DEVELOPMENT OF THE ZY—1 AUTO—DODGING PRINTER

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ABSTRACT:

The auto—dodging printer is a new image reproduction equipment . The aerial light source system which consists of silicon photoelectric elements is used to receive and measure nagative density, and it is integrated by circuit in order to realize the automatic quantitative exposure and light adjustment in differential way. The result of this is large area contrast regulating and details contrast keeping, and hence retains more information in the photography. The equipment uses vaccuum system for plate flattening, so that the accuracy of flattening is assured, and high resolution and well geometric accuracy can be obtained. The color and black/white is compatible. The printer is easy to operate and high efficiency.

I. INTRODUCTION

The auto—dodging printer ZY—1 has been developed in order to obtain the positive duplicates with high image quality and geometric accuracy. The system uses lamps array as a light source, and density measurement and feed—back system are composed of the silicon battery of parallel control and integrated operation unit, quantitative exposure and dodging are realized in defferential form. The system has the functions of contrast adjustment of large area and of retaining the details contrast at the same time. A vaccuum auto—control absorbing system is used as film flattening system, thus it can ensure the flattening accuracy and improve the transmitting ability of image space frequency, meanwhile, the compatibility of B/W and color printing is realized.

II. PRINCIPLE

For photogrammetry and remote sensing interpretation, it requires the image with good contrast, suitable density range, resolution as high as possible, especially the resolving ability nearby should not be lost in the reproduction process. As a result of the influence of uneven illuminating distribution by camera lens, illuminating distribution of the negative is decreasing in $\cos^3 x$ relation from center to edge, it brings about the appearance of uneven density, this influence is particular significant in wide angle and super—wide angle. Moreover, large area of shadow of vegetation and terrain object caused by different solar altitude, also can bring about the appearance of uneven density. When the density range exceeds the tolerance film of aerial duplicating materials, the image information will be lost. In such a case, soft sensitive material of low contrast can be used to fit the density range of negative, but in this way some information of high light layer and dark tone layer will be lost, thus the detail contrast of image, as well as the property of photo interpretation will be decreased. The best way is to carry out a differential exposure in all parts of negative, usually it is called " light adjusting " or "dodging". The method is that the exposure time is longer in high density area of negative, and short in lower density area. if the light—spot on the contact glass projected by differential light is enlarged considerably, then the generalized contrast of negative can be reduced, meanwhile, the contrast within small area of negative can be maintained, the prin-

ciple of differential exposure can be illustrated by the sensitometric curve of standard wedge (Figure 1).

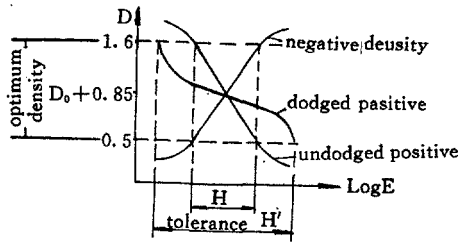

Figure 1: sensitometric curve

From Figure 1 it can be seen that the image density of high light part and low light part of undodged positive exceeded the optimum range of negative density (D0.5—1.6), and nearly all the parts of image of dodged positive is within optimum density, thus more interpretable information is provided, and there are more tolerance under the condition of the same sensitive material.

Differential exposure can be realized through the two ways: sequential or parallel exposure. Sequential exposure generally is used by electronic printer, negative is exposured through cathod—ray tube scanning. The advantage of such an electric printer is that the light—spot of scanning is smaller, which can be dodged on the object within low density range, and it is favourable for the reflection visibility of detail in shadow ranges. But this printer will reduce contrast between objects in small area. In addition, the stability of high pressure curcuit is not up to standard, and high requirements for maintainance technology, as well as high cost etc., which are reasons affected by the popularization of this printer.

The parrallel exposure control is realized through the array light located below a diffusion plate. Normally there is a group of array switch on control plate, operator can get even exposure by manual setting of exposure parameters of light source according to the density distribution of negative. The advantage of this printer is low cost, and easy maintainance. When density range of negative is adapted to the tolerance of sensitive materials, photo in optimal quality can be printed. The advantage is rather high operating skill and high intensity labour needed. Besides it needs more time to make a test, and rather more time and materials are wasted.

Absorbing above advantages, the Auto—dodging Printer ZY—1 uses a group of array light combined by 132 light sources, each light source has an independent autoexposure control curcuit, when turn on light source at the same time, these curcuits can measure the negative density within the light projected area. Continue time of each light is controlled in terms of density. As light passes through negative and sensitive material and reaches its required exposure, light can be automatically turned off, thus the auto—dodging and auto—control exposure can be realized.

The advantage of such printer is wide exposure control range, it not only adjusts the contrast in large area of negative, fits the tolerance of sensitive material and optimum density range, but also maintains contrast of detail and more information of photo image within small range.

III. FLATTENING SYSTEM

Generally there are two kinds of flattening systems for a erial photo printer, one is gas-

ket flattening, which is a popularly adopted. When using the method, the gasket brings pressure to the negative and sensitive paper on contact glass. As a result of the tension of sensitive material caused by gasket pressure, the sensitive material will produce uneven deformation. Another disadvantage of this gasket is that pressure is not easy to control. Due to the slow airleak, the pressure will be gradually decreased in operating period, and leads to image illegible. On the other side, it is often happened that the contact glass will be broken if the pressure too large.

Another flattening method is to use a foam plastic plate. This method needs operator to bring suitable pressure to the plate, the result of flattening is different depends on different operator. Moreover, the ageing and damage of foamed plastic plate will also affect the accuracy of flattening when it is used for a long time.

The auto-dodging Printer ZY-1 uses automatic vaccuum absorbing method, it is an auto vaccuum setting control system combined by a vaccuum pump, pressure-meter of electric contact point, gasket, auto control curcuit vaccuum pressure can be automatically controlled by the system and film flattening is absolutely reliable. When vaccuum pressure reaches -0.08 M Pa in negative side, the pressure is able to meet the requirements of film flattening. Due to the high speed of operation of vaccuum pump (30 L/m), the required pressure can be reached within very short time (1-2 seconds). As the pointer of pressuremeter of electric contact point reaches the required pressure, the system will start exposure automatically.

In order to pass light through gasket, a piece of plexiglass was sandwiched in gasket, in this way, the gasket can do both: flattened and pass light , so that sensitive element can receive light through the photo paper and negative. The pressure of vaccuum flattening is even and close, the diffusion of air medium between positive and negative is reduced, the loss of space frequency transmittence is decreased in the reproduction process, thus the quality of reproduction is improved. It is illustrated through the following three tests. The first test is the comparison of resolution before and after reproduction of Kodak resolution chart film, its format is 23×23 cm^2, there is a group of resolution chart images respectively around its corner and center, the highest resolution of each group chart is 300 line pair.

Kodak 2421 duplicate film and Hope 152 developer are used in reproduction, temperature is 26.5c, developer is 885 set solution. Resolution after reproduction is 120 line pair, the resolution has a great improvement as compared with other kind printer used in China at present. The second test is the comparison of resolution before and after the reproduction of aerial photograph of target. The comparison data as illustrated in Table 1, basically there is no more loss, "low comparison" is decreased slightly. The third test is to reproduce geometric accuracy measurement using kodak target. The format of kodak target negative is 23×23cm^2, 102 mm from its center four fiducial marks, the reproduction condition as the above. The measurement of original film and duplicate film can be done under the Japanese universal measuring microscope respecively, the results are illustrated in Table 1-2.

Table 1: Measurement of reproduction geometric accuracy of kodak target

Geometric accuracy	Fiducial distance of original film	Fiducial distance of duplicate film
x Direction	204.1005mm	204.1000mm
y Direction	204.1005mm	204.1055mm

Table 2: comparison of resolution before and after reproduction of aerial photograph with target.

Resolution of original film before reproduction			
	high contrast	middle contrast	low contrast
x direction	29 line pair	36 line pair	36 line pair
y direction	29 line pair	29 line pair	29 line pair
Resolution of duplicate film after reproduction			
	High contrast	middle contrast	low contrast
x direction	29 line pair	36 line pair	29 line pair
y direction	29 line pair	29 line pair	24 line pair

A test on the auto—dodging printer has been conducted by the photographic teaching and research section of Wuhan Technical University of Surveying and Mapping, measurement on aerial photograph reproduced by different printers suing MTF. The conclusion is that the flattening quality of printer ZY—1, through the comparison and test, the reproduced quality shows that its image has good response either in low frequency (reflecting image contrast) or high frequency part (reflecting image details). It can be seen in the measurement data (Table 3).

Table 3: MTF measurements of aerial duplicating film

	No 622 (film No)					No 530 (film No)				
	R_x	R_y	$\sqrt{R_{xy}}$	R_s	$S_{0.2-0.4}$	R_x	R_y	$\sqrt{R_{xy}}$	R_s	$S_{0.2-0.4}$
ZY—1 Printer	40.16 (1p/mm)	47.20 (1p/mm)	44 (1p/mm)	21.86 25.66 28.76	7.30(x) 8.32(y) 7.81 (average)	38.88 (1p/mm)	33.03 (1p/mm)	34 (1p/mm)	19.47(x) 17.38(y) 18.42 (average)	5.96(x) 5.15(y) 5.56 (average)
Violet light Printer	18.94 (1p/mm)	44.89 (1p/mm)	29 (1p/mm)	10.49 24.46 17.48	8.87(x) 8.69(y) 6.28 (average)	33.67 (1p/mm)	23.24 (1p/mm)	28 (1p/mm)	17.35(x) 12.86(y) 15.10 (average)	6.04(x) 4.45(y) 5.24 (average)

Ⅳ. PRINTING OF B/W AND COLOR PHOTOGRAPH

In order to print B/W and color photograph with the printer ZY—1, an incandescent lamp of low pressure is used as light source. The spectrum of such a lamp includes all the visible spectrum, and light sensitive spectrum range is 400～1100μm, entered into infra—red area. The range of sensitive material used in printing is 380～550μm for B/W paper, 400～700μm for color paper. In order to match the sensitive range of light element and material, a filter is added in curcuit, large part of infra—red and part of red light is filtered. By such a correction, both B/W and color photo can be printed by the printer. The printer is equipped with a color filter frame, which can mount filter. Filter is divided into three colors, yellow, magenta, blue; each color is divided into 14 different density of dark and light. The filter is a special made polyster film, with a characteristic of unfade for a long time and dump without deformation.

Ⅴ. METHOD OF CALCULATION AND ADJUSTMENT

The whole exposure system is constituted by 132 different exposure subsystems, each of which controls exposure of small pieces of area, its exposure calculation will be completed

using the following formula:

$$W=\int . E . dT$$

where: W—exposure T—exposure time

E—adjusting lightness value of lightness and negative density

If it is represented in a form of light sensitive elements and the integral form of integral curcuits, the formula can be written:

$$V_0=1/C \int I_{in} . dT$$

or $V_0=V_s/R_0 \cdot C \cdot E(T)$

where C—integral capacity V_0—integral pressure

V_s—Light sensitive element pressure R_0—Light sensitive element resistance

I_{in}—Light intensity of curcuit

The diagram of basic curcuit principle is illustrated as Figure 2.

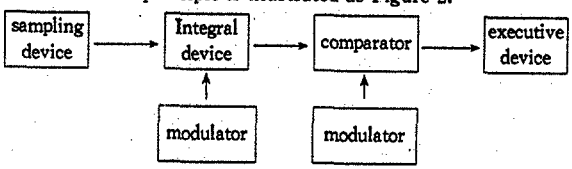

Figure 2: Diagram of curcuit principle

A comparison of integral pressure V_0 with adjustable fixed refering pressure V_{in} has been done in the comparator, as it reaches $V_0=V_{in}$, integral curcuit is cut, and exposure will be stopped. The exposure of each unit area at this time is:

$$E(T)=\frac{R_0 \cdot C \cdot V_{in}}{V_s}$$

Integral time can be changed by modulating V_{in} and the exposure required can be represented by the sensitivity of different sensitive material.

When processing the negative of different contrast, the distance of modulating dodging plate and light source can be adjusted, thus it can change the power of dodge, or add two layers of dodging plate, and improve the uneven phenominem which may be caused by light itself and modulating area.

To obtain the duplicated image of photogrammetry and remote sensing with high quality, besides selection of printer of high property, the selection of duplicated material of high resolution should be paid more attention, through the optimum combination of material and solution, density of different contrast, the printer can be satisfied with the requirements in all areas.

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