特別掲載

A NEW METHOD OF PRODUCING SPOTS FOR THE BLENDING PHOTOSCAN AND REPRESENTATION OF ISODENSITY PATTERNS OF THE PHOTOSCANS BY THE APPLICATION OF THE SABATTIER EFFECT

By

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重ね合わせ photoscan 法のための新しい Spot 製作法と Sabattier 効果を利用した photoscan 像の再現

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目的 photoscan 像から半定量的な情報を得ようとする試みが種々なされているが，最近 Tsien は Sabattier 効果を利用して簡単に等黒化度曲線を画けることを発表した．この方法を photoscan 像に適用して診断の向上に役立てる．

方法および結果

(1) Sabattier 効果を利用するためには従来の dot scan を連続黒化像とする必要がある．それには安河内あるいは Charleston 他の方法があるが，我々は安河内の方法に改良を加えた次の方法を開発した．光源の像の位置に薄い紙 (tracing paper) をおき，散乱光と透過光の組合わせを適当にして，film面での光の強度分布を用いた cone の焦点面での感度分布に近似的に等しくなるようにする．この方法では tracing paper と film 間距離（FFD）を変えることにより，又絞りの大きさおよび形を変えることによつて種々の強度分布をもつ light pattern を作ることができる．

(2) photoscan 像は光の強度分布の相違により変化するが，Sabattier 効果を利用した等黒化像の再現に適した方法を解析した．又被検体の単位面積当りの count 数が小さいと scan 像に斑点を生ずるが，この際には spot を大きくすればよい．この spot 製作法ではその大きさを容易に変えることができるから便利である．

(3) Sabattier像を得るための基礎実験を行い特性曲線のガンマの大きい Fujilith Ortho Film を選定し，露光条件を決めた．

結論　この新しい spot による photoscan 像は分解能もよく colcr scanと併用すればその効果は大きい．又 Sabattier 効果を利用した再現法は露光過度の film の再現にも役立ち，color scan のとれない装置では半定量的な情報を得るのに手軽な方法であると考える．

Introduction

Several methods for extracting some semi-quantitative information from photoscans have been reported[1)-4)]. Recently, Tsien et al.[6)] have reported a method of showing isodose patterns utilising the Sabattier effect with photographic film. This method can be applied to semi-quantitative representation of photoscans, as they have pointed out. In order to apply this method, however, it is necessary to improve the conventional single-dot photoscan so that the photographic density varies continuously from point to point.

Charleston et al.[2)] use a light source in the photoscanner which produces a spot with a Gaussian intensity distribution to smooth out discontinuities. In their report, however, the method of producing such a spot is not described. According to MacIntyre et al.,[5)] a large photographic display area combined with line spacing increments which are small in comparison to the circle diameter is used and the large photographic display area is made up of approximately 10,000 small points of light with a diameter of one micron or less in a quasi-Gaussian distribution on a black background. This method is called the data blending technique.

Another simpler method for smoothing discontinuities of photoscans has been reported by Yasukochi,[7)] who diffused a conventional single spot by a plastic plate which was interposed between the light source and film.

The present paper reports a simpler method for the data blending technique developed from the method by Yasukochi and results of applying the Sabattier effect to the photoscans.

Apparatus

Since the objective is to record the data similar to that seen by the detector, it is considered that the overall size of the intensity distribution on the film should be consistent with the collimator design. In practice, it may be sufficient to make the distribution on the film approximately identical to the response curve at the focal plane of the collimator. Consequently, it is desirable to alter the intensity distribution according to the collimator used.

Arrangement of the optical system for the data blending technique is illustrated in Fig. 1. A thin paper (tracing paper) is placed in the position of the image of a light source (F). The intensity distribution on the film can be varied by changing the point F-film distance (FFD), and size and shape of the diaphragms

Fig. 1. Schematic diagram of optical system for the data blending technique

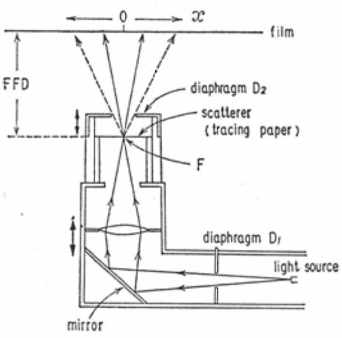


Fig. 2. Intensity distribution of the spot for photoscannig on the film

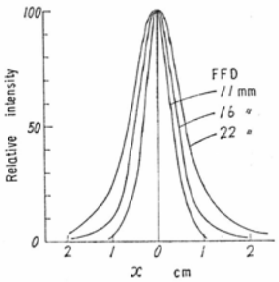
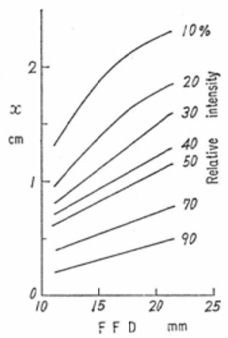


Fig. 3. Variation of intensity distribution of the spot on the film with FFD



D_1 and D_2.

The variation of the measured intensity distribution on the film with FFD is shown in Figs. 2 and 3, which are obtained from films of the spots using the density-exposure curve. These figures are without the diaphragm D_2. The intensity decreases at the periphery, but diffuses to infinite. When the diaphragm is placed at D_2, tail of the distribution is cut off and the display area becomes finite.

The scintiscanner used, manufactured by the Tokyo Shibaura Electric Co., Ltd., is able to take the color scan, dot scan, and photoscan, and the part of a light source system of this scanner has been improved as described above.

Experiments of Photoscanning

Using a thyroid phantom, whose radioautograph is shown in Fig. 4, photoscans have been recorded by this data blending method with various intensity distributions to determine the adequate averaging system for representation of photoscans utilising the Sabattier effect.

The results obtained are as follows:

1. Variation of photoscans with FFD obtained without diaphragm D_2.

Fig. 4. Radioautograph of a thyroid phantom

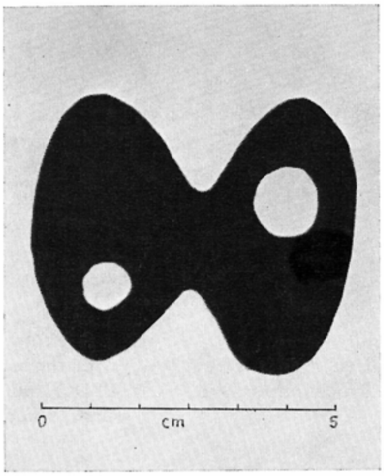
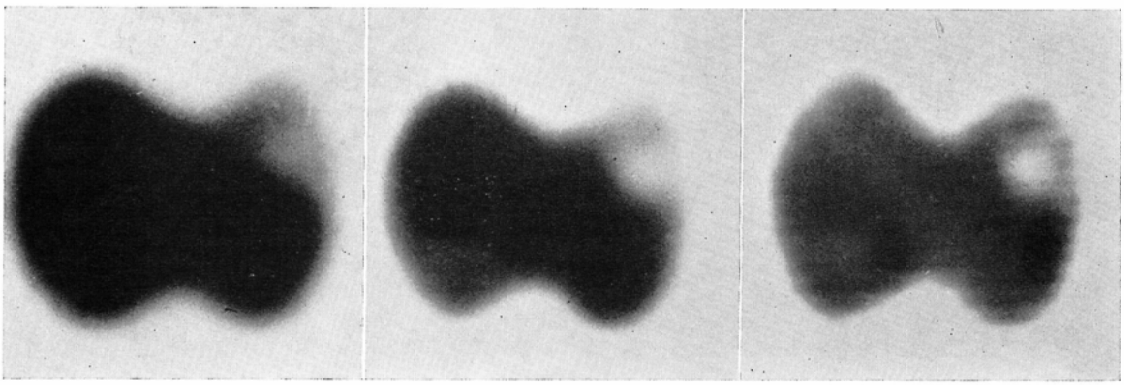


Fig. 5. Photoscans of a thyroid phantom obtained without diaphragm D_2.
Spacing 4mm, scanning speed 25cm/min.

(a) FFD 22mm (b) FFD 16mm (c) FFD 11mm



The results are shown in Figs. 5 (a), (b), and (c), as obtained without the diaphragm D_2. Since the display area is infinite in this case, the image of photoscanning is smoothed out in both the x and y axes, although the resolution is poor. By decreasing the FFD, which means to decrease the effective diameter of the light pattern, the resolution becomes higher, but striped patterns or line structures are produced. This may be due to the fact that the intensity is overemphasized at the center in comparison to the periphery and the effective diameter of the display area is small in comparison to the line spacing.

2. Variation of photoscans with line spacing obtained with diaphragm D_2.

Since the display area is finite in the case of placing the diaphragm D_2, line structures are observed. When the line spacing is large in comparison to the display area, the line structure shows a lower density or white line. Since decreasing of the line spacing results in increasing overlaps, the line structure becomes

Fig. 6. Photoscans of a thyroid phantom obtained with diaphragm D_2. FFD 16mm, diameter of light pattern 1.0cm, scanning speed 25cm/min.

(a) spacing 4mm (b) spacing 2mm

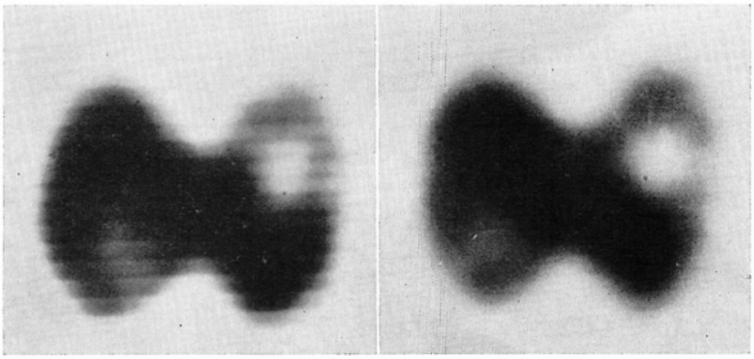


Fig. 7. Photoscan(b)of a thyroid phantom obtained with a light pattern as shown in (a). FFD 16mm, spacing 2mm, scanning speed 75cm/min.

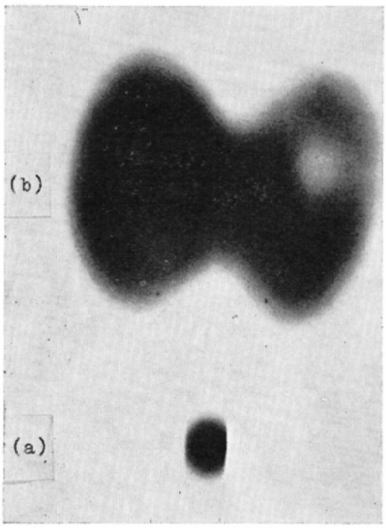
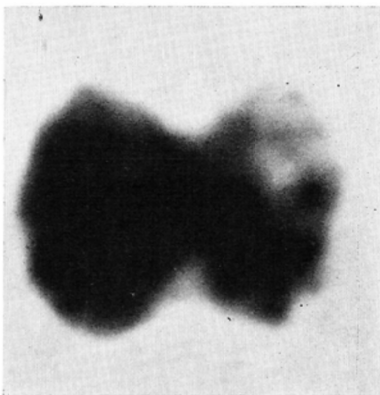


Fig. 8. Photoscan of a thyroid phantom obtained with the lower counting rate. Maximum cps 25, FFD 11mm (without diaphragm D_2), spacing 4mm, scanning speed 25 cm/min.



higher in density and finer. These results are shown in Figs. 6 (a) and (b), wherein the phantom is scanned with a 10 mm diameter light pattern with a scanning speed of 25 cm/min.

The resolution of photoscans obtained with the diaphragm D_2 is higher than that without the diaphragm, but the line structure produced with the diaphragm may not be adequate for representation by the application of the Sabattier effect. In order to improve this line strucutre, a light pattern as shown in Fig. 7 (a) has been used. This pattern is preferable to others for the application of the Sabattier effect, although the resolution becomes slightly lower as shown in Fig. 7 (b).

3. Variation of photoscans with counts per unit area.

When counts per unit area are few, spot structures are produced as shown in Fig. 8, which has been already pointed out by Charleston[2] and MacIntyre.[5] In the case of an objective with lower count rates, therefore, it is necessary to use a large light pattern, low scanning speed, and small line spacing.

In practice, when the FFD is only increased from 11 mm to 22 mm, with the same conditions for the others, the spot structures shown in Fig. 8 have been smoothed out.

Representation Utilising the Sabattier Effect

Sabattier found that if an exposed emulsion was only partially developed, given a uniform exposure, and further developed and fixed, a partial or complete reversal of the image was obtained. Rakow and Tsien et al.[6] showed that isodose patterns could be obtained from films exposed to X or γ rays utilising the Sabattier effect.

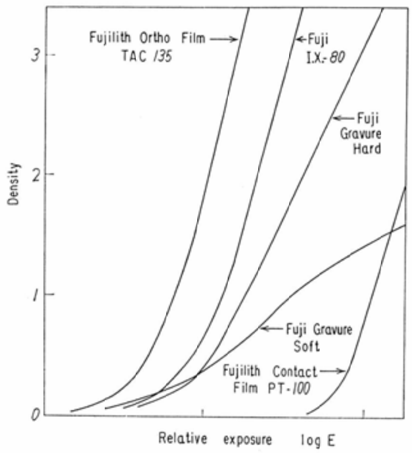


Fig. 9. Density-exposure curves for various films.

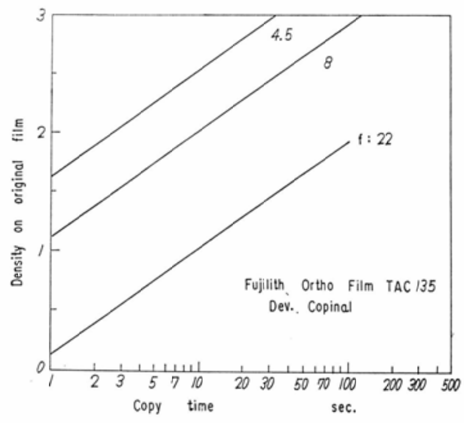


Fig. 10. Copy time for the isodensity line film versus original film density. Time of first development 2min, second exposure 20 sec, total development 4 min.

According to Tsien et al., the best results are obtained when high-contrast films are used as the original films. For a similar reason, we decided to use Fujilith Ortho Film for the representation film of isodensity patterns and its density-exposure curve is shown in Fig. 9 in comparison with other films.

Using a standard step-density film, a graph of copy time (first exposure) versus original film density was obtained as shown in Fig. 10. An enlarging machine was used as a light source for printing.

Five isodensity patterns of the photoscanning film of a thyroid phantom obtained by this method are

Fig. 11. Isodensity patterns made from the film shown in Fig. 7.

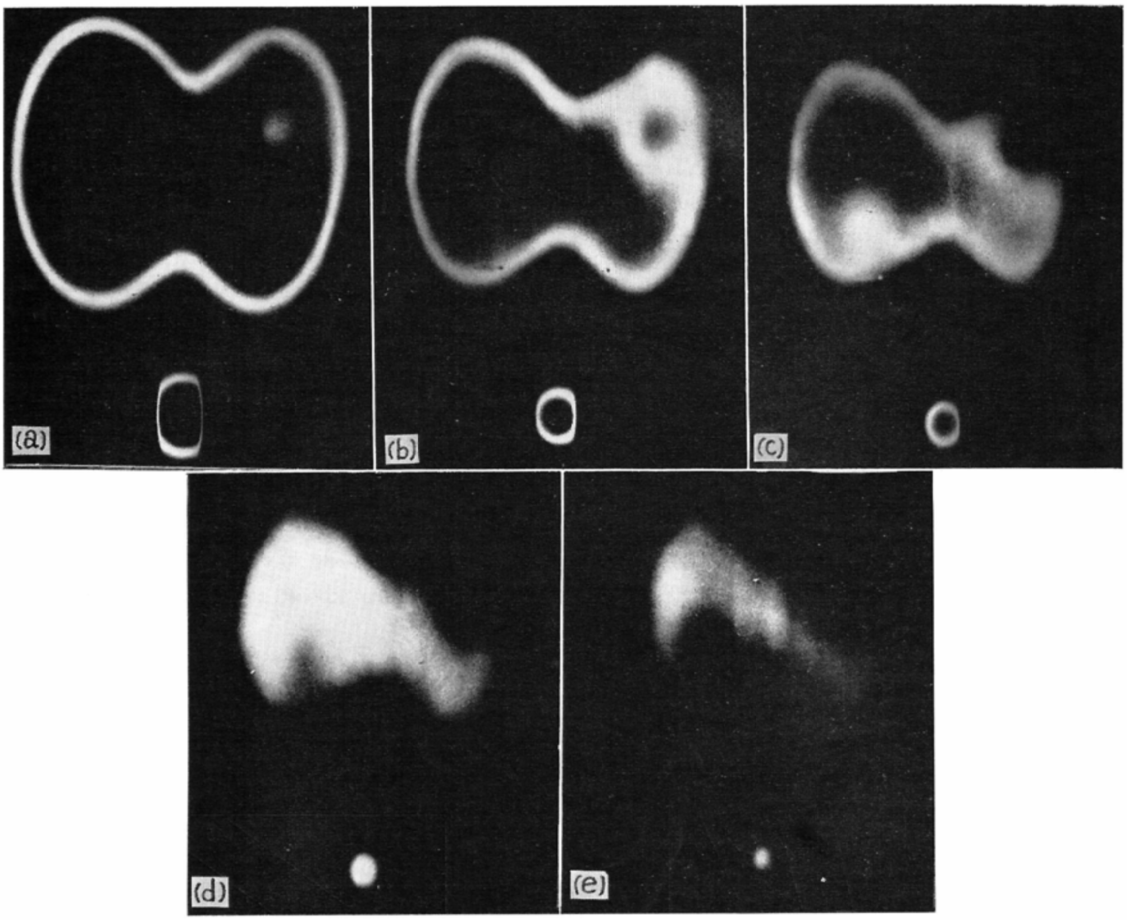


Fig. 12. Composite print of three isodensity patterns shown in Figs. 11 (a), (b)and (d).

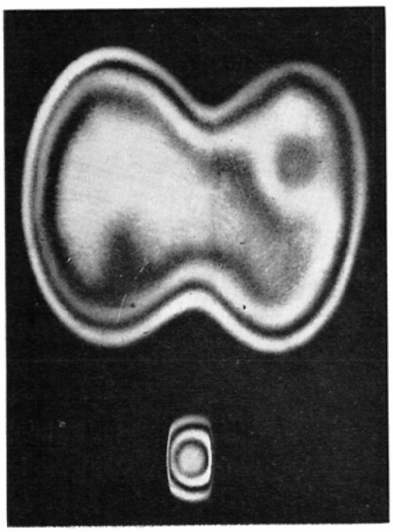


Fig. 13. Composite print of three isodensity patterns shown in Figs. 11. (a), (c) and (e).

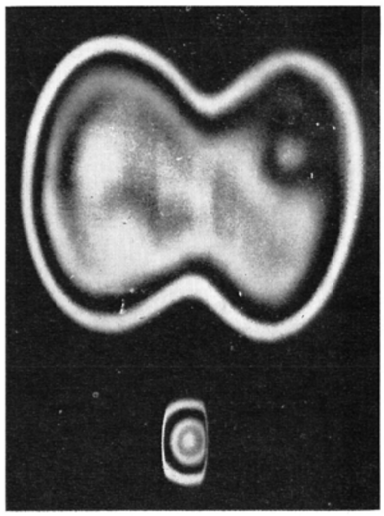


Fig. 14. Isodensity patterns made from the film of liver scan shown in Fig. 15.

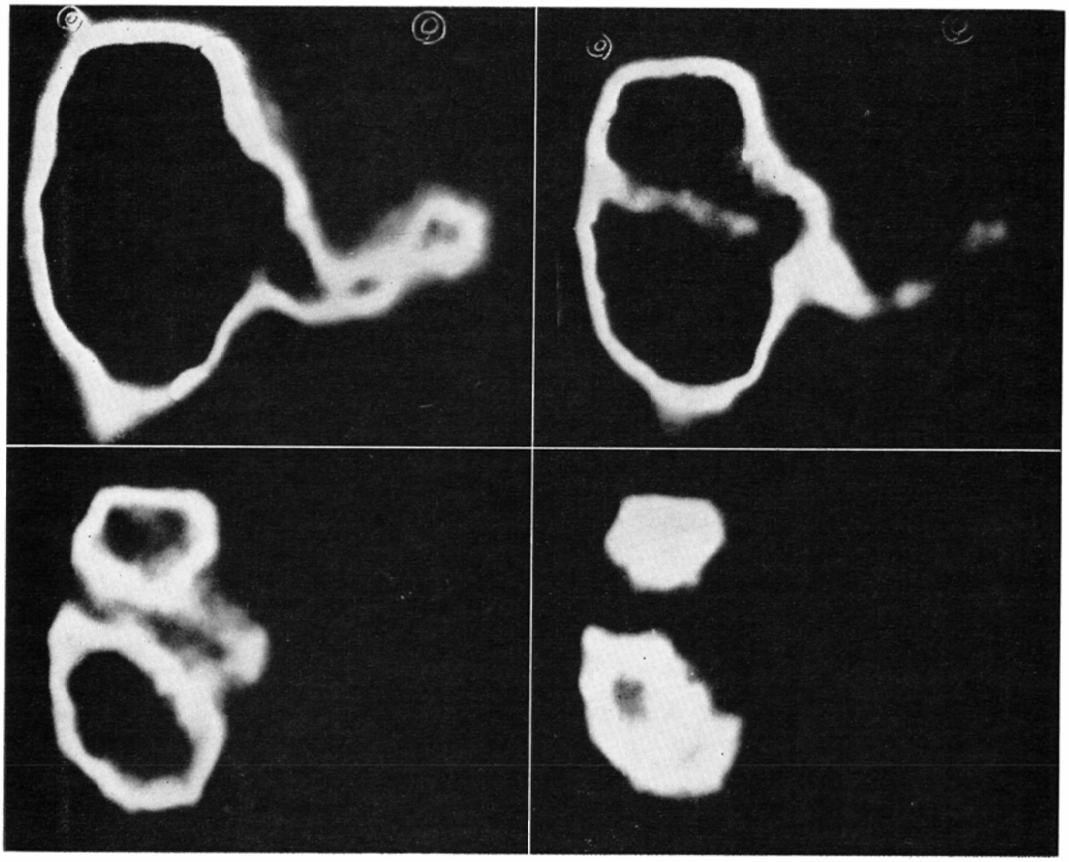


Fig. 15 Liver photoscan obtained with the data blending technique.
FFD 16mm, spacing 4mm, scanning speed 25 cm/min.

shown in Figs. 11 (a), (b), (c), (d), and (e). The original film is shown in Fig. 7. Each of these isodensity patterns shown on these films was exposed, one after another, on a single film. The final results are shown in Figs. 12 and 13 as printed further on a sheet of bromide paper. Fig. 12 is a composite print of three isodensity patterns shown in Figs. 11 (a), (b), and (d). Fig. 13 is a composite print of the films shown in Figs. 11 (a), (c), and (e).

Isodensity pattern films of a liver scan are illustrated in Fig. 14 in comparison with the original photoscan (Fig. 15).

Discussion

In radioisotope scanning, it is desirable that full information of an objective can be recorded on one scan with a sufficiently small standard deviation that no contrast or accentuation is needed. For this purpose the data blending technique has been developed. In this technique, it is necessary to minimize the random fluctuations of counting rate by averaging over an area consistent with the distribution of count detection of the collimater. The method described here is useful to accomplish this purpose, since the technique is simple and the intensity distribution of the photographic display area can easily be changed according to the collimator or counting rates of the objective.

In any of the spatial average scans it is often necessary to outline underlying structures which give only small differences in counting rate or optical density. This can readily be done by the application of the Sabattier effect to the blending photoscans. This method has the effect of intensifying the scan in the region required and is useful to retrieve overexposed photoscans.

Summary

1. The method of producing a spot with a Gaussian intensity distribution for the blending photoscan has been reported.

2. Fundamental experiments were carried out to determine the adequate technique for the representation of photoscans utilising the Sabattier effect.

3. Examples are shown for using this technique on a scan of a thyroid phantom and a liver.

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