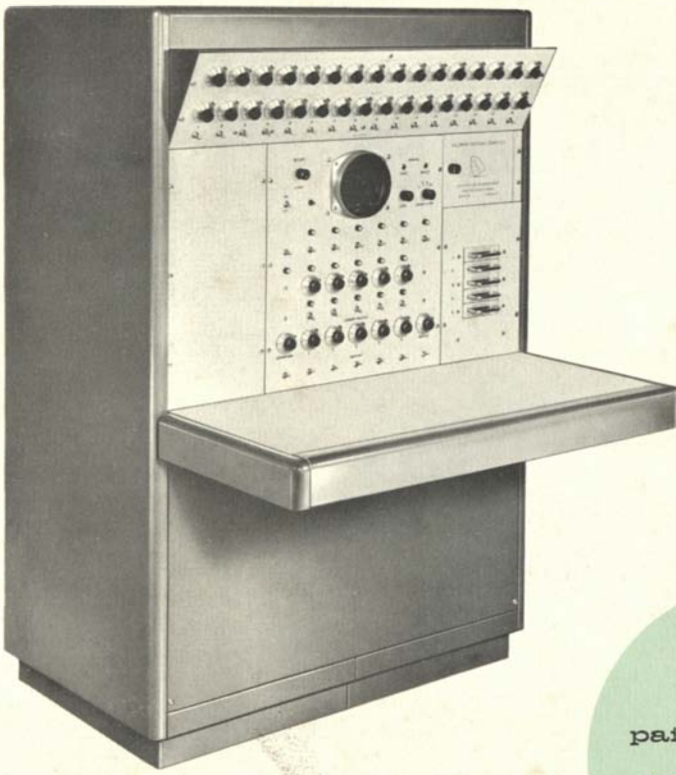
BULLETIN 10-561A

THE DAVIDSON AND HEMMENDINGER

COLORANT MIXTURE COMPUTER



for
fast, accurate
shade matches
and
production
color control

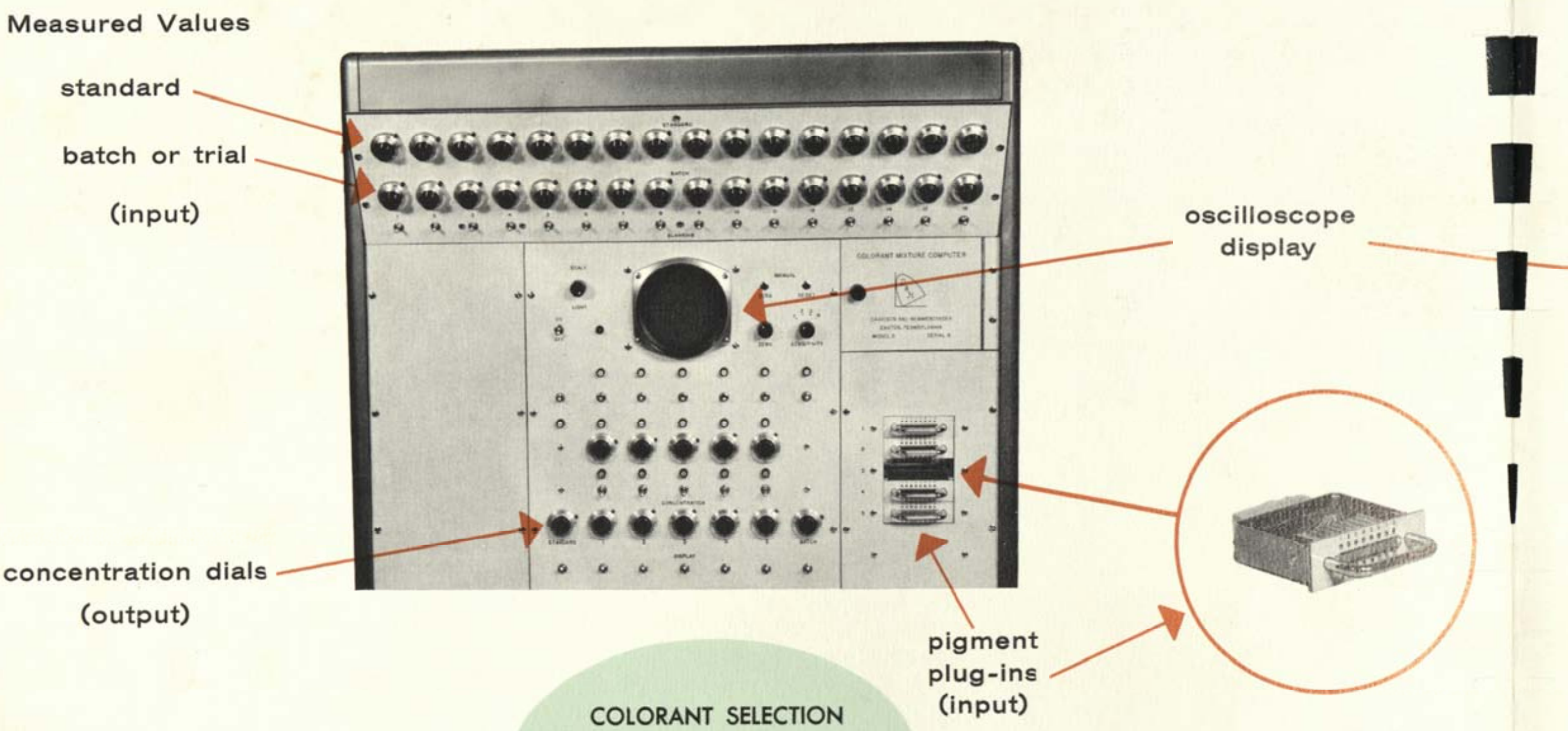
in
plastics
paints, ceramics
textiles, paper
coatings
etc.

D & H

Designed and Manufactured by

DAVIDSON AND HEMMENDINGER

Easton, Pa.



COLORANT SELECTION

Suitable dyestuffs or pigments to match the sample under all lights are quickly determined.

FORMULATION

Correct amounts of each colorant required are read directly from the computer dials.

PRODUCTION CONTROL

Production color batches in process are brought up to standard simply and efficiently.

WIDE FIELD OF APPLICATION

The computer can be used with most colored systems, including most types of pigmented or dyed reflecting surfaces, transparent sheets, and self-luminous phosphors.

INCREASE PRODUCTION

by reducing number of adds required to correct a batch.

REDUCE COSTS

by reducing equipment occupancy time and achieving more uniform production schedules.

IMPROVE QUALITY

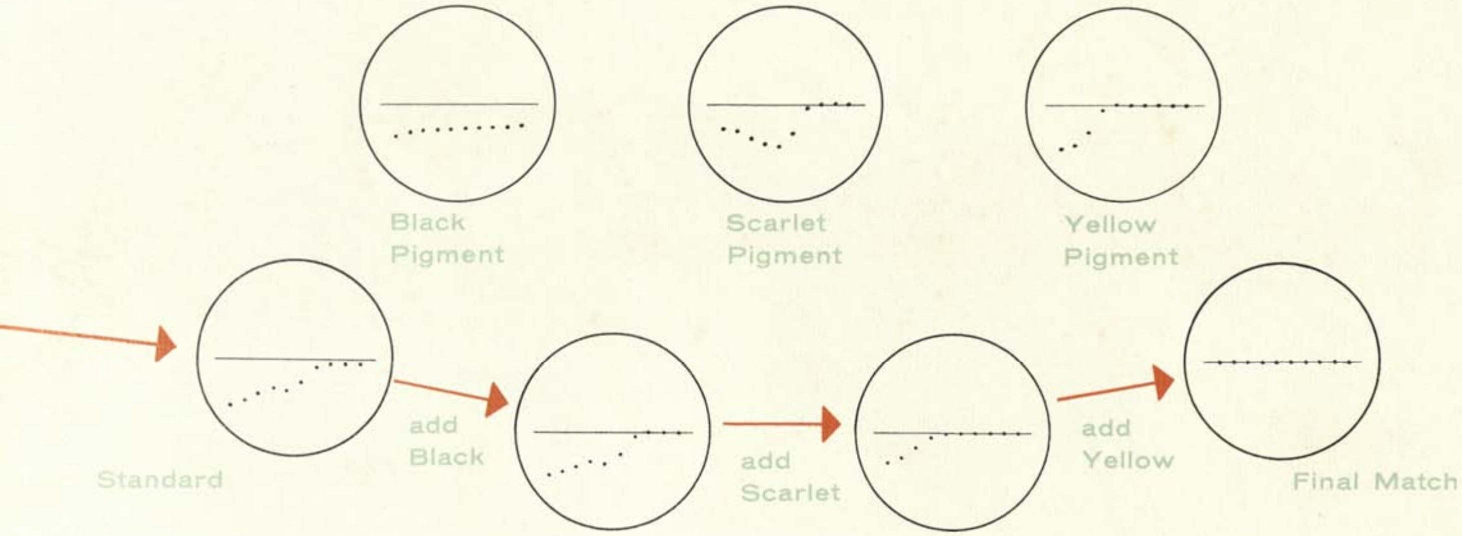
by eliminating reliance on visual color judgments.

SIMPLIFY FORMULAS

by reducing the number of dyestuffs or pigments required to match the shade.

ELIMINATE METAMERISM

(matches which change under different lights) by using correct colorants.



PRINCIPLES OF OPERATION

The Davidson and Hemmendinger Colorant-Mixture Computer solves the problem of color matching by displaying on an oscilloscope a series of dots representing a spectrophotometric curve. Each dot represents one of ten or sixteen equations (depending on the model), which are to be solved simultaneously. Each of these equations represents the sum of the contributions to light absorption made by each dyestuff or pigment at a particular wavelength and for the concentration set on the concentration dials. If the sum of these contributions equals the light absorption of the standard at that wavelength, the dot representing the equation appears at the zero line on the oscilloscope. If all dots appear on the zero line, all equations have been solved, the reflectance of the proposed match equals that of the standard at all wavelengths, and hence the colors will be matched. The proposed formula is then made up of the chosen colorants at the concentrations shown on the dials of the computer. If the dots do not appear on the zero line, the operator adjusts the concentration dials until they do.

When measured values for both the standard and the batch or trial match are placed in the computer, the difference in absorption between the two appears on the oscilloscope. In this case, when the dots are brought to the zero line, the concentration dials represent the amounts of each colorant to be added to or subtracted from the formula for the batch or trial. If no combination of dial settings will place all dots on the zero line, a non-metameric match cannot be made with the colorants chosen. The operator then replaces one or more of his plug-in boxes with those representing different colorants and tries again. If no alternative colorants are available, the computer may be used to obtain the best metameric match.

The equations solved by the computer are based on the use of some function of reflectance which is a measure of the absorption and is proportional to colorant concentration. The function $(1-R)^2/2R$, based on the Kubelka and Munk two-constant turbid media theory, is most frequently used and has proved adequate for most problems, but the computer is not restricted to use of this function. In any case, tables of suitable functions are available.

Measured values of the function for standard and batch or trial are placed in the computer on dials. Values for the various colorants are set into the plug-in units. Each plug-in unit represents a different colorant, and the values may easily be changed to represent any desired colorant.

OPERATING PROCEDURE

In the figure above, the oscilloscope face is shown as it would appear during the course of a colorant-mixture calculation. The first view, starting from the left, shows the position of the dots when values for a specified tan standard are placed on the "standard" dials. The appearance of this curve would suggest to the operator that a black, a red or scarlet, and a yellow must be used to make the match. He would select the plug-in boxes representing suitable pigments and insert them in the computer; the absorption curves for these pigments may be displayed on the oscilloscope as shown in the upper three illustrations. Now the operator increases the setting on the concentration dial for the black pigment until the dots take the position shown in the illustration to the right of the standard. He then adds scarlet and finally yellow. In the problem above, he would rapidly discover that no solution of the problem could be found with a red pigment, but that a scarlet pigment is required. When the dots all appear on the zero line as in the final illustration, the pigment concentrations may be read directly from the concentration dials. The order in which the pigments are added on the computer makes no difference in the final result.

The formula obtained in this manner will be close to that required to match the standard. It can be corrected by measuring the color produced by the formula and placing the appropriate values into the computer. A correction to the formula can then be calculated.

ACCURACY AND SPEED

Calculations, including manual input of the data, take about five minutes per formula if the colorants to be used are known, as in the case of correcting a production batch. The time required for formulation when suitable colorants must be selected varies with the complexity of the problem and the experience of the operator. The accuracy is such that for a large range of colors in several different materials, an inexperienced operator can make a color match to within normal commercial tolerances in about three trials. In the case of correction to a production batch, generally only one or two trials are required since the production batch itself forms the first trial. Even in simple formulation problems, the use of the computer typically leads to a two-fold reduction in the number of successive trials, relative to conventional methods of color formulation; in complex formulation problems a much larger reduction can be achieved.

STEPS REQUIRED TO MAKE A COLOR MATCH

1. Measure the reflectance of the standard at ten (or sixteen) wavelengths on a spectrophotometer or a filter photometer.
2. Change the reflectance values to values of the appropriate absorption function by means of a table.
3. Place these values on the computer dials.
4. Select plug-in units representing the colorants to be used and insert them in the computer.
5. Adjust the concentration dials until a straight line appears on the oscilloscope.
6. Read the concentrations for the colorant formulation directly from the concentration dials.

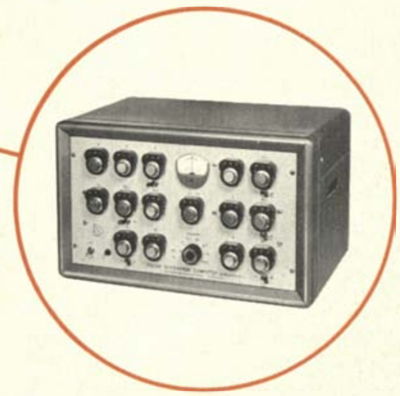
OTHER PRODUCTS AND SERVICES OF D & H

TRISTIMULUS DIFFERENCE COMPUTER

The Tristimulus Difference Computer is an accessory for the Colorant Mixture Computer. It permits the adjustment of colorant formulas to ensure that tristimulus values of a sample will match those of a standard, without requiring spectrophotometric measurements on each successive trial. It is useful where metameric matches must be made and is also useful in expediting production control.

COLOR DIFFERENCE COMPUTER

The Color Difference Computer provides a measure of color difference based on tristimulus values, or tristimulus ratios, of sample and standard. The tristimulus measurements may be made either with a spectrophotometer or with a filter photometer.



TRISTIMULUS COMPUTER

The Tristimulus Computer is a digital computer, which provides tristimulus values for both daylight and artificial light, automatically as the sample is being measured. It is designed to be used with the General Electric Recording Spectrophotometer and can also be used with other spectrophotometers.

SPECIAL COMPUTERS AND DEVICES

Digital and Analog Computers for other applications are designed and manufactured by the Davidson and Hemmendinger engineering staff.

D & H

Color measurements made on a General Electric Recording Spectrophotometer equipped with Tristimulus Integrator.

Sales and rentals of the General Electric Recording Spectrophotometer and Tristimulus Computer.

Preparation of color standards and color-tolerance standards.

Consulting on the industrial applications of spectrophotometry and color measurements.

One week courses on the fundamentals and applications of color measurements.

DAVIDSON AND HEMMENDINGER

2857 Nazareth Rd.

Easton, Pa.

BLackburn 8-2345 TWX Easton, Pa. 7111

PRINTED IN U.S.A.