"The Priest Photometer for Color." G. W. Agee, *C. O. P.*, **4,** No. 9, 42.

"Report on Calibration of 16 Lovibond Glasses." I. G. Priest, *C. O. P.*, **4,** No. 9, 43.

"Color of Soybean Oil." R. W. Ellison, *C. O. P.*, **4,** No. 6, 49.

"Standard Lovibond Colorimeter." David Wesson, *C. O. P.*, **6,** No. 6, 36.

"Variations in Color Readings of Coconut Oils." P. W. Tompkins, *C. O. P.*, **6,** No. 7, 30–1.

SAN DIMAS, CALIFORNIA

THE K. AND E. COLOR ANALYZER

BY CARL W. KEUFFEL

The K. and E. Color Analyzer is a practical direct reading Spectrophotometer. It is used for determining the spectral transmission curves of all transparent substances, liquid or solid, such as colored solutions, oils, glass, etc., also for determining the spectral reflection curves of solid substances such as paper, soap, flour, etc. These curves can then be used to form the basis for a system of color specification or color control.

1. Spherical Light Source.
2. Photometer.
3. Spectromter.
4. Wave Length Scale.
5. Photometer Scale.
6. Holder for Standard Sample.
7. Holder for Reflection Samples.
8. Holder for Transparent Samples.
9. Field of View thru Eye Slit.
10. To Vacuum Ventilator.
11. Plug for Vacuum Ventilator
12. 400 Watt Lamps.
13. Lever for Raising Photometer.
14. Sector Discs.
15. Universal 110 Volt Motor.
16. Speed Control Rheostat.
17. Entrance Slit.
18. Collimator Objectives.
19. Dispersion Prism.
20. Bi-Prism.
21. Eye Slit.
22. Cast Aluminum Base.

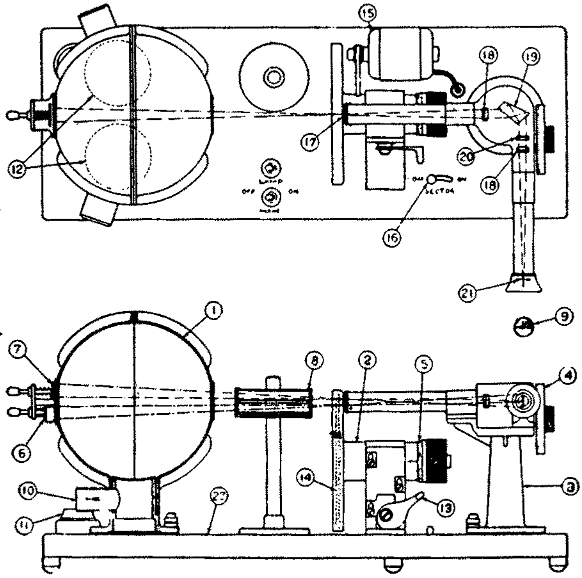

Diagram of K & E COLOR ANALYZER

Fig. 1

The Instrument consists essentially of (see Fig. 1);

A. The Constant Deviation Spectrometer (3) with its wave-length scale (4).

B. The Direct Reading Rotating Disc Photometer (2) with its photometer scale (5).

C. The Light Source (1) with its holder (6) and (7) for the samples when reflection measurements are made.

D. The stand with adjustable holder (8) for transparent substances.

When measuring a transparent liquid such as cottonseed oil, the sample contained in a glass tube of the desired length is placed in the holder (8) so that light from the upper beam passes through the tube of liquid. Two glass end plates are placed together on one end of an empty tube with a drop of the oil between them and this tube is placed in the path of the lower beam. This is done to make the instrument read directly the transmittance of the oil, and cancels the effect of the glass end plates of the tube or cell. The two beams then pass through the sector (14) which controls their relative intensity. This is done by turning the nurled head to whicht he photometer scale (5) (reading directly in per cent) is attached. The light from the beams then passes into the spectrometer where the beams are dispersed by the prism (19) into a spectrum. By turning the drum, to which the wave-length scale (4) is attached, any part of the spectrum can be selected and brought into the divided field for comparison. If we now analyze the colored light transmitted by the oil with respect to the relative amount of light of each wave-length in the spectrum, we will have the spectral transmittance of the oil.

An oil appears colored by transmitted light because it has the property of selective absorption or transmittance. This is a property inherent in the oil itself, and it is this property which we are concerned in measuring. When the light which has been transmitted by the oil impinges on the retina of the eye, it stimulates the optic nerve and produces the sensation of color. This sensation is not the same for any two observers because it depends upon the physical state of the observer's eye.

We are concerned with the measure of a certain *property* of the oil and not with its *effect* on an observer, *i. e.*, we wish to measure the *stimulus* which produces the sensation and not the *sensation* itself. The Color Analyzer measures this stimulus directly and absolutely. Its readings are independent of the color vision of the observer's eye, *i. e.*, a color-blind person will get the same results as a person with normal color vision. This is not the case with a "Colorimeter" which we may define as an instrument by means of which the observer adjusts a stimulus (under given conditions and limitations) to evoke a color matching the color being tested. Usually this adjusted stimulus is not identical with the actual stimulus of the color to be matched. In such a procedure different observers may obtain systematically different results according to the differences in the color vision of each. This is characteristic of all types of "Colorimeter."

When a colored object is viewed by the same observer but under lights of different quality (sun light, light from carbon lamp, light from tungsten lamp, etc.) the sensation produced under each light will be different, and the color of the object, although it has not changed physically, will appear changed to the observer. Measurements made with a "Colorimeter" therefore are dependent on the light source with which the sample to be measured is illuminated. Measurements made with the Color Analyzer, however, are independent of the quality of the light source.

The following is a quotation from I. G. Priest (*Trans. I. E. S.*, Vol. XIII, No. 1, p. 413).

"Of whatever value the so-called 'Colorimeter' may be in special cases, it must be admitted that the fundamental basis of color specification is spectrophotometry."

While it has long been recognized that the spectrophotometer is a requisite in color work, providing, as Mr. Priest says, the fundamental basis of color specification, the only spectrophotometers hitherto available have been highly scientific instruments so elaborate in design, expensive in original cost, and so difficult to set up and to operate as to place them beyond the pale of the ordinary laboratory.

H. E. Ives (*Journal of the Franklin Institute*, Dec., 1915, p. 700) says: "A spectrophotometric table derived from at least 25 points (for a continuous spectrum) gives the only unique description of a color, and it appears probable to the writer that the requirements of precision technical color measurements are most likely to be met by the development of simple and rapid means of plotting and recording accurate spectrum plots of reflection or transmission characteristics." The K. and E. Color Analyzer was developed to meet this need and has been in practical use in many of the industries for over two years.

Mr. I. G. Priest has for some years advocated the method of spectrophotometric analysis for specifying the color of cottonseed oil. His researches in this field have shown that oils can be accurately graded by this method. The time taken to make a measurement depends upon the number of points necessary to determine the curve properly. In order to determine exactly how few points on the transmittance curve would still properly specify the color, further research would be necessary. It has been found, however, that the transmittance curves of various cottonseed oils have their maxima and minima at the same wave lengths (see Fig. 2) and this suggests that readings at the following wave lengths, 540, 590, 610, 635, 670, 700, would be enough to specify the color of the oil. It may be difficult to visualize the color represented by six such readings, but it is possible to compute from these readings a single value (expressed in wave length) for the *quality* of the color and another value for the *brightness* (expressed in per cent). These two numbers give an exact description of the color which can with some experience be easily visualized. In Fig. 3 the transmittance curve for the cottonseed oil is 1 and the transmittance curve of the Lovibond glasses which match this oil is 2. The numerical value for quality of the color of the oil is 583.2 and for the glasses is 581.8. The value for brightness is 1 = 28.5%, 2 = 28.9%. This example was taken from an article by Priest on the "Relations between the Quality of Color and the Spectral Distribution of Light in the Stimulus." There are other ways in which the spectral distribution curve can be changed to a simple notation of three numbers which will exactly represent the curve and which can easily be visualized as a color.

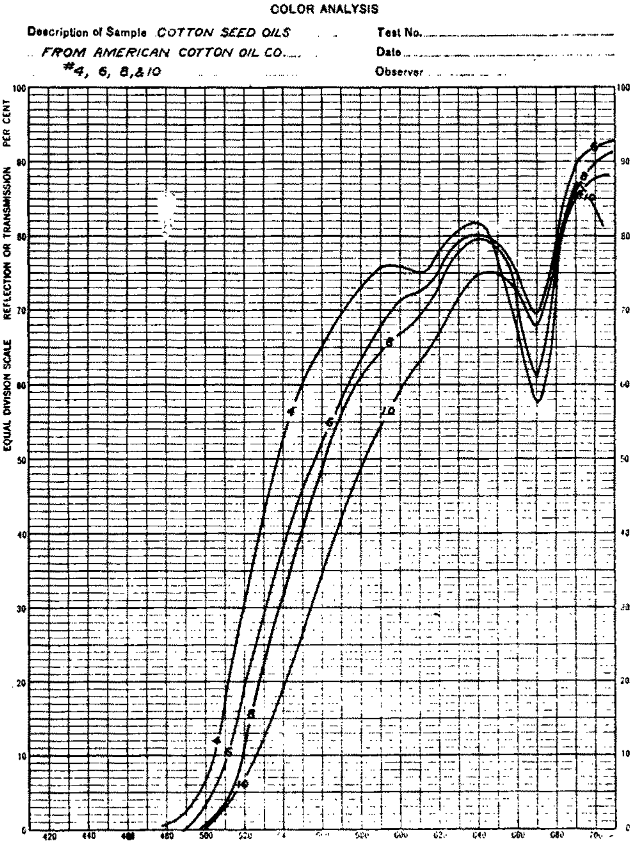

FIG. 2

The three curves A1, A2, and A3, shown in Fig. 4 indicate another useful purpose to which the measurements made on the Color Analyzer may be put. These curves show the cottonseed oil A1 before bleaching, A2 after bleaching and A3 after deodorizing. The measurements prove that the processes through which the oils were put have taken out the absorption bands which showed in the unbleached oil. A study of the transmittance curves taken at various stages of a refining process could be made to determine the efficiency of the process and may suggest methods for improving the process.

It is probably true that the K. and E. Color Analyzer seems unnecessarily elaborate and expensive for grading cottonseed oils, yet we have found that unless an instrument is well designed and manufactured it cannot be made to give the accurate results which are necessary in color measurement.

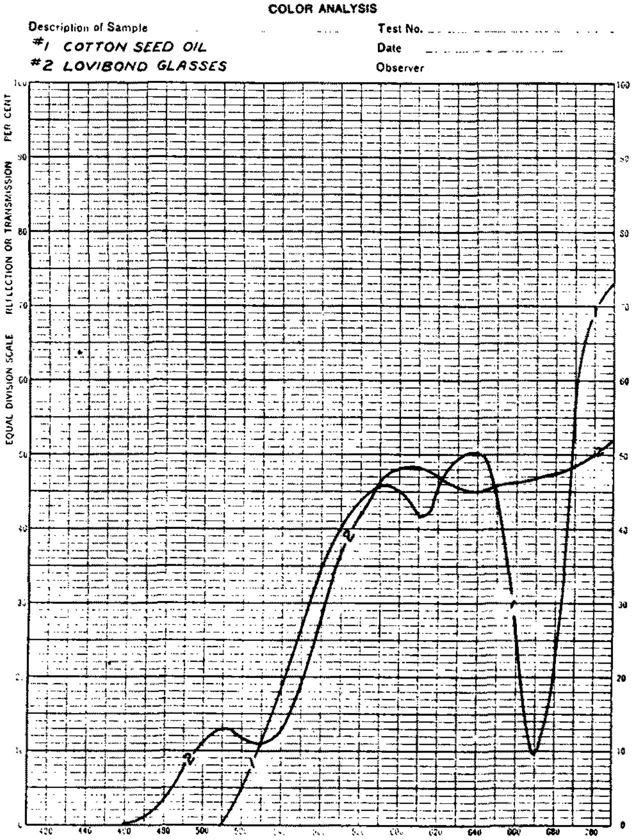

FIG. 3

The fact that the samples of oil are in a closed tube makes them easy to label and handle, especially when a large number of tests have to be made. The readings can be taken by inexperienced observers since no skill in color matching is necessary. The instrument is not limited to the measurement of transparent substances, but will equally well measure the color of solids or other substances such as pressed cottonseed cakes. Wherever the K. and E. Color Analyzer has been purchased for a certain problem, it was quickly found that it could be equally well used for other problems which were not thought of at the time of purchase. It is impossible to predict what improvements we may be able to make as soon as we can accurately measure a quantity. In this connection it is fitting to call to your attention the following quotation from Parsons:

"We understand now that practically all we have mastered in science is what we have been able to measure or weigh."

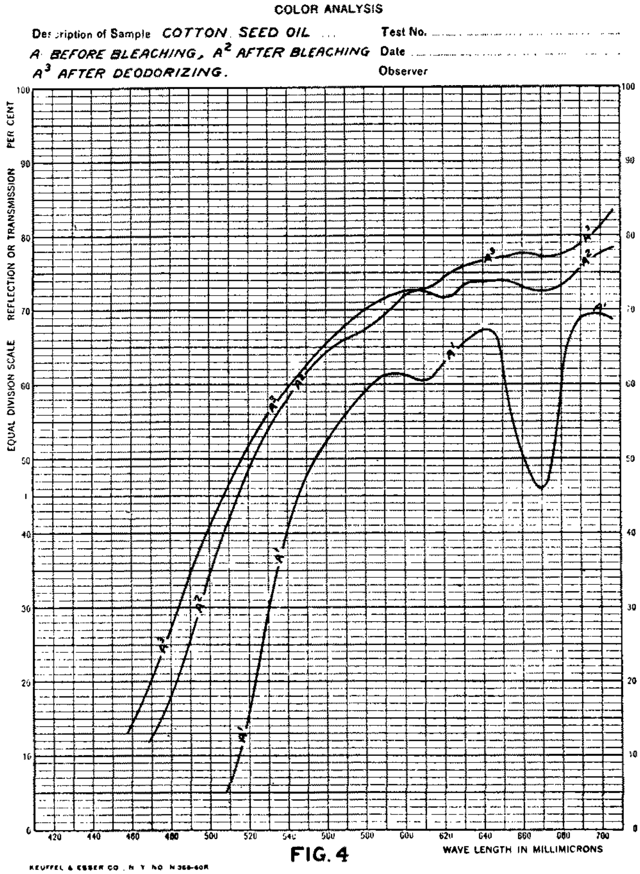

FIG. 4

In conclusion the outstanding features of this method of color measurement may be summarized as follows:

a. We can exactly specify a color by measuring its stimulus with the K. and E. Color Analyzer.

b. That this measurement is independent of the color vision of the observer.

c. That it is independent of the light with which the sample is illuminated.

d. That in the case of cottonseed oils it will probably be sufficient to determine only 5 or 6 points on the curve.

e. That it is possible to compute from the curve a single value for quality and one for brightness, which together give a simple system of notation for color. Aside from this, other methods of notation using three numbers are also available.

f. That the spectral transmittance curves may be useful in studying the efficiency of the bleaching and refining processes.

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THE DETECTION AND ESTIMATION OF SMALL AMOUNTS OF CHROMIUM IN FATS

BY A. O. SNODDY

It frequently happens that it is desirable to know whether a fat has been bleached by means of chromic acid and how much, if any, chromium has been left in the finished product made from such a fat.

Fats which have been bleached by chromic acid, even after refining and treatment with fuller's earth and repeated filtration, almost invariably contain small amounts of chromium, the persistence with which the chromium remains with the fat being due perhaps to its being present as a chromium soap, which is either actually soluble in oil or else so thoroughly protected by an oil coating that it escapes caustic refining and clarification treatments. The amount of chromium left in the fat will depend to some extent upon the care with which the treatments subsequent to the chromic acid bleaching are carried out and varies from a few hundredths to one or two parts of chromium per million of fat.

Advantage may be taken of the fact that dichromates react with symmetrical diphenylcarbazide, to give an intensely colored compound, to determine small amounts of chromium in the ash from such a fat. In the course of his work with phenylhydrazine E. Fischer[1] obtained phenylsemicarbazide and diphenylcarbazide. Skinner and Ruheman[2] obtained diphenylcarbazide by heating one mole of ethyl carbamate with two moles of phenylhydrazine until ammonia was no longer evolved. They also used urea instead of ethyl carbamate, this being considered at present the most efficient way of preparing this compound. They noted that mild oxidizing agents such as $CuSO_4$ and $HgCl_2$ gave colored compounds with diphenylcarbazide, and gave this as one of the differences between carbamide and those substances which contain groups of two atoms of nitrogen directly connected. They proposed this reaction with copper sulfate as a qualitative test for copper and showed that thiocarbazides also gave

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[1] *Ann.*, **190,** 113 (1877); *Ann.*, **263,** 272 (1891); *Ber.*, **22,** 1935 (1889).

[2] *Ber.* **20,** 3372 (1887); *J. Chem. Soc.* (London), **53,** 551 (1888).