RAPID CALCULATION OF LOGARITHMIC AVERAGE BACTERIAL COUNTS OF MILK

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Determination of logarithmic averages of bacterial counts is a necessary and laborious task in grading raw and pasteurized milk. As the plate count determination replaces the methylene blue test for the ever increasing number of bulk milk producers, the problem becomes greater. A slide rule type of device has been developed that may materially simplify this task. This method is explained with information relative to its principle, application, accuracy, and advantages.

The administration of a milk control program which is based on the Public Health Service's Standard Milk Ordinance entails the routine computation of large numbers of logarithmic averages. Under the ordinance the bacterial quality is judged on the *logarithmic average* of the bacterial counts of the four most recent samples of the milk or milk product from the supply in question.

The use of logarithmic, rather than arithmetic, averages creates a clerical difficulty which can be serious at times. The calculation of the logarithmic averages is a procedure which does not readily lend itself to simplification or short cuts, and the usual office machines are of limited value in speeding up the procedure. The Public Health Service Code does suggest one method using a calculator, but this method requires constant reference to a table of fourth roots. It offers little advantage over the conventional method.

A new technique for rapidly determining logarithmic averages has been devised. The method is actually an application of the slide rule principle to the problem. It has been used for a period of several months on bacterial counts of pasteurized milk and raw bulk milk and has saved time, without sacrificing accuracy.

The New Technique

This new method takes advantage of the fact that four samples are averaged in all cases. As can be seen in Figure 1, the method uses a special slide rule which has two scales; both are logarithmic. The larger scale has a cycle of 12 inches and is stationary, the smaller scale has a cycle of three inches and is movable.

In using the new slide-rule method of computation it is necessary that the first logarithmic average be established in the usual manner. As will be seen later, full efficiency of the slide rule will be achieved only if samples are recorded by plant, by product and by

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date. Once the initial average is established subsequent logarithmic averages are found without further reference to logarithmic tables and without any mathematical computations whatever. The operation of the slide rule proceeds as follows.

The Slide-Rule Technique in Operation

The large stationary scale is used for the logarithmic *average* bacterial count; the smaller movable scale is for the *individual* count. First, locate the current logarithmic average on the large scale; opposite this, on the small scale, place the bacterial count of the oldest sample (the one being dropped) which contributed to that average. Then find on the small scale, the bacterial count of the newly reported sample; the new logarithmic average will be found directly opposite this on the large scale. By thus setting the value of the oldest sample opposite the current average, the new average will be found opposite the new sample. Only one setting of the scale is required for the whole operation.

A series of actual bacterial counts is shown in Table 1 and both procedures analyzed. In calculating these counts by the conventional method when Sample E is reported, the logarithm of 22,000 (4.34) must be added to the logarithms of the three previous bacterial counts. The same result may be obtained by starting with the total of the logarithms of the four previous samples (15.60), subtracting from it the logarithm of 3,000 (3.48), and adding the logarithm of 22,000 (4.34). The result (16.46) is the same as obtained by adding the logarithms of Samples B, C, D, and E. Actually, this subtracting and adding is the basic principle involved in the operation of the slide rule device. Figure 1 shows the setting for calculation of the above example. The bacterial count of the individual Sample A (3,000) on the small scale is set opposite the logarithmic average bacterial count of the previous four samples (8,000) on the large scale. The logarithmic division of the scales and the four-to-one relationship between the scales results in subtracting the logarithm of 3,000 from four times the logarithm of 8,000 or from the total logarithm of the four samples whose logarithmic average is 8,000. The slide rule automatically adds the logarithm of 22,000 (4.34) without resetting the scales and the new logarithmic average (13,000) is shown on the large scale opposite the value (22,000) on the small scale.

Efficient use of the device requires the arrangement of data as indicated previously in Table 1. All four bacterial counts contributing to the expiring average must be readily observed; otherwise, the time saved by rapid calculation will be dissipated in a search for the oldest sample contributing to the current average. For this reason it is advisable that the official record of the laboratory results list the samples chronologically by plant and by product. An incidental advantage gained from the keeping of records in this manner is the fact that this grouping facilitates the calculation of the average temperature, since the last four temperatures will also be grouped together.

PRACTICALITY AND APPLICATION

To determine the practical value of this new method of calculation, a simple time study was made to compare both methods. On the average, the slide rule reduced by over 50 per cent the time required between the recording of the initial data from the laboratory report and the final recording of the new logarithmic average. With the slide rule method it was noted that most of the time was spent writing in the record

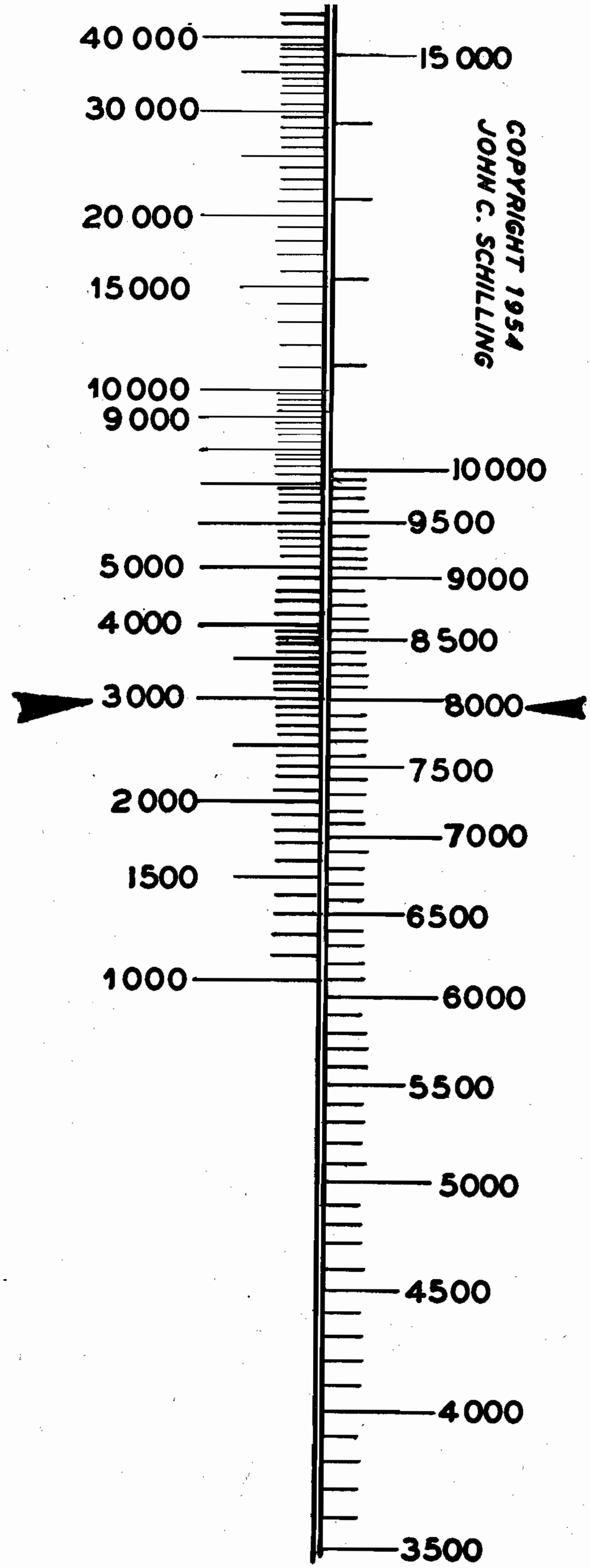

Figure 1. A portion of the calculating device showing specific setting for determining log. average count of results shown in Table 1. The full scales are extended to the limits described in the text. (Anyone interested in obtaining this device should communicate with the author – *Editor*).

TABLE 1 — HYPOTHETICAL RESULTS FOR CALCULATION OF LOGARITHMIC AVERAGE BACTERIAL COUNT.

Sample	Bacterial count	Logarithm	Total last 4 logarithms	Average logarithm	Logarithm average bacterial count
A	3,000	3.48	—	—	—
B	6,000	3.78	—	—	—
C	11,000	4.04	—	—	—
D	20,000	4.30	15.60	3.90	8,000
E	22,000	4.34	16.46	4.12	13,000

book; with the conventional method of calculation, more time was used in referring to tables and in figuring. Obviously the amount of time required for writing in the record is the same regardless of the method of calculation used.

To be sure, there was some hesitancy on the part of clerical personnel in accepting the strange, rather mysterious new method — and some reluctance to trust the results obtained by the device. However, once the clerical people agreed to try it they very quickly developed a high degree of proficiency in its use.

SCOPE AND EASE OF OPERATION

It may seem that the device has been made unduly large. The large stationary scale has been devised to include logarithmic average counts from 3,000 to 750,000; this necessitates that the large scale be 29 inches long. The small sliding scale will accommodate individual samples with bacterial counts from 1,000 to 10,000,000; thus it is 12 inches long. The range and the length of the cycle of the large scale governs the size of the device. This particular range was selected primarily to facilitate the calculation of logarithmic averages for products whose standards range from 30,000 in the case of Grade A pasteurized milk, to 400,000 in the case of Grade A raw milk for pasteurization after dumping and before pasteurization. The choice of 3,000 as the lower limit on the logarithmic average scale is obvious since lower bacterial counts are normally reported simply as "less than 3,000". The scale was arbitrarily extended to 750,000 to accommodate calculations where the logarithmic average might exceed the requirement while conditions requiring degrading or permit revocation do not exist. The latest edition (1953) of the Public Health Service Recommended Milk Ordinance and Code makes the 400,000 maximum bacterial count on Grade A raw milk after dumping and prior to pasteurization an individual sample requirement, and consequently does not require the calculation of logarithmic averages on samples of this type. In light of this change, it would probably be satisfactory to make the upper limit of the large scale somewhere near 350,000. This would shorten the device by four inches.

In some situations the device may even be lengthened. It might be necessary for milk less than Grade A; where samples of raw cream are routinely tested; or where it is the practice to count individual organisms, rather than clumps, when samples are examined by the direct microscopic method.

It would be inadvisable to reduce the size of the slide rule by reducing the length of the logarithmic cycles. Thus, if the large scale had a cycle of 6 inches with the smaller scale having a cycle of 1½ inches, the overall length would be cut in half. Such a proportional reduction, however, would make accurate reading of the scales difficult in many instances. This is particular evident on parts of the small scale where a difference of two in the second digit from the left is represented by a distance of only 1/32 inch. Experience has shown that although this instrument is approximately three feet long, it is not cumbersome to manipulate. It is supported on six half-inch rubber pads and can be operated with one hand.

COMPARATIVE ACCURACY

The accuracy of this new method has been found very satisfactory. It is reasonable to believe, and has been shown so far, that errors due to the human element are less likely to occur in this method. Accuracy is actually increased by this method on calculations involving individual counts and/or logarithmic average counts below 10,000. This is because counts reported by the laboratory with a second significant figure from the left, such as 3,400 or 9,700, can be used as such on this device. In using the conventional method, logarithms of the closest thousand were used in such cases. Although more complete logarithm tables can be used, the logarithmic tables given in the various editions of the Public Health Service Recommended Milk Ordinance and Code give logarithms of only every thousand under 10,000. Greater accuracy is also achieved in the conversion of an average logarithm to a logarithmic average count under 10,000.

DIFFICULTIES AND DISADVANTAGES

The method has some minor disadvantages. Any error made in calculating a logarithmic average will be perpetuated because the existing logarithmic average count is always used to calculate the new logarithmic average. Such an error, however, can be rectified by arithmetic check or it may be obvious under certain conditions which are likely to develop. For instance, four consecutive counts of 7,000, 9,000, 8,000, and 9,000 couldn't produce a logarithmic average of 9,500 because none of the individual counts is over 9,000.

Another difficulty is encountered when more than one sample of a product is taken on the same day. In this case, it is necessary to calculate the *daily* logarithmic average count from conventional logarithm tables before using the device. In our particular situation more than one sample of the same product is not taken in most instances. Where more than one daily sample is taken, the procedure recommended by the Public Health Service Milk Ordinance and Code (1953) is followed.

REPORT OF THE COMMITTEE ON RECOGNITION AND AWARDS — 1956[1]

Two awards for distinguished service – *The Citation Award* and *The Sanitarians Award* –are presented annually by the INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, INC. It is the responsibility of the Committee on Recognition and Awards to conduct those activities of this Association concerned with selection of the recipients, presentation of the awards, publicity, and related matters.

The purpose of *The Citation Award*, which was formally established in 1952, is to bestow well-deserved recognition upon members of this Association who, through long and distinguished service, have contributed greatly to the professional advancement, growth, and reputation of the International Association of Milk and Food Sanitarians, Inc. The rules for this Award state that a suitably framed citation shall be presented each year to the member whose past services have been judged to be the most outstanding.

Any member of the Association, or an Affiliate Association, may nominate an individual for *The Citation Award*. Such nomination must be accompanied by a statement listing the individual's past contributions and services to the Association, and it must be mailed prior to April 15 if the candidate is to receive consideration for the current year's award. All nominations are reviewed and rated by the Committee on Recognition and Awards, and the names of the two candidates rated the highest are then submitted to the Executive Board who selects the recipient. This year five nominations were received by the Committee. Dr. Kenneth G. Weckel, whose services to this Association have been so outstanding, was selected as the recipneit of *The Citation Award* for 1956. It was presented to him at the annual meeting banquet.

[1]Presented at the 43rd Annual Meeting of the International Association of Milk and Food Sanitarians, Inc., Seattle, Washington, Sept. 5-7, 1956.

The second of these two awards, *The Sanitarians Award*, is in the opinion of the Committee, one of the most important honors that can be conferred upon a professional public health worker. It was created for the purpose of bestowing long overdue recognition upon the local sanitarian – the man whose contributions to public health have been so great. *The Sanitarians Award* is sponsored jointly by five manufactures of sanitation chemicals, the Diversey Corporation, Klenzade Products, Inc., Oakite Products, Inc., Pennsylvania Salt Manufacturing Company, and the Olin Mathieson Chemical Corporation, and is administered by our Association. It consists of a framed citation and one thousand dollars in cash, and is conferred annually upon a local sanitarian from the United States or Canada who within the past five years has made a meritorious contribution in the field of milk and food sanitation to the public health and welfare of his community.

The rules governing the eligibility of candidates for *The Sanitarians Award*, method of nomination and method of selection, are published each year in the December or January issue of the *Journal of Milk and Food Technology*. The Committee on Recognition and Awards has sole responsibility of the selection of the recipient, and the Executive Board has no voice in the selection. This year eight nominations for *The Sanitarians Award* were received by the Committee. All of the nominees were outstanding men, and had made significant contributions to the health and welfare of their communities. Selection of the recipient from among these men was a difficult task, however, the Committee judged the over-all contributions of Mr. John H. Fritz, Chief of the Milk and Food Section, Division of Public Health Engineering, Kansas City, Missouri, Health Department, to be the most outstanding and he was selected as the recipient of *The Sanitarians Award* for 1956.

Last year, in its report, this Committee called at-