Densitometry Meeting

Densitometers and densitometry constituted the subject of a symposium of the Scientific and Technical Group of the Royal Photographic Society of Great Britain held April 28, 1956, at the Imperial College of Science and Technology, South Kensington, England.

Among the papers read before the group were: "An Automatic Densitometer," by R. J. Hercock and G. Sheldrick; "A Densitometer for Colour Print Materials," by P. B. Watt; "Balance-Indication and Density Range Extension in a Split-Beam Densitometer Using Low Frequency Beam Chopping," by D. M. Neale; "A Method of Driving a Chopping Disc at Slow or Moderate Speeds," by E. A. Harvey; "A Simplified Treatment of the Relation Between Diffuse and Specular Density," by P. G. Powell; and "Densitometers and Densitometry," by S. L. Fulton and G. Syke.

An Automatic Densitometer

In presenting this paper, Mr. Hercock discussed the necessity for accurate densitometry in photographic work and described the limitations of early densitometers. In one of the earliest photoelectric densitometers two mutually perpendicular beams were taken from a lamp, one passing through the unknown specimen and the other through a calibrated optical wedge. After diffusion, both beams entered a double-windowed photocell which was connected to the grid of a triode valve, the variations in anode current of which were shown by a galvanometer. A mechanical shutter presented each beam alternately to the cell and by adjusting the reference wedge, equality of intensity was indicated when no deflection of the galvanometer spot resulted. Thus the value of the unknown density could be obtained from that of the reference wedge.

Disadvantages of this machine are (a) the light falling on the photocell depends upon the density of the specimen, (b) the sensitivity decreases as density increases, although this may be partially compensated, (c) the switch from one beam to the other cannot be made smoothly, and the galvanometer "kicks," (d) the d-c circuit is liable to cause drift of the galvanometer spot, and (e) manual balancing introduces a possible "operator error" at high densities.

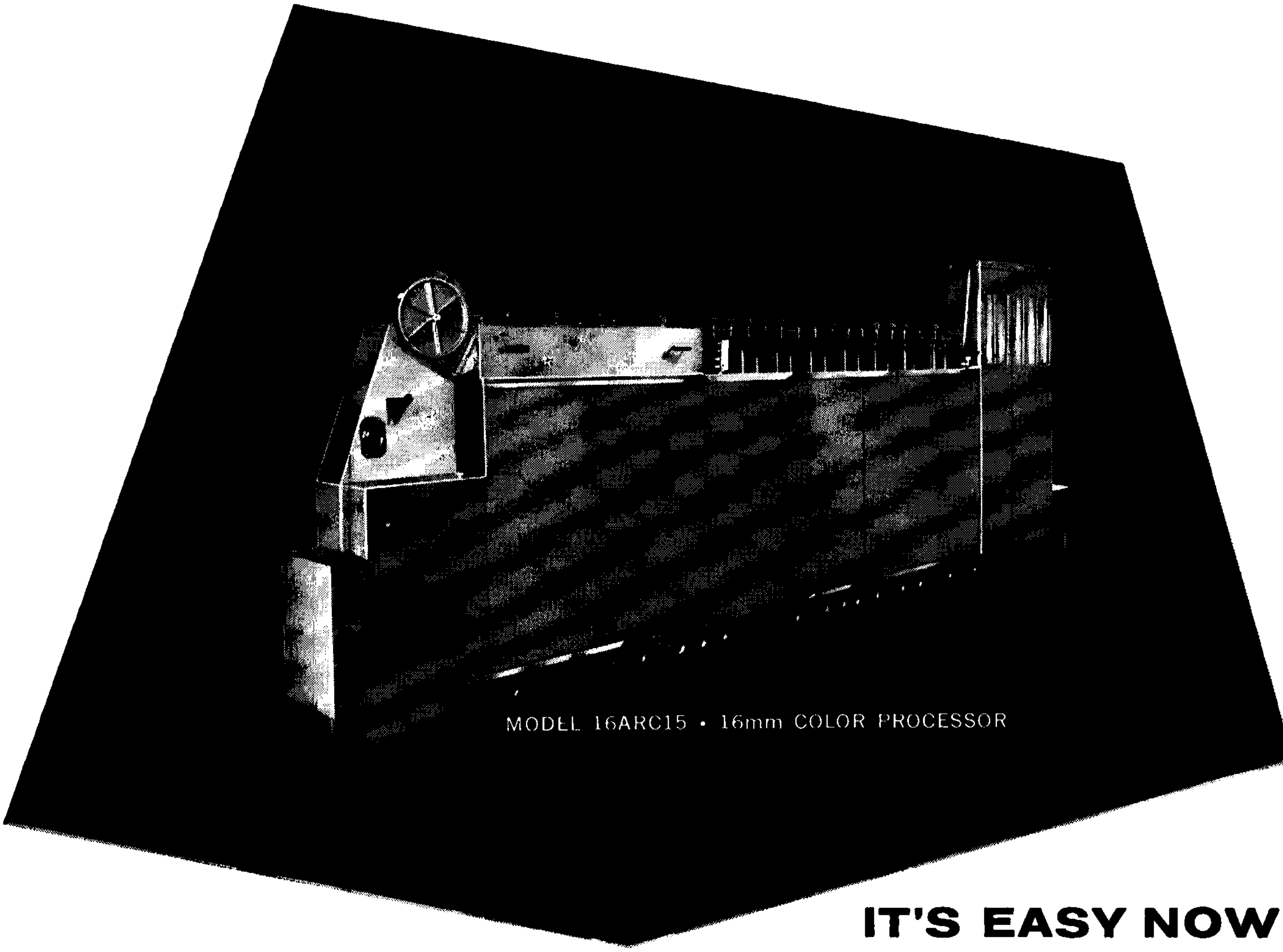
In the present instant these have been overcome as follows: (a) the measuring wedge and unknown density are in the same beam so that as the unknown density is increased the density of the measuring wedge is decreased and therefore both beams are kept at constant intensity; (b) by virtue of this modification the sensitivity is constant throughout the whole range; (c) a single beam is split into two by a rotating mirror; (d) the amplifier is a-c instead of d-c; (e) the movement of the wedge is controlled by a motor which responds to the photocell, eliminating errors in estimation of balance point.

The optical system was shown diagrammatically. The light from a lamp is alternately reflected and transmitted by a 3,000-rpm rotating mirror, one beam passing through a small wedge to form the reference level, the other passing through the unknown density and the measuring wedge. If the beams differ in intensity, a 50-c signal will be obtained from the multiplier, and the wedge can be adjusted until the two beams are equal, when the signal disappears. Over-adjustment gives a signal 180° out of phase with the first and by comparison with the 50-c reference voltage the direction in which to move the wedge is determined.

He explained that in the electrical circuit the output from the photomultiplier is fed to a cathode follower, which is in turn coupled to an a-c amplifier with a push-pull output. The output from the amplifier is fed to one field of a small induction motor, the other field being fed from the a-c mains. Depending on whether the signal voltage is $\pm 90°$ out-of-phase with the reference voltage, the motor will rotate in one direction or the other. This motor drives the measuring wedge in such a direction as to restore the balance of the optical system, the system being electrically damped to avoid oscillation or overshoot. The measuring wedge is also coupled to a stylus over a typewriter ribbon and graph paper, and when balance is established, depression of a foot switch plots the point. When the plot has been made a pawl releases one step of a ratchet cut to correspond to log E intervals of the exposing device, and the paper is moved to the next position.

Densitometer for Colour Prints

Mr. Watt reported that the specification



IT'S EASY NOW!

HOUSTON FEARLESS 16mm Anscochrome Labmaster

The world's leading specialists in complete systems engineering, introduce the very newest, the very finest—the Model 16ARC15 Anscochrome Processor. A continuous processing unit, it simplifies 16mm color film handling; is time saving and easy to operate. So compact it's measured in inches. So designed to require only routine service.

SPECIAL FEATURES: Doubles in black & white and reversal operation. Daylight operating 7-15FPM. • Laminated fibreglas chemical resistant construction. • Dry box temperature control from 0% to 100% in 1% increments • Infra-red heat from unbreakable steel strip heaters. • Unbreakable Cycolac spools and Pyrex glass ball bearings.* • Exclusive Houston Fearless clutch drive eliminates film breakage. • Built in refrigeration for first developer, bleach, second developer and hypo temperature control. • 220 V. 60 cycle single phase power; 1600 lbs. wt.

*AVAILABLE NOW! Cycolac spools with Pyrex ball bearings for existing film processing equipment.

Division of Color Corporation of America

HOUSTON FEARLESS
11801 West Olympic Blvd. Los Angeles 64, Calif., U.S.A.

Please send complete details on Model 16ARC15 Anscochrome Labmaster.

Name ________ Title ________

Company or Facility ________

Address ________

City ________ Zone ________ State or Country ________ of the machine were that reflection densities up to 3 should be recorded with an accuracy of 0.01 for $D = 0$ to 1, 0.02 for $D = 1$ to 2, and 0.1 for D greater than 2, and that interference filters could be used as well as gelatin filters. The simplest achievement of this was to use a lamp of constant brightness, the reflected light falling on a photocell, the amplified nonlinear signal being indicated by a meter designed to give an almost linear density calibration.

The convention of illuminating normally and collecting light scattered at 45° to the normal was employed. In order to obtain high photometric efficiency without use of beams of large angular width, an annular collector was used to pick up all light scattered at 45° to the normal. This was achieved by making the collector a narrow zone of an ellipsoid of revolution, this zone containing the minor axes. Thus when the paper is placed at one focus of this ellipsoid, the light reflected converges at the other focus, the width of the zone limiting the light to that reflected at 45 ± 6° to the normal. This collecting surface was approximated to a circular cross section of appropriate radius of curvature without loss of efficiency, and was made from chromium plated brass, Mr. Watt showing how this surface had been generated on the lathe.

The illuminating system follows conventional lines, including colour filters and a sector wheel to modulate the light at 100 c. Phase sensitive detection is used instead of a bridge rectifier to avoid the bottom bend in the characteristic of the latter. The meter gives an almost linear density calibration from D = 0 to 1 and by altering the amplifier gain this can be extended from D = 1 to 2, and it is necessary to use the nonlinear scale only above D = 2.

Balance-Indication and Density Range

Mr. Neale opened his remarks with a brief survey of variations in split-beam null deflection methods, stressing the necessity for the chosen technique to have good stability and sensitivity which is uniform over the whole density range.

In the model shown, uniform sensitivity is achieved by connecting the photocell directly to the grid of an electrometer valve, and since the grid current is an exponential function of the grid potential this, and to a fair approximation the anode current, are logarithmic functions of the light intensity incident on the photocell. Typical results were quoted for this circuit using a sampling beam of less than $\frac{1}{4}$-in. in diameter, uniform sensitivity being obtained up to D = 1 dropping by 20% at D = 2. With a $\frac{1}{4}$-in. sampling beam, it is easy to maintain uniform sensitivity to D = 3.5.

The circuit is, however, a d-c amplifier and controls must be applied to eliminate changes in mean galvanometer deflection at different densities, and the galvanometer "kicks" as the beams alternate. These limitations are removed by a three-position sampling switch in synchronism with the continuously rotating beam chopping shutter. This circuit was described at length, the action of the sampling switch being demonstrated by comparison of waveforms. With a chopping frequency of 7 c, the difference between the cathode potentials is readjusted abruptly fourteen/sec. A moving coil microammeter has sufficient inertia to smooth out these steps, and the balance indicator appears to respond to the balancing control of the densitometer smoothly and accurately.

At high densities the photocell passes very little current and behaves as a very high resistance. With other factors this represents a time constant so large that a rectangular grid waveform cannot be preserved with chopping frequencies above 10 c. In practice the 7 c adopted gives instantaneous response and also makes it easy to filter out mains hum or ripple in the lamp supply. Consequently a-c supplies may be used for lamp and valve heaters.

By addition of further density extension circuits it should be possible to obtain even greater range of uniform density but this has yet to be tried, the results so far being a densitometer using only three thermionic valves with substantially uniform sensitivity up to D = 4.5 with short and long term stabilities of the order of 0.002 density x units.

Densitometers and Densitometry

Mr. Sykes described from the professional designer's viewpoint the elements of a photoelectric densitometer, and Mr. Fulton discussed the need for a reliable densitometer and how the Baldwin Vacuum Cell Photometer could meet the need.

The papers presented at the Symposium will be published in the Journal of Photographic Science by the Royal Photographic Society, 16 Princes Gate, Kensington, London S.W.7.