5. ENTRAINMENT LOSSES:

Early results from the first continuous deodorizer, with respect to negligible loss of glyceride, have been confirmed in the later installations. This considerably lower loss in continuous versus batch operation is not due to any magic but can be explained by the functioning of the two types of operation:—

First, if a batch unit as well as the continuous were fitted with the same efficient type of entrainment eliminators, there should still be considerably less loss in the case of the continuous deodorizer, by virtue of the greatly reduced quantity of injection steam blowing through the oil,—since entrainment from this source would be in general comparable with the amount of steam passing through the oil.

Secondly, there is no loss due to hydrolysis of glycerides in a continuous unit, which might result in the formation of the more volatile constituents such as fatty acids and glycerine,—as may occur in the relatively deep batch of oil in the batch process.

6. METHODS OF HEATING:

The continuous deodorization units so far installed have incorporated the use of Dowtherm vapor generators for producing Dowtherm vapor for heating of the oil.

Although in some cases there might be sufficient steam pressure available to give adequate temperature, —Dowtherm (having a boiling point of 500° at atmospheric pressure) gives a high temperature heating medium usable at relatively low pressures; resulting in corresponding ease of control, elimination of high pressure piping, gauges, valves and fittings,—and has proved to be eminently satisfactory. This is proved not only by its success in continuous deodorization units, but by its general acceptance by the vegetable oil industry as applied to batch deodorization as well. Table No. 1 gives the properties of Dowtherm liquid and vapor and Figure No. 6 shows an outdoor installation of a Dowtherm vapor generator with a capacity of 1,500,000 Btu. per hour.

The fuel efficiency of Dowtherm vapor generators is relatively high, so that the cost of production of Dowtherm heat is comparable with that of high pressure steam produced by large steam generators.

The Evaluation of Oil Meal Color By the Methods of Photometry

By EGBERT FREYER

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BUFFALO, NEW YORK

THE present official method for grading meal samples as "prime" or "off" in color consists in comparing the meal with a strip of colored paper, revolving both at high speed to eliminate texture differences. "The color of the meal must be equal to or lighter than the standard to establish grade." For the grading to be reasonably precise this procedure must assume that all meals and the standard have the same hue, and that different specimens of a given standard all have the same color dimensions. Neither of these conditions is fulfilled. During an abnormal growing season in certain localities a large proportion of meal samples may have hues appreciably different from that of the standard, and even during normal years chemists may receive abnormal samples which it is impossible to match visually against the standard. In such instances it is apparent that, in borderline cases, the chemist's decision is largely arbitrary. Concerning the constancy and uniformity of the Munsell standards, the writer has no definite information—only what is implied by the fact that the one standard strip in his possession differs by about 10% in the brightness of the two ends. Now spectrophotometry, the science of exact color evaluation, provides methods for dealing with this situation as precisely as it affords complete color definition of transparent materials, of which an outstanding example is represented by the spectrophotometric color analyses of vegetable oils made at the Bureau of Standards.[1] But just as we have considered such methods to be impractical and too expensive for everyday commercial use in the case of oils, they may likewise be dismissed with reference to meal color.

After a few preliminary trials in matching meal colors against different comparison standards, in which a prime condition was control of brightness of the two fields, the writer became convinced that grading the *brightness* of meal could be easily done without elaborate apparatus. The writer here avoids the use of the words, color or hue. If the industry requires a method which indicates differences of dominant wave length reflected, or in the subjective sense, of hue,—then the result can only be attained by expensive apparatus and an exacting technique; and any attempt to compromise will only result in such inadequacy and confusion as occasioned the formation of the present Meal Color Committee.

Aside from the desirability of forgetting hue differences in grading for the sake of using a simple and accurate brightness tester is the consideration that newer processing methods are likely to result in the production (from sound, prime seed) of meal with a somewhat different hue—such as would, perhaps unjustly, be called "off" under the present method, but which might at the same time be even *brighter* than meal made by old conventional methods. In fact, accounts have reached the writer which indicate this very situation to be arising, if not in a commercial sense, at least in some Company laboratories.

However the Society and the Industry may decide on this point, the writer's present efforts have been con-

fined to devising reliable methods for grading *brightness,* in the conviction that therein lay the only practical solution to the problem.

Figure 1 shows a simple photometer devised for the most part from material found in the laboratory. Alongside a central standard two stages are provided to hold the comparison surfaces; one is fixed at the lower limit and holds the standard (or a diffuse white ground in case color glasses are used for the basis of grading),—the other is variable along a vertical line. The scale measuring its position is marked in centimeters from the light source and, assuming the applicability of the inverse square law to this arrangement, in "relative darkness" as referred to the standard being considered, the reciprocal of this being the "relative brightness." (Tests showed that the inverse square law was applicable within about the accuracy of the measurements, as the reflector in most of the measurements was made a dull black. The light source was a 150 watt clear glass daylight lamp.) Thus as the stage was raised it came closer to the light source and appeared brighter in the split field eyepiece. A match was obtained by moving the sample surface, held in a small flat tray and pressed smooth, up and down making it alternately brighter and darker than the standard, until a brightness match was reached. Then it was clamped in position by means of a thumbscrew in the control rod guide, and the reading taken. Usually from four to six readings were made and averaged. The agreement among different readings and between two different observers is shown in Table 1-B. In 1-A are shown relative brightnesses on the series of meal samples obtained.

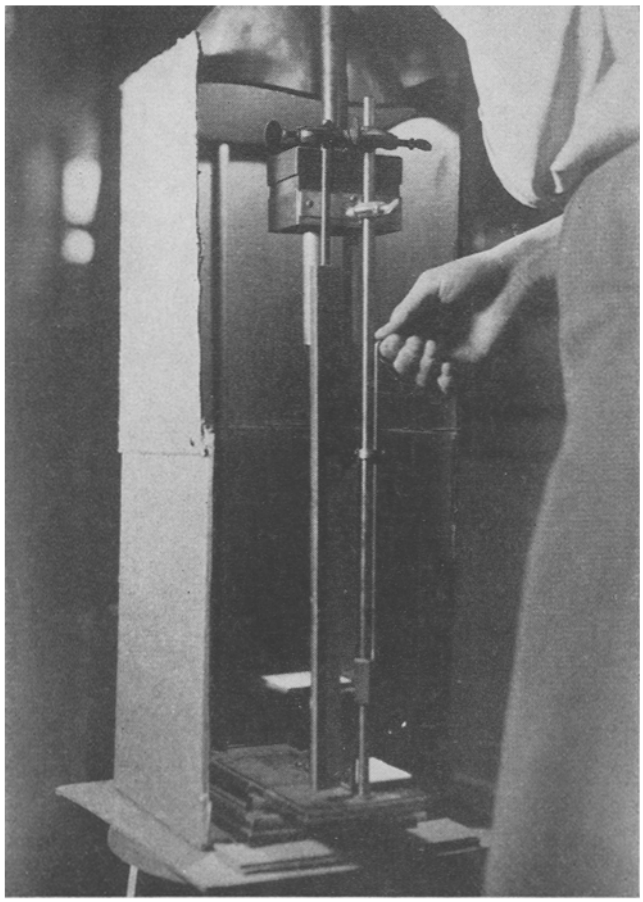

Fig. I. Visual Matching Photometer for meal brightness determination.

Even after making adjustment to equal brightness of the fields, the color match between the samples and the Munsell standard color strips was none too good, and not as close as between the samples and the best Lovibond glass combination. Also, the slight hue differences among the samples rendered it impossible to obtain perfect matching on all samples with the best single red and yellow color glass combination. However, should an apparatus of this type be regularly used in meal brightness grading, the use of a single combination of standardized color glasses over a standard white surface would be preferable because of the latter's permanence. On the other hand, exact matching of the field brightnesses was easily obtained by the use of a Gibson Green [2] mono-chromatic light filter transmitting at 5600 A, approximately the optical "center of gravity" for the visible spectrum. Passing a nearly pure light, hue differences become eliminated and a brightness match is attained—but only in terms of the light of the specific wave band transmitted. Use of this filter has one serious drawback; the fact that the field brightness is reduced to something like two per cent of that experienced in its absence; hence matching is more difficult and something of an eye strain unless a very high intensity light source is used. It was actually found that in spite of slight hue differences without the monochromat, the accuracy of brightness matching under this condition was about the same as when using the filter. In the case of quite appreciable hue differences, however, it was found that different observers were confused in varying degrees by such differences and they would therefore report different brightness readings—which is just the situation which gives rise to the need of an improved method.

A further objection to using the Gibson monochromat is the circumstance mentioned above, that it gives brightness grading only in terms of one narrow band. Conceivably, a sample which reflects a relatively large amount of spectral green and a small amount of orange might show a higher brightness reading than some other sample which is high in the red-yellow components but low in spectral green, but which in white light may actually be brighter. It would take a fairly large amount of spectral energy distribution data on meals covering a good range of hue differences to show how serious this objection might be. The writer is not aware that such data exists, but he believes that the curves for different meals of the same oil seed would be found to conform so to a type, as in the case of oils, as to render this theoretical drawback relatively unimportant for practical purposes.

With the knowledge that for commercial rating purposes it is not necessary actually to evaluate the sample brightness quantitatively, rather only to say that it is brighter than, or darker than some standard, a simple comparator type of apparatus suggested itself as being more suitable for the end in view. Such an apparatus was adapted from the Wesson tintometer, simple form, shown in Figure II. Photometrically, the Munsell standard is brighter than just-prime samples due to its smoother surface texture giving a less diffuse reflection. Therefore in matching samples against this standard photometrically some light,—this excess due to higher surface reflectance—must be lost or absorbed. The same is true for the correct Lovibond combination viewed over ground opal glass or a magnesia block. This result was achieved by adjusting the angle of

reflection from the sample to a somewhat different value to that of the light received from the standard in the case of Munsell paper, or from the white ground under the Lovibond glasses. Thus the operation of this apparatus is apparent from the drawing. Once the value of this brightness difference between the standard and a standard sample were established, the angle between sample holder and the standard surface holder could be rigidly fixed and the apparatus constructed to make it permanent. Or, the same result could be obtained by passing the light from the standard surface through a neutral gray filter having the proper absorption factor, in which case the sample and standard surfaces would occupy the same plane. This would simplify the device still further, especially if the two or three Lovibond glasses and the neutral filter were all cemented into one unit. To facilitate matching by eliminating the surface texture of the sample a simple lens is placed over it somewhat out of focus, and the light absorption of this would be taken into account in the final adjustment of equality between standard sample and standard surface. Moreover, the monochromatic light filter would be required for reasons given above; and finally it should be mentioned that closer matching could be obtained by replacing the direct vision eyepiece with the prismatic split field type.

Apparatus Employing Photronic Cell

To overcome some of the objections mentioned in connection with this visual photometric apparatus, principally to obtain brightness data in unfiltered white light, and to make the method independent of the observer error found in judging a close match under none too favorable conditions, it was decided to try the photo-electric cell as an indicator of equality or inequality between the brightness of sample and standard. An electric exposure meter was calibrated in terms of relative brightness and fitted with a brass sample holder,—then mounted in proper relation to a white light source. For convenience in this preliminary experiment the clean surface of the brass holder was used as an arbitrary reference standard. First, the indicator needle was brought to a certain graduation mark under light reflected from the standard surface by adjusting the value of the illumination; next, the sample was inserted and the amount of deflection read; then the standard setting was checked again for any change of light intensity which might have resulted from a slight change in line voltage. The relative brightness values so obtained are shown in Table I and are seen to agree reasonably well with the visual data, even for the several borderline samples.

So quickly and easily were these readings made that the writer felt convinced of this method's all-round superiority and accordingly set about devising an apparatus and procedure for a more extended test, possibly in committee work. The principal requirements considered in the design were the following: Simplicity and ease of manipulation, uniformity and reproducibility of standard conditions, adaptability to use of existing stock photocell light meters (for economy's sake), elimination of essentially all light from the cell except that reflected from sample or standard surface, and reasonably good sensitivity. The General Electric meter was found most suitable for this application with one-half the cell window area blocked out (one-fourth at each end). It is shown in Figure III in the apparatus of which the following are the specifications:

TABLE II

(A)—Buckeye

Sample	Original Grade	Additional Grading EBF	JD	FW	Freyer, Photometer Grade Relative Brightness (Daylight lamp)	Remarks
A	Prime	Off	Off		100	
B	Off	Prime	Off	Prime	100	B: (68% thru 40 mesh
C	Prime	Prime	Prime		110	(33% thru 100 mesh
D	Prime	Prime	Prime		107	
E	Prime	?	Prime		105	

(B)—B. A. Lab.

Photoflood light used / Basis foot candle reading		No. 2 Daylight 50	No. 2 Daylight 40	No. 1 Regular 50	No. 1 Regular 40	
1	Off (close)	95	95	118	117	Reddish
2	Off	91	92.5	116	115	Reddish
3	Off	90	90	112	112	Reddish
4	Slightly off	97	98	115	115	Reddish
5	Off	90	90	106	103	Reddish
6	Prime	104				Normal
7	Prime	98				Reddish
8	Prime	106				Normal
9	Prime	104	EBF:			Normal
10	Prime (match	102	"lighter than standard"			Normal

(C)—SCOCo

1S	Prime	154	1S: (77% thru 40 mesh	Greenish
2S	Prime	154	(40% thru 100 mesh	Greenish
3S	Prime, close	116		About normal
4S	Off, close	114		Dull reddish
5S	Off, reddish	126		Slightly reddish
6S	Off, yellowish	108		Orange

Group (C): All fine ground in lab. for routine analysis. Could not be officially graded in this condition. This group therefore should be ignored in comparing the indication of photometer with the visual grading.

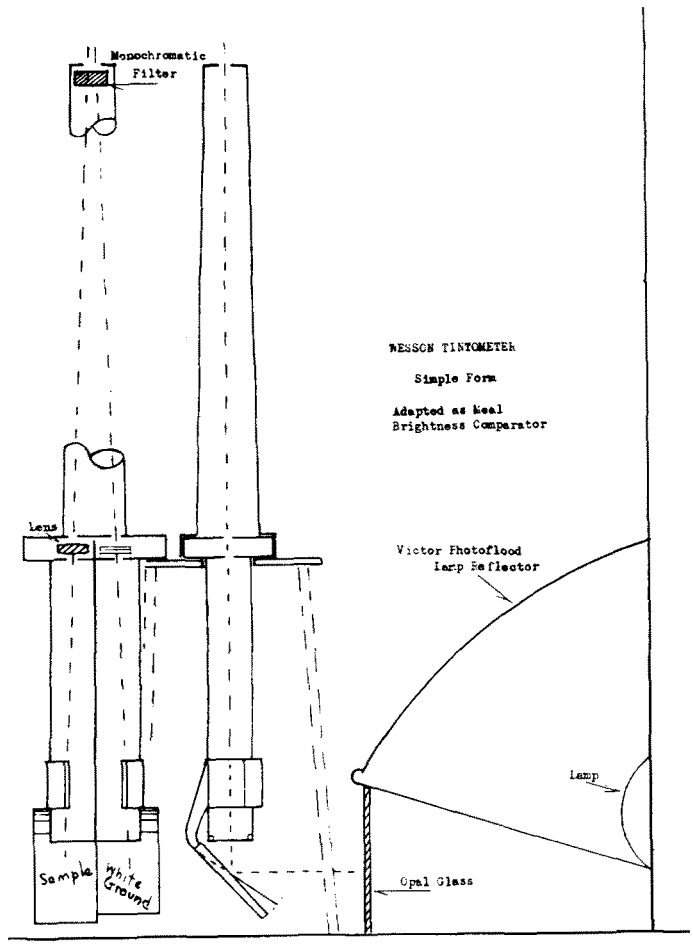

Fig. II. Wesson Tintometer, simple form, adapted as a meal brightness comparator.

Description of Photocell Apparatus

Size of test surfaces, 2¾" x 3¾".
Height of test surface above holder, 5/16".
Height of cell window above test surface. 4½".
Test surface area covered by photocell; i.e., the effective field, 3¼ x 2½".
Length of cell hood, 2½".
Cell hood opening, 1⅛ x 1½".
Cell window opening—adjusted to be exactly .563 + .003 sq. in., or .75² in.
Standard aperture: to be determined: see below.

Test surface carrier should have stops at both ends so that when sample pan or standard surface is shoved from the central position (one by the other), the test surface to be read becomes properly centered under the cell.

The important features of this apparatus concerned with standardization are the following: (1) area of cell window opening; (2) area of standard aperture; (3) diffusive reflection power of the standard surface. While adjustment of the two areas is a simple matter, it must be done carefully and within an accuracy of 1%. The standard surface adopted in this work was a slab of 5/16" ground opal glass. While the magnesium carbonate block is satisfactory for color work, its susceptibility to soiling, pitting and minor surface damage rules it out in the present application for practical everyday use. Since slight variations in the brightness of different lots of opal glass occur, it would be desirable, should this method eventually be adopted, for the Meal Color Committee to obtain from a single plate a dozen or so slabs, ground and cut to size. One of these should then be carefully preserved as the Society's primary standard.

On the basis of this preliminary work the standard aperture area appears to be close to .13 sq. in. or a hole .406" in diameter. This is 23.1% of the cell window area; so we may tentatively define a standard meal sample (just prime) as one which reflects in the test apparatus an amount of light equal to or greater than 23.1% of the light reflected from the standard white

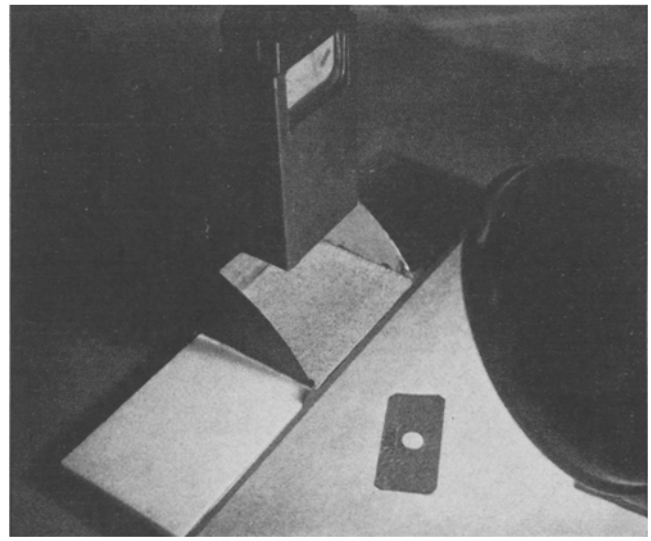

Fig. III. Photoelectric Meal Brightness Tester showing sample in place for reading and standard white surface—also a standard aperture.

surface under the same illumination. However, should we allow a variation in the brightness of the white surface, then the apparatus would be standardized by changing the above fraction to compensate for the deviation of the brightness of the surface from that of the primary standard, i.e., by changing the area of the cell window or of the standard aperture.

Now to establish the *exact* value of the fraction (or aperture ratio) necessary to cause a standard sample to read 100 relative brightness or "just prime" in this apparatus, will require that as large a number of borderline samples as possible be read and the relative brightnesses recorded. These samples should preferably have been graded "just prime" by several different oil chemists experienced in grading meal color, using as many different specimens of standard Munsell strips as available. From the average relative brightness values so obtained the amount by which the aperture ratio should

TABLE I

BRIGHTNESS VALUES REFERRED TO BASIS OF NOS. 5, 6 & 8 AS JUST PRIME; NO. 7 "OFF"
Just Prime or Standard = 100

Meal Sample Number	Visual Gradings CHC	EBF	Visual Photometer vs. Munsell	Visual Photometer vs. 6.1y-3.2r over matte opal glass	Meter "Tempiphot" Photocel	G. E. Light Meter* in Final Apparatus
1	(Very light; (Prime	Prime	120	—	110	112
2	Prime	Prime	111	—	105	107.5
3	(Close to prime; (graded prime	(Uncertain (called 'off'	96	—	95	90
4	Prime	Prime	109	105	103	102
5	Prime	Prime	107.5	103	101	101
6	About prime	About prime	102	102	101	96*
7	Uncertain	Off	98	94	96	98
8 (Reddish)	Off	Prime	101	103	101	99
Munsell				80	92	

* Readings taken several weeks later; a check then against photometer showed some change in No. 6 containing weevils, from 102 to 97; it is believed others also darkened slightly.

B Comparison of Actual Readings; Relative Darkness, Munsell = 100 (41%)

De Lane: With Monochromat, 144, 145; Without, 143, 144..... Average, 144
Freyer: " " 140, 143; " 136, 139, 144, 143, 139..... " 144

(The displacement equivalent to this average difference of 3 is 6 mm, or 1.1% of the distance from the light source.)

be changed could be readily figured. This then would establish the standard brightness for a given kind of oil meal.

It should be mentioned that the uniformity of the standard here considered assumes a uniform sensitivity over the entire area of the photocell window area used. The writer cannot vouch for the validity of this. Should this point prove to be an appreciable source of non-uniformity among different instruments, the proper course would then be to have some central agency standardize each apparatus, using, in addition to the standard white surface, a standard sample or its equivalent, which might be a standard filter placed before the cell window to reduce the light from the white slab by the same amount as would a standard sample.

In Table II are given some additional test data obtained with this apparatus on meals submitted by committee members in response to a request for samples which had been graded by the official method, most of which might be considered to be "just prime" or "just off." The main object of this series was to show how close to or how far from proper exact adjustment the writer had made the tentative aperture ratio, originally chosen on the basis of two or three "close" samples. It is interesting to note that in the first group (A) two samples representing conflicting gradings against the Munsell standard gave readings of 100, or just prime and with 1% in brightness of being "just off." In the second group (B) there was good agreement except for the reversal of grades on two samples on which the departure from grade was only 2% and on one of which there was disagreement between two observers in matching against the Munsell standard. The results on the third group (C) show how large an effect particle size has on brightness,—a well-known circumstance. The very fine grind on these samples, as compared with ordinary commercial practice, and the presence in them of paint brush bristles suggested that they may have been ground for laboratory analysis, as subsequent inquiry proved to be the case. This group of samples could not be graded under the present official method, but since they *were* graded the results are given to show the importance of the grind effect, which indicates that it may have to be more carefully considered in this relatively exact photometric method than in the case of visual matching. The present method states that meal samples shall be graded "as received," and directions are given for laboratory grinding of *cake* to a degree presumably intended to be the same as represented by the average commercial meal grind. Hence any attempt on the observer's part to compensate in matching for the effect of a fine grind, or more important, the grading of laboratory ground *meal* samples is contrary to the intent of the official method.

Further Notes on the Apparatus

The apertures used have been punched in thin black cardboard and not attached to the apparatus in any way. In cases where the nearest hole area is larger than the exact value desired, the small calculated unwanted fraction has been blocked out by gluing across the hole a small strip of the proper size. In routine use the aperture should be in a built-in metal strip arranged to slide over the cell window whenever the standard surface is centered, and not require lifting out the lightmeter for each reading on the sample. This is necessary both to give the standard needle setting and to protect the cell and microammeter from overload.

Operation: A sample tray is filled with meal which is leveled off with a large spatula and the surface smoothed to the edges under gentle pressure with a smooth surface about 2½" square. With the standard aperture in place the standard white slab is moved into place and either the light stand or the apparatus moved until the needle registers 50 foot candles; then the white slab is replaced by the sample and the aperture removed. If the meter now reads 50 or more the sample is prime. Also, if the meter has been properly set to read zero while in the apparatus and receiving no light, then twice the actual foot candle reading on the sample is the "relative brightness' referred to a standard sample as 100. This assumes that the cell receives no extraneous light, a condition which depends upon the low reflectance of the cell hood interior which is made as dull a black as possible. The reflecting inner surface of the hood support should be polished to avoid any diffuse reflection which might be picked up by the inner walls of the cell hood.

Illumination: For the design and light meter just described an intense light is required. The best source was found to be a #2 daylight photoflood lamp in a rather small conical reflector (Victor). Using the ordinary white frosted photoflood lamp there is ample light without need of the reflector incorporated in the apparatus. With the #1 and #2 daylight photofloods, however, this was required in order to give the desired sensitivity reached by obtaining a reading of 50 foot candles under standard conditions. Considering that we are now determining brightness instead of color (although our brightness differences are primarily consequent upon differences in the depth of the color), it is very probable that the slightly yellow light (of lower color temperature) of the ordinary photoflood lamp would be just as satisfactory for this application as the weaker but white light from the "daylight" type. Thus by eliminating all extraneous light from the cell hood, such as would come from any reflecting surfaces below the plane of the entrance, the apparatus will give fundamentally true relative brightness values within the accuracy of the meter indications. However, for the sole purpose of deciding between prime and "just off" brightness, there would be no serious objection to the reception of a small amount of outside light as long as it is always present in the same amount, i.e., both for sample and for standard surface. This is the case in using the daylight lamp requiring supplementary reflector. Should the lower wattage #1 regular (yellowish light) lamp be preferred, the aperture ratio would have to be adjusted for this light as implied in the high readings in Table II obtained under this condition with aperture ratio for white light.

The apparatus as built could be improved in certain details, especially the provision of a housing for the standard white surface to keep it clean; this would simply be a cover for the right end of the surface holder track. It would also be a convenience to have the sample pan coupled mechanically to the standard aperture slide so that when the sample replaces the standard surface the aperture would at the same time be removed from before the cell window. Perhaps a service test would reveal other desirable improvements.