Gales Foam Analyzer—A Novel Approach to Beer Foam Measurement[1]

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ABSTRACT

A new method for the measurement of beer foam is described. The method uses an optoelectronic device to measure the liquid runoff rate. The device, called the Gales Foam Analyzer, consists of a glass cylinder in which foam is generated, a series of phototransistors placed in opposition to a series of light-emitting diodes and a counting circuit. In operation, foam is generated in the glass cylinder. A series of 15 light-emitting diodes is cyclically pulsed to produce radiant energy at various levels of the foam cylinder. The presence of foam at a given level blocks the light path so that no signal is received by the phototransistor at that level. As the liquid level rises, a given level will then contain beer, which allows radiation to reach the phototransistor, activating the counting circuit. In an analytical determination, the contents of the foam cylinder are repetitively scanned for a predetermined time period. The foam analyzer circuitry totalizes the count, thereby giving a measure of the liquid runoff. When applied to a series of American lagers, reproducibility is good and differences between beers are shown.

Key words: *Analytical method, Beer foam, Gales Foam Analyzer.*

Beer foam quality has been, and will continue to be, a major concern to the brewer and brewing chemist. Methods for the evaluation of beer foam appeared in the very early brewing literature and new methods and modifications have continued to be developed into present times. The literature will not be surveyed here; this has been done by Brenner, McCully, and Lauffer (2). Incomplete satisfaction with existing methods precipitated an attempt to develop a method which would be operator-independent, reproducible, and measure foam quality as perceived by the consumer. To satisfy these criteria, an optoelectronic device capable of measuring the liquid runoff of beer foam was developed.

EXPERIMENTAL

Equipment

The foam analyzer is shown in Fig. 1. The apparatus consists of a counting chamber which supports a glass cylinder and an instrument cabinet containing the power supply, electronic circuitry, and digital readout. A Nalgene funnel with a 6-mm i.d. tip diameter is attached to a ring stand so that the beer stream will be directed down the center of the glass cylinder. The custom-made glass cylinder is 51 mm o.d. and is 72 cm long with a flat bottom. Fifteen light-emitting diodes (LEDs) and their associated phototransistors are spaced on 0.8 cm centers starting 7.5 cm from the bottom of the counting chamber. A double convex lens having a 6-mm diameter and a 9-mm focal length is placed 9 mm in front of each LED to provide a collimated radiation beam across the foam cylinder to an opposing phototransistor. Near infrared-emitting LEDs were selected because phototransistors are most sensitive to this type of radiation. Near infrared radiation offers the additional advantage of being more efficiently transmitted through beer than visible radiation. The LEDs and phototransistors are placed behind the covers shown in Fig. 1.

The device is powered by a single 118-V AC to 5-V DC power supply. Cyclical pulsing of the LEDs is accomplished by an oscillator with a calibration control, a series of 5 J-K flip flops, a matrix network, and AND gates leading directly to the LEDs. On the counting side of the circuit, each of the 15 phototransistors supplies base current to an associated switching transistor. The switching transistors activate decade counters which feed decoders to display a four-place digital readout. A simplified schematic diagram of the circuitry is shown in Fig. 2.

Method

Prior to each foam determination, the glass cylinder is rinsed with cold tap water followed by four rinses of distilled deionized water from a squeeze bottle. After the last rinse, the cylinder is inverted and held for 10 sec after which any drops of water remaining on the lip are shaken off. The cylinder is then placed in the counting chamber and the funnel is centered. A 12-fluid-oz bottle or can of beer which has been attemperated to room temperature is opened and poured into the funnel. The sample is poured as rapidly as possible while still maintaining a smooth pour. The size of the funnel controls the flow of beer into the cylinder minimizing any pouring differences. Immediately after all the beer has entered the cylinder, foam occupies the entire counting area, thus blocking all radiation paths, and the digital readout will display a steady number. The "Zero" button is pushed, setting the digital display to zero. A beer/foam interface forms in the lower

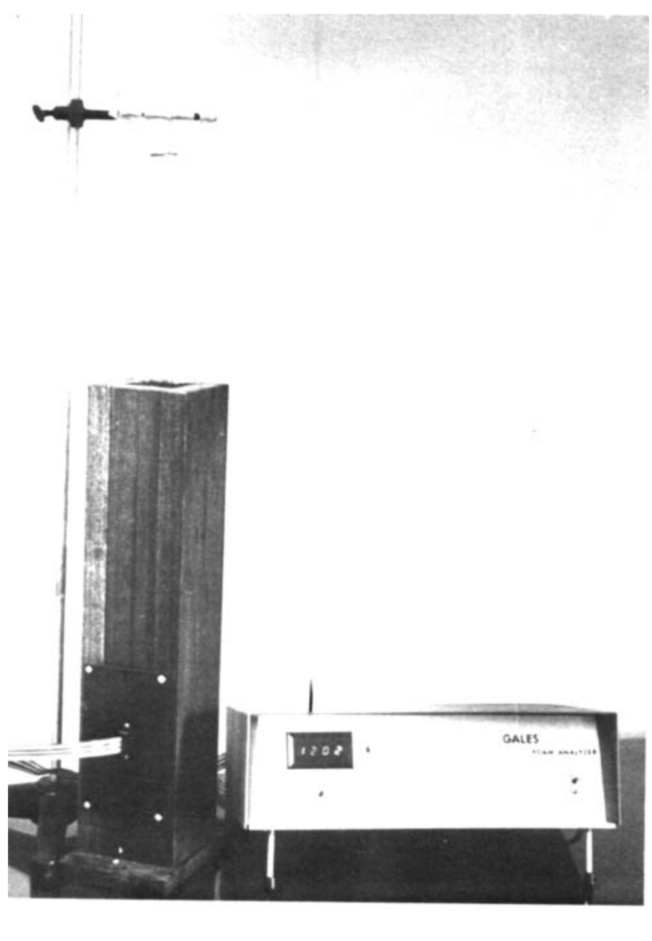

Fig. 1. The Gales Foam Analyzer.

[1]Presented at the 43rd Annual Meeting, St. Louis, May 1977.

portion of the cylinder below the first LED and moves upward. As the liquid level clears the first LED, the display changes from 0000 to 0001. At this time a stopwatch is started. The contents of the cylinder are repetitively scanned with a count being registered for each level containing liquid. The 15 levels are scanned in exactly 1.8 sec. During each scan cycle the number of levels containing beer is added to the previous total and displayed. At the end of 2 min, the "Count/Stop" switch on the face of the instrument is moved to the "Stop" position, freezing the display.

It should be clearly understood that a lower count indicates a better foam stability than a higher count. Because reporting a lower number for better foam could cause some confusion, data are reported in Gales Foam Analyzer (GFA) units which are 1000 minus the count, 1000 being the maximum 2-min count with no foam being present in the cylinder. This calculation (1000 − count = GFA units) would place most American beers in a range from 300 to 450 GFA units, with a higher value indicating better foam.

The instrument is calibrated to give a count of 500/min. This calibration may be accomplished without the cylinder in the counting chamber, with an empty cylinder in the counting chamber, or with the cylinder filled with beer with no foam. Calibration is achieved by adjusting a potentiometer inside the instrument case. After initial calibration, readjustment is rarely needed.

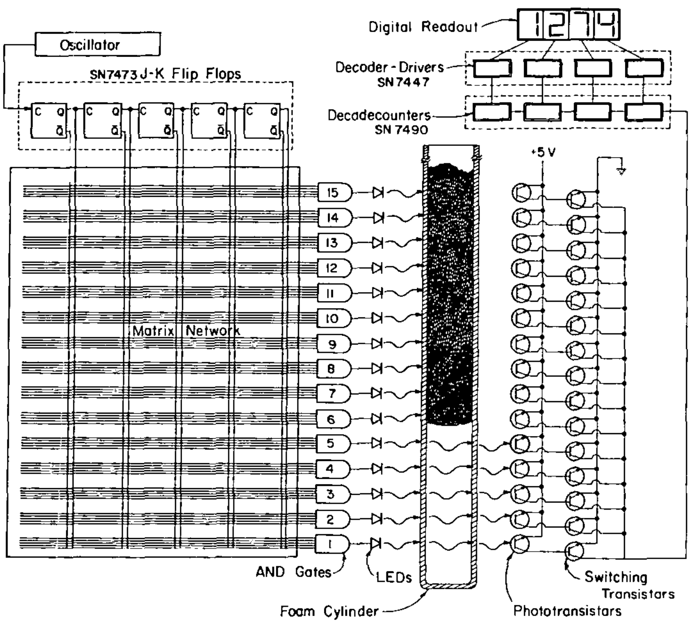

Fig. 2. A simplified schematic diagram of the foam analyzer circuitry.

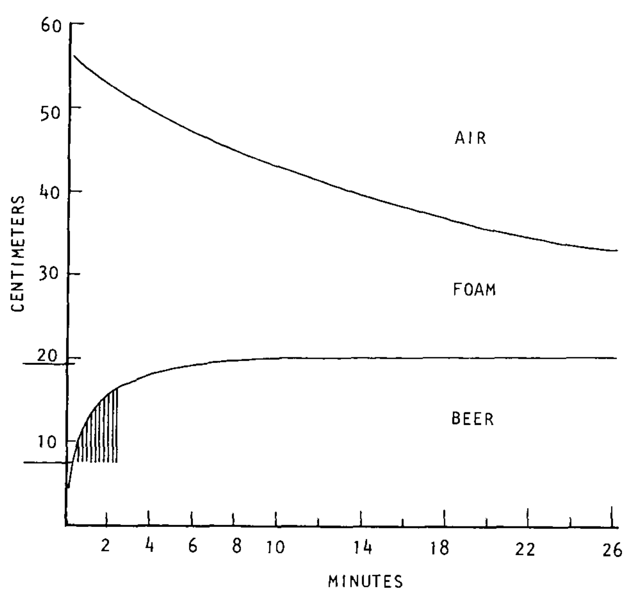

Fig. 3. The geometric relation of beer and foam in the cylinder with time.

RESULTS AND DISCUSSION

The geometric relation between beer and foam with time is shown in Fig. 3. These data were obtained by pouring beer into the cylinder and measuring the height of the beer/foam and foam/air interfaces with time. Hash marks on the Y axis indicate the level at which the foam analyzer would scan the cylinder contents. The vertically slashed region would correspond to the area measured by

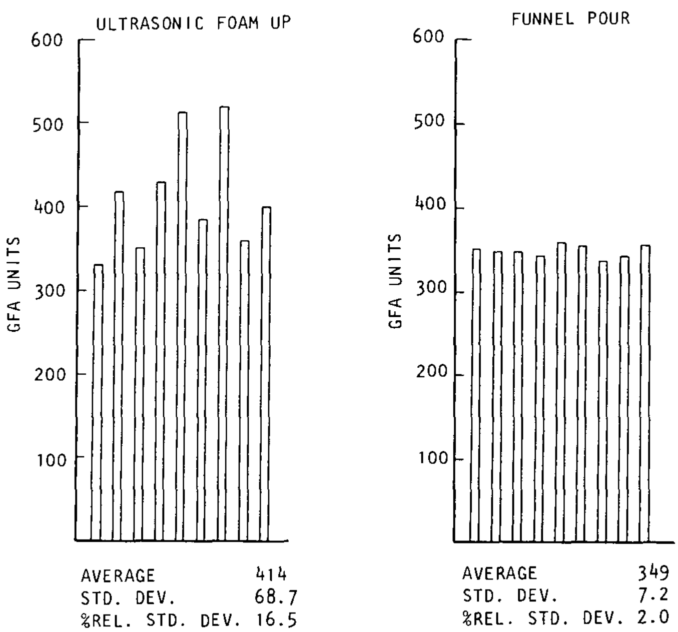

Fig. 4. A comparison of methods used to generate foam.

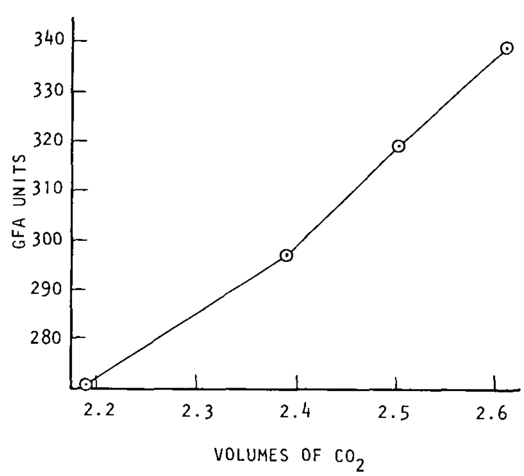

Fig. 5. GFA units *vs.* volumes of CO_2.

the analyzer during a 2-min test. It should be noted that the rise of the beer/foam interface occurs relatively rapidly and represents only a moderate fraction of the total foam. However, the liquid runoff rate has important implications in the appearance of beer foam. A beer retaining a relatively large liquid volume will contain small bubbles and will have a creamy appearance which is generally considered to be an important consumer criterion.

Several experimental parameters were varied to determine the best test conditions. Length of the timing period, pour *vs.* ultrasonic foam-up, beer temperature, and CO_2 level were examined. Referring back to Fig. 3, it will be noted that at the end of the 2-min timing period some liquid remains in the foam, perhaps suggesting a longer timing period. A series of 12 samples each of six American lagers was tested for 2 min followed by an additional 4-min timing period. The six beers ranked in the same order by the 2- and 6-min tests. The % relative standard deviations for the 2-min counts ranged from 0.7 to 1.9. Results for the 6-min counts were slightly better with % relative standard deviations ranging from 0.4 to 1.2. However, the relative range was much smaller for the 6-min test, 10.8% *vs.* 19.9% for the 2-min test. For this reason, 2 min was selected as the standard test period.

Ultrasonic treatment was considered as a means of generating foam. Foam generated in this manner contains very small bubbles and is more stable than a foam created by pouring. In a reproducibility study based on nine samples each, the ultrasonic method of generating foam proved to be inferior to the pouring

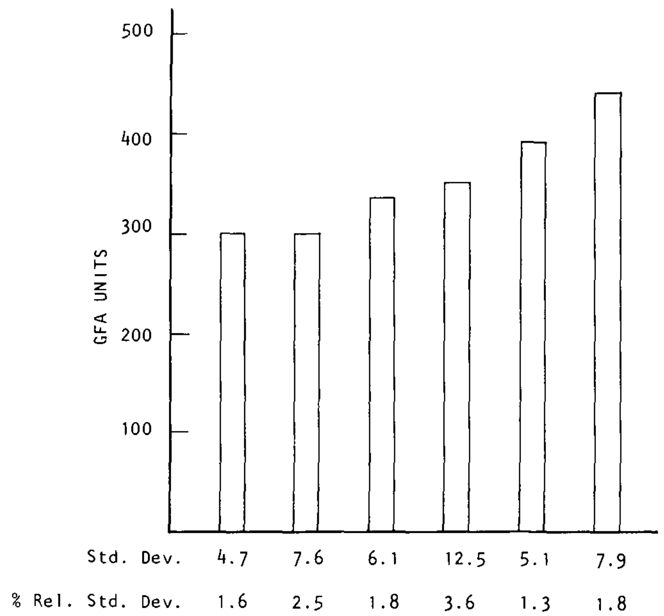

Fig. 6. A reproducibility study of six American beers (12 samples of each beer).

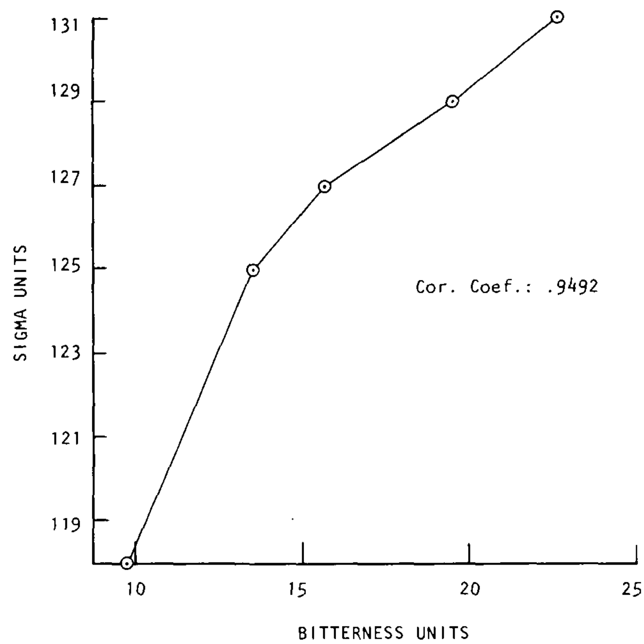

Fig. 8. Sigma units *vs.* Bitterness Units.

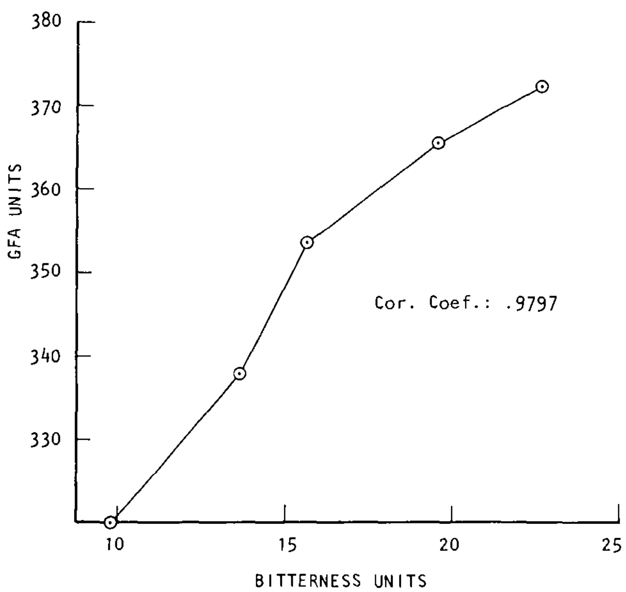

Fig. 7. GFA units *vs.* Bitterness Units.

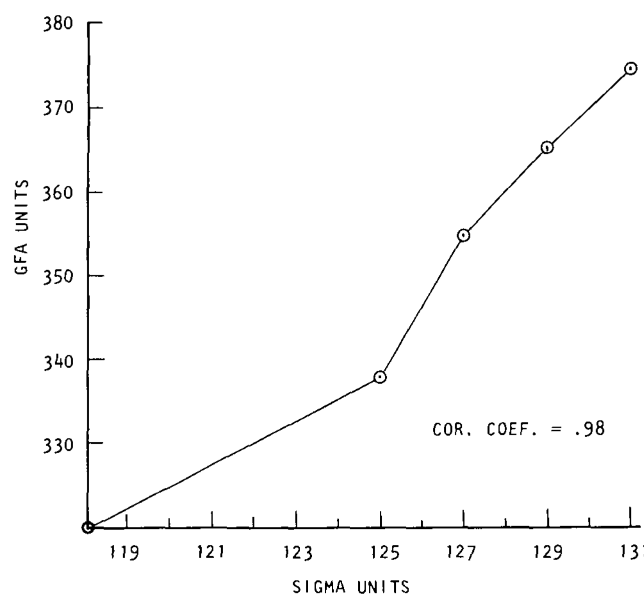

Fig. 9. GFA units *vs.* Sigma units for a series of beers with increasing Bitterness Units.

method with a % relative standard deviation of 16.5 *vs.* 2.0 for the pouring method, as indicated in Fig. 4. Therefore pouring was adopted as the standard procedure.

Beer temperature will affect the results of this test. A beer temperature of 70°F was selected as a convenience (room temperature) and because beers at 32° and 45° F do not always form a clear foam/beer interface. On occasion, at the lower temperatures, a hazy cloud of small bubbles was found to form in the beer below the interface, which might block the radiation path.

The CO_2 content is an important factor in foam measurement by this method. Figure 5 shows the effect of CO_2 on GFA units. When comparing beers of different CO_2 levels, or where extra precision is required, it is possible to measure the CO_2 on the same package used for foam analysis. This is done by using a Zahm & Nagel piercing device equipped with a pressure gauge. The pressure in an unshaken sample may be related to CO_2 volumes by tables in Beer-13 of *ASBC Methods of Analysis* (1), using the fact that an unshaken sample registers about 3 p.s.i. less than a shaken sample at 70°F. Constructing a curve of this type allows results to be normalized for CO_2 content if this is desired. As indicated in Fig. 5, an increase of 0.1 volume of CO_2 increases the GFA value by 16 units. Most American beers are similar in carbonation level so this correction is generally not necessary.

To determine the reproducibility of the method, 12 samples each of six American beers were analyzed using the standard test conditions. The results, shown in Fig. 6, show a good range and acceptable reproducibility with individual % relative standard deviations ranging from 1.3 to 3.6. For routine analysis, triplicate determinations have proved to be an adequate sampling.

In the evaluation of any production processing modification foam considerations should not be ignored. A single processing modification may not cause a large effect on beer foam. However, numerous small modifications may result in a significant cumulative effect. It is therefore important to have a method for foam evaluation with enough sensitivity to measure small differences.

The hopping level was shown to have a pronounced effect as indicated in Fig. 7. In this experiment, increased Bitterness Units (BU) levels were achieved by the addition of a commercial pre-isomerized hop extract to packaged beer. The beers described in Fig. 7 were also analyzed by the Sigma method (Beer-22,A) (2). The results, shown in Fig. 8, show the same; *i.e.*, better foam stability with increasing BU; comparing GFA with Sigma for this series of beers results in a linear graph with a correlation coefficient of 0.98, as indicated in Fig. 9. While these particular beers showed a high correlation between GFA and Sigma, the results are not considered typical. Experience has shown a much looser correlation exists between GFA and Sigma when different beers are compared.[2]

These examples are included to demonstrate the feasibility of this method for the evaluation of beer foam. While it is not anticipated that this method would serve as a sole replacement for more traditional methods, it is, nonetheless, a rapid, reproducible, operator-independent method which can aid in the evaluation of beer foam.

[2]Unpublished data.

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Literature Cited

1. AMERICAN SOCIETY OF BREWING CHEMISTS. Methods of analysis (7th ed.). The Society: St. Paul, MN (1976).
2. BRENNER, M. W., McCULLY, R. E., and LAUFFER, S. *Amer.* Soc. *Brew. Chem., Proc. 1950,* p. 63.

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