, characterised in that the first stage can itself be further divided into two stages, to thus result in a three-stage process, of which in the first stage the container is partially filled with a dilute syrup, and in the next stage a certain quantity of water uncarbonated or weakly carbonated is added to the maximum level allowed by the subsequent isobaric stage.

8. A method as claimed in any one of the preceding claims, characterised in that the containers to be
30 filled are bottles.

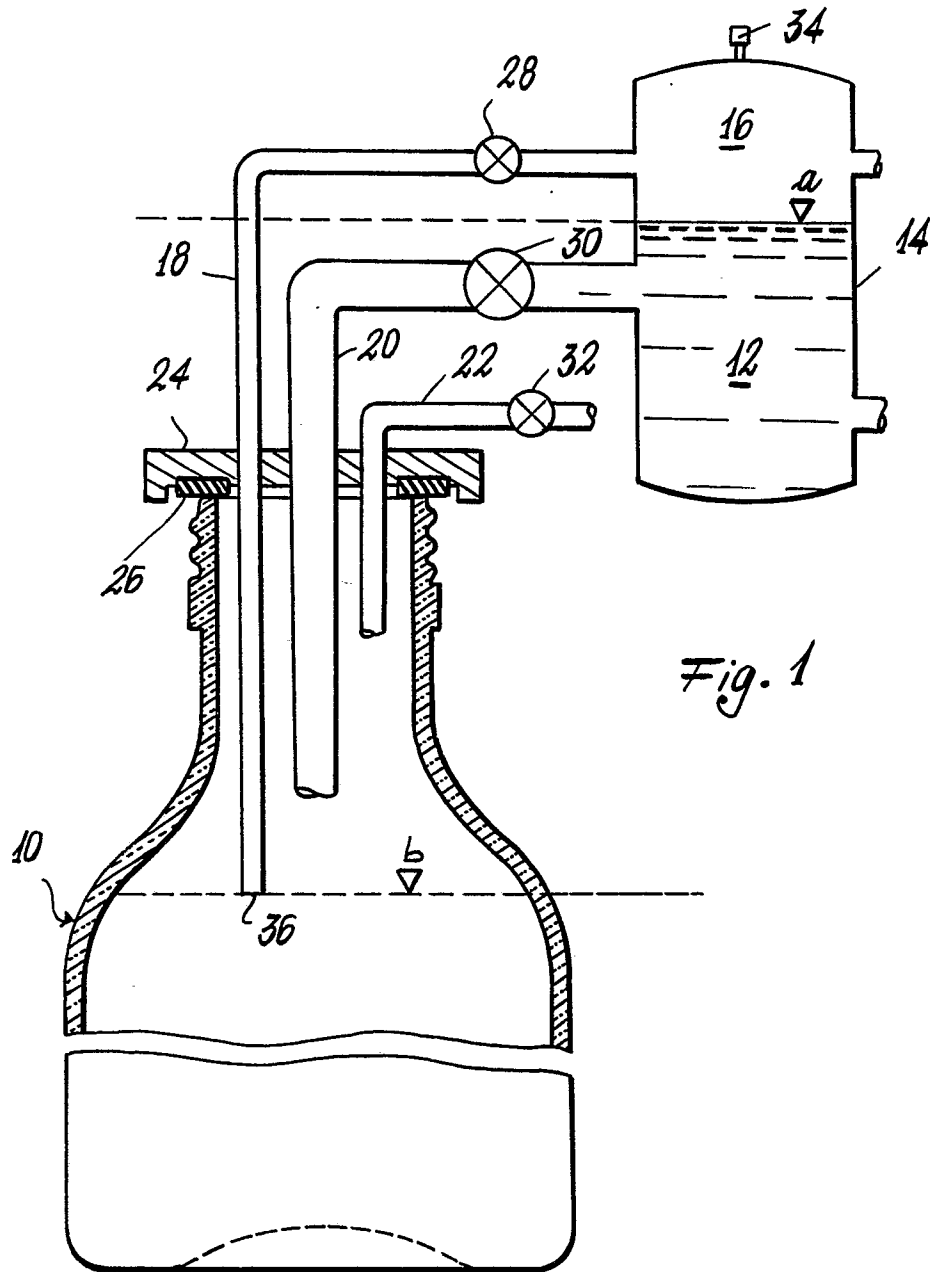
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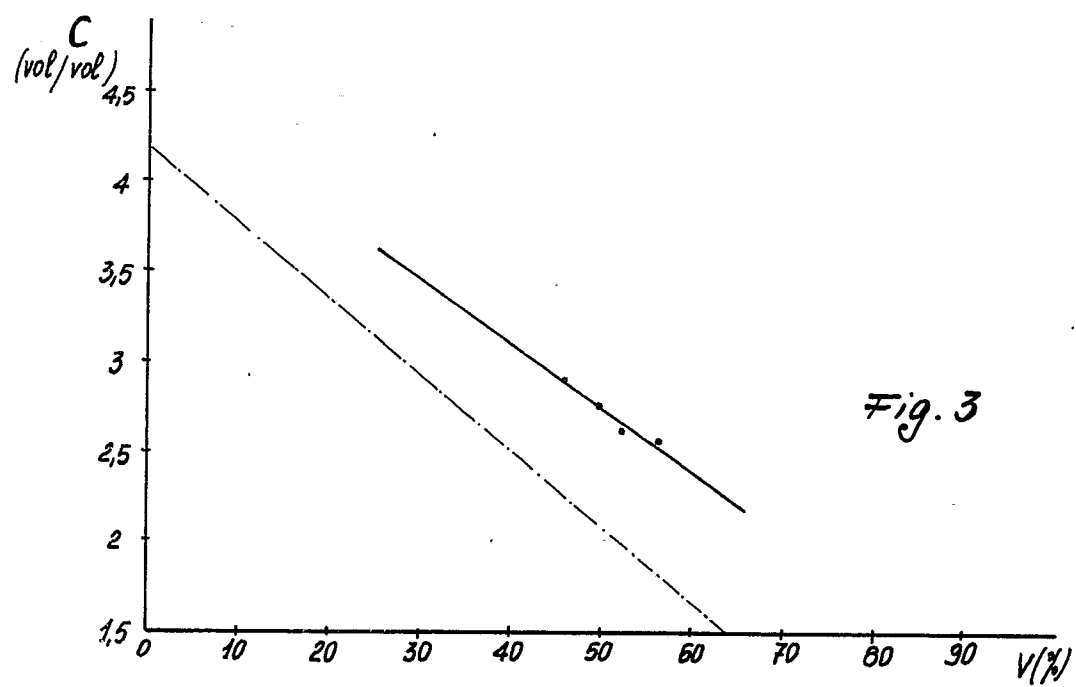
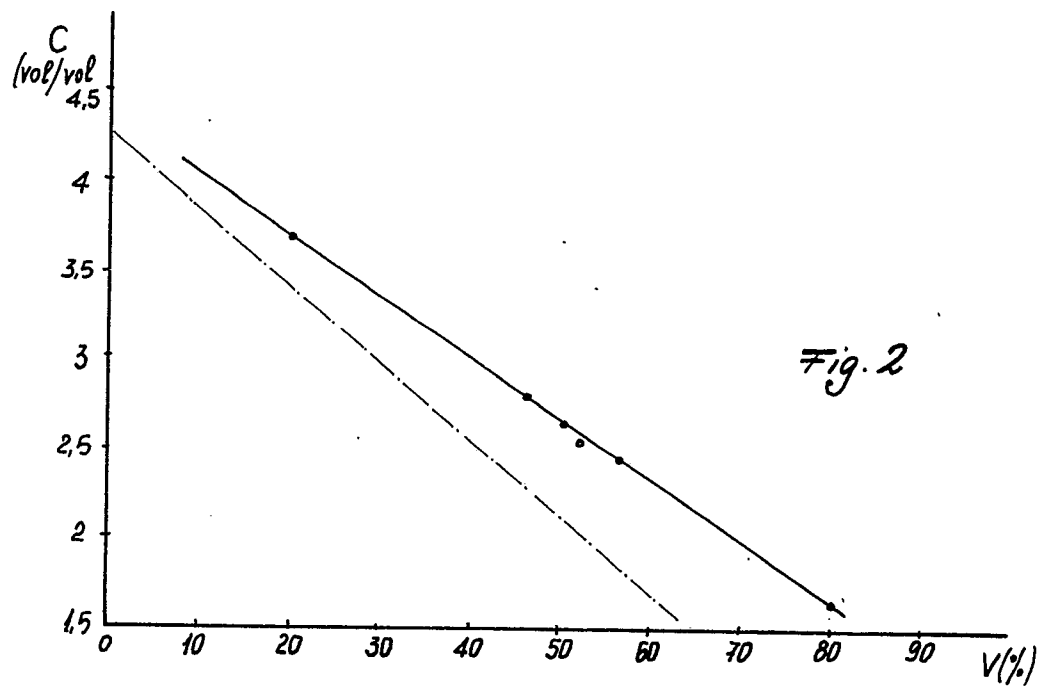
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	DE-A-2 133 805 (DEUTSCHER BRUNNEN) * Pages 2,3 * ---	1,2,4-8	B 67 C 3/06 B 65 B 3/04
Y	GB-A- 341 129 (PICKUP) * Page 2, lines 36-125; page 1, lines 43-47 * ---	1,2,4-8	
A	DE-A-2 005 595 (HOLSTEIN & KAPPERT) * Claims 1-3 * ---	1	
A	GB-A- 956 005 (AUTOMATIC CANTEEN CO.) * Page 3, lines 7-49 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B 67 C B 65 B B 67 D A 23 L
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 15-03-1990	Examiner SCHELLE, J.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	