United States Patent [19]

Baker

[11] **3,853,564**

[45] **Dec. 10, 1974**

[54] **GRAPHIC AID AND METHODS RELATED THERETO**

[75] Inventor: **Elton N. Baker,** Elgin, Ill.

[73] Assignee: **Fotel Inc.,** Villa Park, Ill.

[22] Filed: **Mar. 1, 1972**

[21] Appl. No.: **230,866**

Related U.S. Application Data

[62] Division of Ser. No. 36,979, May 13, 1970, Pat. No. 3,657,983.

[52] **U.S. Cl.** **96/41,** 96/79, 96/38.3

[51] **Int. Cl.** **G03c 5/04**

[58] **Field of Search** 96/41, 43, 79, 116, 38.3

[56] **References Cited**

UNITED STATES PATENTS

1,469,415	10/1923	Herzberg	96/79
1,777,144	9/1930	Innes	96/43
1,864,091	6/1932	Parsons	96/48 R
1,896,567	7/1933	Trist	96/116
3,552,288	1/1971	Corley	96/41
3,615,474	10/1971	Rosenberger	96/41

Primary Examiner—David Klein

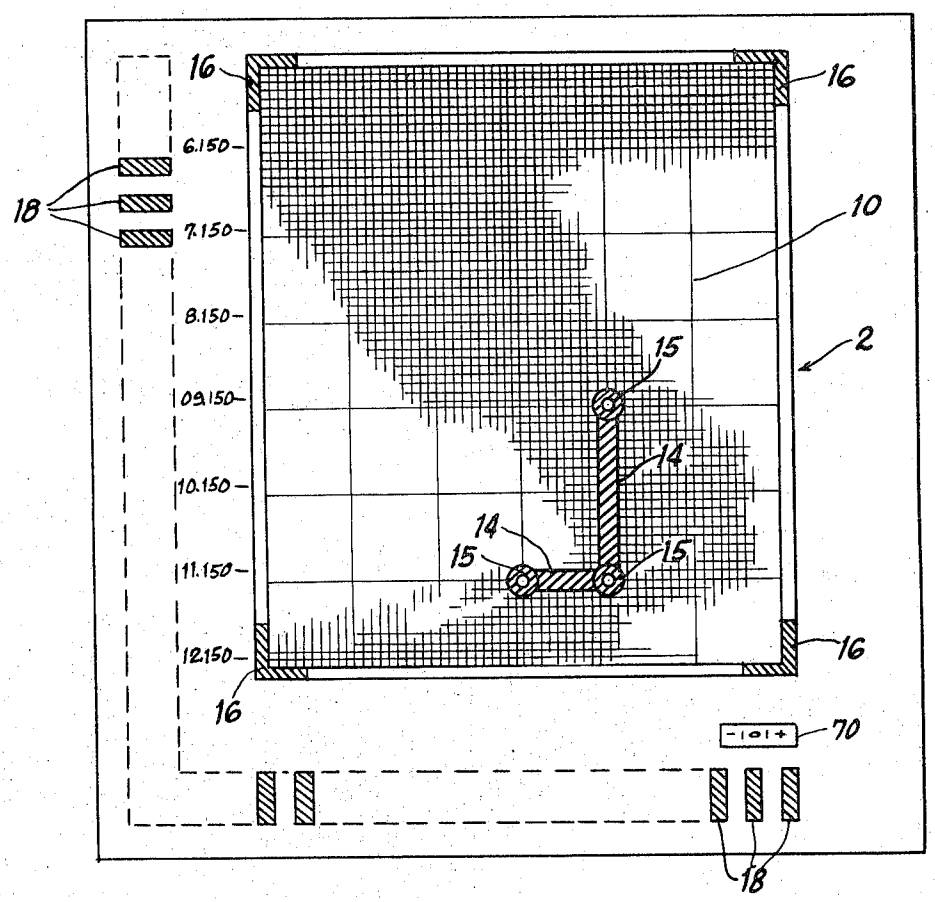
Attorney, Agent, or Firm—Neuman, Williams, Anderson & Olson

[57] **ABSTRACT**

A master grid layout sheet and methods of manufacture associated therewith are disclosed for use in graphic art work such as the layout and reproduction of printed circuits and the like. In typical printed circuit work precision art work and subsequent photographic reproduction thereof are normal intermediate processing steps. The master sheet includes a pattern, usually of orthogonal reference lines, printed thereon in a predetermined critical gray or neutral monotone. The monotone has a visual density such that the reference line pattern is visible to a draftsman but the light transmission density or opacity thereof is insufficient to cause the pattern to be reproduced in a controlled photographic reproduction of the master sheet.

12 Claims, 7 Drawing Figures

FIG. 1



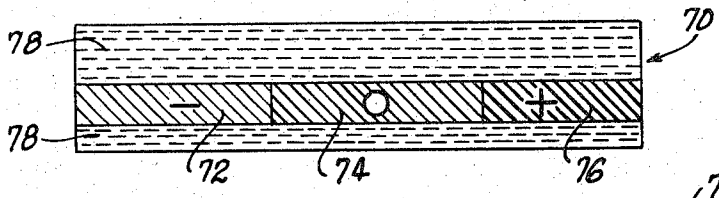


FIG. 2

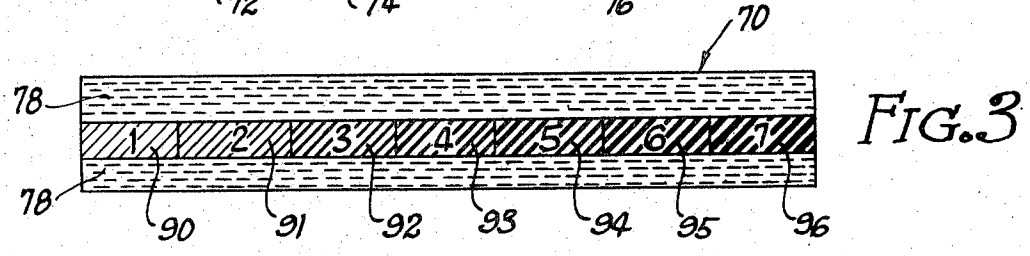


FIG. 3

FIG. 4

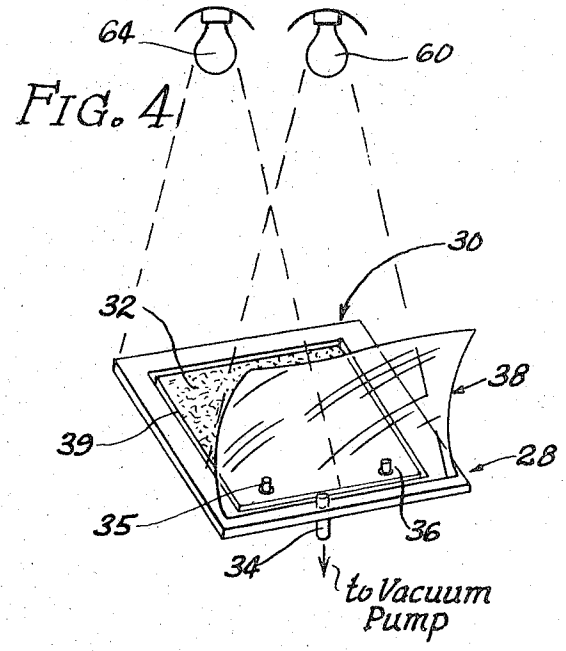


FIG. 5

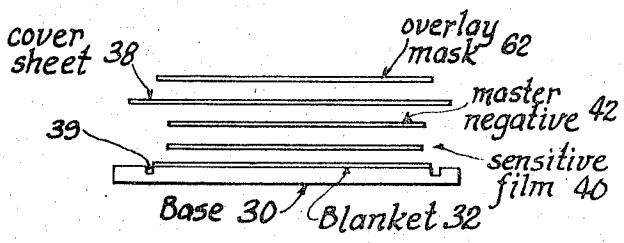


FIG. 7

GRAY GRID MASTER

LOG E vs DENSITY RESPONSE CURVE (H & D CURVE)

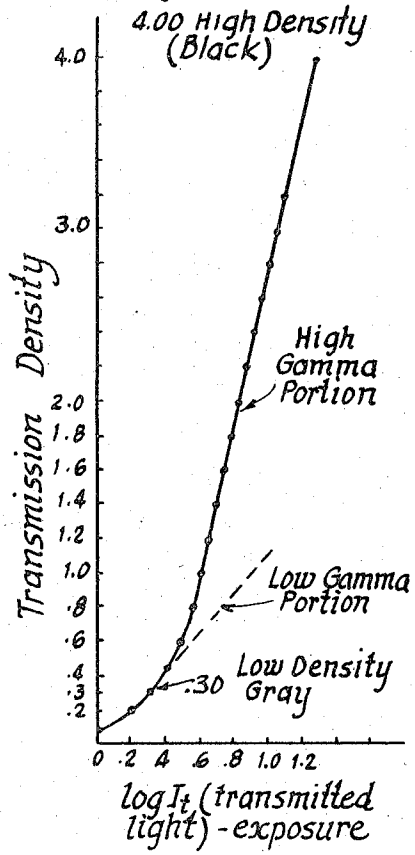
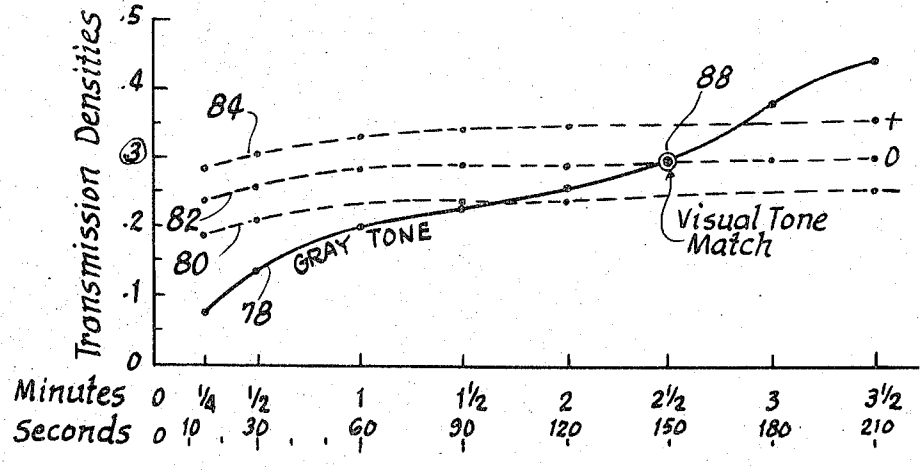


FIG. 6

DEVELOPMENT GUIDE FOR TRAY PROCESSING



GRAPHIC AID AND METHODS RELATED THERETO

RELATED APPLICATIONS

This application is a divisional application of copending application Ser. No. 36,979 filed May 13, 1970 and entitled "GRAPHIC AID AND METHODS RELATED THERETO" which is now U.S. Pat. No. 3,657,983.

A processing control method for forming the master grid sheet is also disclosed. The process utilizes a visual process control guide which provides a standard of comparison for obtaining the critical transmission density of the gray monotone pattern. Thus the development process by which the master grid sheet is formed may be consistently controlled to produce the critical transmission density for the reference pattern thereon. The subsequent processing of reproductions of the art work may be controlled in correlation with the critical density of the monotone pattern to cause the pattern to disappear in the final product.

FIELD OF THE INVENTION

The invention is directed generally to methods and apparatus for graphic reproduction and more particularly to the preparation and photoreproduction of drafting in the production of electronic circuits.

BACKGROUND OF THE INVENTION

Many electronic devices such as printed circuits and the like include one or more conductors which are, for example, printed, plated, etched or formed by a chemical deposition process on a base of insulating material. Ordinarily one or more master sheets including drawings or other pictorial representations of the conductors in accurate relative registration must first be made. Prior art methods and apparatus for drafting such electronic devices often include underlay reference grid sheets or color reference lines on the master sheet itself. Similar layout grids are utilized in other areas of the graphic arts.

Underlay grid sheets introduce errors because of these shortcomings: (a) accidental grid shift is possible even though the reference is pinned or taped to the master; (b) the master and reference grid must be maintained in intimate contact during the layout process; (c) maintenance of circuit component placement cannot be checked once the master is removed from the underlay grid; (d) the grid must be selected to be of the same size as the master to prevent misregistration; and (e) it is difficult to interrupt a project once it is begun, or make revisions, corrections or alterations thereon because of difficulties in re-establishing registration.

Producing color grid lines on master sheets, which are intended not to reproduce in subsequent photoreproduction, suffers from two manufacturing shortcomings: (a) typical color images require, in addition to regular exposure and processing, several very difficult operations: a bleach-etch process, a manual redevelopment for black image detail, and a manual dye application for color lines; and (b) production control of the color intensity to provide both good drafting visibility and subsequent total photographic drop out is difficult. In addition to manufacturing problems, the use of a color grid conflicts with the techniques of photographic color separation used to reproduce from a master drafted with two color tapes.

SUMMARY OF THE INVENTION

Thus it is an object of this invention to provide a method and apparatus which avoids or minimizes all the aforenoted shortcomings.

It is another object of this invention to provide a master grid layout sheet for use in graphic art work such as the layout of printed circuits and the like where precise art work and photographic reproduction are requisite intermediate steps, the master sheet including a pattern of reference lines which are visible for circuit drafting purposes, but drop out during the processing of a photographic reproduction of the master sheet.

It is a further object of this invention to provide a method for controlling the density of the reference lines during the process of producing the master grid layout sheet, so that the qualities noted above are consistently provided.

Further and additional objects will appear from the description, accompanying drawings and appended claims.

In accordance with one embodiment of this invention, a master layout sheet is provided including a diaphanous base having both effectively opaque images which appear on both the master layout sheet and the reproduction thereof and a light gray or neutral monotone pattern disposed thereon. As used herein the term "effectively opaque" means sufficiently dense to provide sharply contrasting areas in the ultimate reproduction which will determine the printed circuit pattern, and the term "neutral monotone" denotes a homogeneous neutral density substantially less than "effectively opaque." The monotone pattern may comprise a network of orthogonal reference lines or the like and is of a precisely selected critical density, dense enough so that it is visible to an artist laying out a circuit design on the master sheet, and yet sufficiently transmissive so that it will not be reproduced in a properly processed photographic copy of the master. In order to precisely control the density of the monotone pattern, a visual processing control guide is incorporated in a selected area of the master layout sheet. The processing guide includes a test patch having the same density as the monotone pattern, and monotone or homogeneous in nature, and a plurality of comparator patches which are not monotone but, on the contrary are halftones or the like. One comparator patch is a standard patch having an average or effective density bearing a known relationship to the density of the monotone pattern. The remaining comparator patches have effective densities which establish predetermined upper and lower limits for the density of the monotone pattern. Further, the comparator patches, because of their non-homogeneous character develop their final effective density more quickly than the monotone test patch thus establishing a standard of comparison which may be used to control the development of the monotone test patch and thereby the pattern on the master layout sheet to precisely the proper density.

IN THE DRAWINGS

FIG. 1 is a plan view of a master layout sheet and visual processing guide in accordance with this invention.

FIG. 2 is a detailed view of a visual processing control guide for use in tray processing of a master layout sheet developed in accordance with this invention.

FIG. 3 is a detailed view of an alternative processing guide for use in machine processing of a master layout sheet developed in accordance with this invention.

FIG. 4 is an illustration of a vacuum contact device for exposing a suitable sensitive film in producing a master layout sheet in accordance with this invention.

FIG. 5 is a partially exploded side view of the vacuum contact device shown in FIG. 4 illustrating the relative placement of the elements during exposure of the sensitive film to produce the master layout sheet.

FIG. 6 is a set of curves illustrating the relationship between development time and visual effects in the visual processing guide of FIG. 2 to achieve the optimum density of the gray monotone reference pattern on the master layout sheet.

FIG. 7 is a Hurter-Driffield characteristic curve of a sensitive film suitable for production of the master layout sheet of this invention.

Referring now to the drawings and in particular to FIG. 1, a preferred embodiment of a master grid layout sheet 2 is shown which is particularly suited to close tolerance printed circuit art work. The grid layout sheet is of a diaphanous material and includes a pattern of orthogonal reference lines **10** on the surface thereof. The master can also include board corner marks **16**, edge contact connectors **18** and other common features. In drafting a circuit on the master layout sheet, a draftsman applies a suitable adhesive tape to the master layout sheet **2**, positioning the tape to represent the conductors of the printed circuit. The tape may be cut to desired lengths and applied to the master to represent conductors **14**, using the reference network lines **10** as guides. Through-board connections and terminal points may be applied in the form of printed or die-cut self-adhesive pads **15** located using intersections of the reference lines **10** as guides.

The master layout sheet **2** is purposely of large dimensions, for example, four times the desired finished board size, so that after the desired circuitry configuration is achieved, the board may be reduced in size by a photographic reproduction process with enhanced precision in the ultimate product. This reduction step causes any placement error in the printed circuit configuration as laid out on sheet **2** to be diminished in the same proportion as the master is reduced. The photographic reduction of the finished master sheet to final size is made on a camera such as a graphic arts darkroom type which reproduces the printed circuit art work with minimal distortion of its geometry and to very precise dimensions. In a typical manufacturing process the photographic reproduction, which may be positive or negative in form, may be used to produce a silk screen mask for printing a resist on a suitable copper clad conducting board, or to expose a light sensitive resist on a conducting board. The resist selectively covers or exposes the copper circuits during plating or etching processes which remove the unwanted copper or add desired protective metallic layers in accordance with the pattern of tape on the master sheet **2**.

Thus the presence of the reference lines **10** on the master grid layout sheet **2** during the art work layout process is very important in holding drafting errors to a minimum. However, should any of these reference lines appear on the photographic reproduction of the art work, an erroneous circuit connection of spurious metallic areas is produced in the printed circuit board. If the reference lines **10** are to be visible to a circuit draftsman working on the master layout sheet **2** but are not to appear on a photographic reproduction thereof, the transmission density of the lines must be held within critical limits. Density, in photographic work, is the logarithm (to the base **10**) of opacity and is defined by Opacity = I (incident light)/T (transmitted light) Therefore, Density = Log (I/T) Thus if the incident light is designated as 100%, the following examples will illustrate the meaning of density as applied to this invention: (a) If all the light is transmitted (very nearly true of glass), then the opacity would be unity and, since the logarithm of one is zero, the density would be zero; (b) If none of the incident light were transmitted (rarely encountered in photography), the opacity and density would be infinity; (c) If 50% of the light is transmitted, the opacity would be 2, and the log of 2, which is 0.30, would be the density; (d) If 10% of the light is transmitted, the opacity would be 10 and the density would be 1.00; and (e) If 0.1% (1/10 of 1%) of the light is transmitted, the opacity would be 1,000 and the density would be 3.00.

A table of Common Logarithms (to the base 10) will show the above-defined relationship between opacity and density by reading opacity as the number and density as the logarithm.

The Log (I/T) shall be referred to herein as transmission density. It has been determined that the reference lines **10** on the master sheet **2** should have a critical monotone density located within the general range of 0.20 to 0.40 above base density of the film, and preferably have an optimum critical transmission density of 0.30 controlled within ±0.05 density above base density. Clear film of the type described herein has a base density of 0.05 to 0.07 which is inherently compensated for in tray processing by the fact that both the processing guide and the reference pattern are referred to the same base density. In machine processing, where transmission density readings may be taken by a densitometer, the densitometer may be calibrated to read 0 (zero) through a clear area of this base film.

Monotone density (gray) as used herein applies to a single density value of a typical photographic continuous or homogeneous tone. Effective visual density is used herein to designate the apparent density produced by the halftone technique which is used for the comparator patches of the processing guides. A halftone produces visual densities by the technique of controlling the ratio of transmitted light to the incident light, in accordance with the previous definition: Density = Log (I/T). The halftone achieves this by the use of dots or lines having a single high density value to effectively absorb a portion of the incident light. The ratio of transmitted light is dependent upon the ratio of the size of high density areas to clear areas. These dots or lines occur in regular, repetitive spacing of a frequency sufficiently high to prevent visual resolution of the non-homogeneous pattern so that the visual effect is comparable to that produced by homogeneous densities.

On the master layout grid sheet of this invention and in practicing the method of this invention the reference lines must be printed in a homogeneous gray monotone, each increment of each line or area being printed at the same critical transmission density within the lim-

its prescribed above when processed as described herein. A monotone reference pattern having the prescribed critical transmission density has sufficient visual density to be visible to the naked eye and be usable in drafting the printed circuit art work as well as having a transmission density so low that the pattern will not appear in a photographic reproduction of the completed printed circuit art work when processed as described herein. The exact density value for the monotone reference pattern should preferably be maintained within a plus or minus 0.05 limit around the critical transmission density of 0.30 above base density in order to provide visibility of the reference pattern for the draftsman without exceeding the upper density limit imposed by the exposure and processing parameters of the subsequent photographic reproduction.

High density (black) features which are common to a plurality of printed circuit layouts, such as edge contact connectors **18**, are printed on the same master grid layout sheet. These features typically have a density not less than 3.00 above the density of the base. Some latitude in the density of the black features above this lower limit is permissible, with emphasis being on the quality of image geometry and the sharpness so that these features are accurately portrayed in the photographic reproduction of the master sheet. The parameters set forth herein are interrelated and depend in part on the available materials. Variations are possible within the functional constraints set forth herein.

The use of accurately controlled methods of exposure and development in the production of the master layout sheet insures that the monotone reference lines **10** will be eliminated in subsequent photoreproduction, whereas black features such as **18** will be sharply and clearly reproduced. The method utilizes a processing guide **70** (shown in FIG. **1** and explained in detail below) including a test area **78** of the optimum monotone density and a plurality of comparator patches **72, 74, 76** specially designed to provide standards by which the development of the critical low density levels may be monitored. These patches are preferably non-homogeneous halftones.

The sensitive film which becomes the master grid layout sheet is exposed in a vacuum contact film exposure device shown in perspective in FIG. **4.**

The exposure device **28** includes a base **30** having an embossed blanket **32** incorporated therein. An outlet **34** to a vacuum pump (not shown) is mounted to the underside of the base **30** and communicates with the embossing of blanket **32.** Registration pins **35** and **36** and film cover sheet **38** are affixed to the upper side of the base. The base may be made of rigid acrylic plastic and the embossed blanket of black flexible vinyl plastic to provide means for air evacuation, thereby providing vacuum contact between the elements of the exposure device during the exposure process described below, while maintaining a nonreflective background for the exposure of the film therein. The cover sheet **38,** which may be 0.004 inch Mylar, is used to sandwich a sensitive film **40** to be exposed and an image bearing negative **42** through which the exposure is made in intimate contact between cover **38** and blanket **32.** A channel **39** provides communication between the vacuum outlet **34** and the blanket **32** to draw the cover sheet **38** down tightly on the sensitive film and master negative.

The procedure for exposing a sensitive film **40** to print thereon both the optimum density monotone pattern of reference lines and the high density standardized circuit features (which are to carry over into the final printed circuit) will now be explained in detail with reference to the partially exploded view of the exposure device in FIG. **5.** The arrangement for making an exposure places the sensitive film **40** (emulsion up) over blanket **32** covered in turn by master negative **42** (emulsion down) and cover sheet **38.**

The master negative **42** is opaque except for transparent lines and areas corresponding to reference **10,** corner marks **16,** edge contacts **18** and the test patch or processing guide **70.** The comparator patches **72–76** and **90–96** include subareas of effectively opaque density and subareas of effectively transparent density which are individually small enough to produce a visual averaging so that the overall appearance of the area is that of half-tone effects. The principal of the invention in this regard requires either effective opacity or effective transparency and no intermediate density to provide relative immunity in the comparator to variations in the developing parameters and in particular to the development time.

As shown in characteristic response curve FIG. **7,** the emulsion and developer are carefully chosen to provide a curve portion of low gammaa or contrast embracing the low density (gray) levels as well as a curve portion of high gamma so the development of a low density may be critically controlled without sacrificing the high density capability required for the black images. Kodaline Ortho Estar Base 0.007 developed in DuPont 24D meets these requirements and is the combination used for the evaluation in FIG. **7.** There are other satisfactory combinations of emulsions and developers including some films which have a matte surface or are effectively translucent.

During exposure of sensitive film **40,** the master negative **42** is held in alignment overlying the film by register pins **35** and **36.** The sensitive film **40** and master negative **42** are sandwiched in overlying registration by cover **38** and the vacuum pump is started. A soft pile roller such as a paint roller sleeve may be used to assist in the evacuation of air from between film **40** and negative **42** to promote intimate contact therebetween. A first exposure of the entire image of the master negative is made from the low intensity light source **60,** FIG. **4,** by using a timer (not shown) to control the exposure duration.

Prior to the second exposure, without releasing the vacuum, an area mask **62** is placed in register, using register pins **35** and **36,** over the corresponding areas of the master negative and squeegeed flat to the cover sheet. Vacuum contact for the mask is not required because it contains no fine details. This mask blocks out the areas to be developed to the gray monotone density but is open in the areas for the black image details such as the edge contact connectors **18** and the comparator patches of the processing guide **70.** The second exposure is made from the high intensity light **64.** Both exposures are made for the same time increment, typically about 10 seconds, controlled by a reset timer. The two light sources **60** and **64** have a light intensity ratio of about 1 to 10 which represents a Log Exposure difference of 1.00. A switch directs the timer output to the appropriate light source. The power supply of the timer

is provided by a voltage regulating transformer to insure a consistent intensity of the light sources.

An optional third exposure step may be added to the method detailed above to add patch areas of the gray monotone density outside the area of the monotone reference lines. For example, some fine details such as register marks and dimension lines which are drafted onto the master grid layout sheet require more critical exposure at the final reduction than employed for bolder high density (black) features and the drafted circuit details. The fine details can be protected from overexposure and "blooming" from adjacent clear areas by including a gray patch overprinting the fine lines, the patch to be of the same monotone density as used for the pattern of monotone reference lines. Prior to this additional exposure, the vacuum is released and overlay mask **62** and master negative **42** are removed. A mask (not illustrated) having open areas for these patches but with complete opacity to protect all other areas is located in register in place of the master negative. The open areas may either be transparent portions of a film mask or physically cut out from an opaque sheet. The vacuum is again applied and another exposure is made from the low intensity light source **60.** The vacuum is released and the film is now ready for the controlled processing procedure.

It should be understood that modifications of the exposure process may be made without departing from the invention, provided only that the interrelationship of parameters is maintained. For example, a single lamp may be used for the exposures with proper adjustment of the exposure times. In another method, a single exposure is made with a single light source. This method is carried out by incorporating a mask of uniform density over all areas of the master negative which are to appear in low density monotone. The density of the mask should be approximately 1.00, which will provide the necessary 1 to 10 exposure ratio between the low density and high density patterns of the master. A single exposure is then made using high intensity light **64.** The aforementioned methods all use a single master negative. Another method uses two or more master negatives, each contributing a portion of the total image with each receiving its appropriate exposure.

In developing the exposed sensitive film **40,** the density of the gray monotone portions within the optimum limits is a critical production requirement. At the same time the black features must be reproduced at the maximum transmission density to provide effective opacity. Obviously the use of instrumentation such as a densitometer is not possible during tray development and therefore the use of the visual control guide, FIG. **2,** is imperative for manual processing. A densitometer may be used to monitor samples with machine processing; however, the visual machine processing guide, FIG. **3,** appearing on each master provides an instant and convenient evaluation. Therefore, either of the processing control guides **70** in FIGS. **2** and **3** may be used in the development processing step to enable the operator to consistently produce master sheets having monotone line patterns within the optimum gray density range.

The tray processing control guide, shown in FIG. **2,** preferably includes at least three comparator density patches, indicated generally at **72, 74** and **76** which quickly attain and thereafter maintain a stable visual density over a wide range of development changes during processing of film **40,** and a monotone sample patch **78** which develops to transmission density at the same rate as the monotone reference pattern during the development process.

The changes in visual density with development time of the comparator patches **72–76** and the test patch **78** are illustrated in the graph of FIG. **6.** As shown therein, the developing process is terminated when a predetermined ocular relationship between the density of the comparator patch **74** and the test patch **78** is achieved. In the preferred embodiment the comparator patches comprise halftone patterns of saturated high density area interspersed with clear or low density areas to produce visual tones of a desired effective visual or optical density. The three exemplary patches are comprised of three different halftones varying in the ratio of opaque to clear area, the central patch being a halftone having an effective visual density bearing a known relationship to the gray monotone density to be used for the master sheet reference lines. The left-hand patch **72** is a submarginal halftone having an effective visual density too light to be consistently visible for use as a reference line, and the right-hand patch **76** has an effective visual density so dark that a monotone reference line of this density might carry over into a photographic reproduction of the master layout sheet. The monotone test patch **78** is matched to the half-tone patch **74** of the reference pattern. As shown in the graph of FIG. **6,** the comparator patches which are exposed to half-tone patterns develop rapidly and then maintain a nearly constant visual density, thereby establishing the optimum density of the monotone reference pattern. These can be observed by reflection during the developing step under an appropriate safe light.

Processing of the sensitive film **40** exposed by the method disclosed above to produce a master grid layout sheet having reference lines of optimum density such as the sheet **2** shown in FIG. **1** can be done manually with trays or by an automatic processor. The design for a control guide for manual processing is shown in FIG. **2.** The curves of FIG. **6** illustrate the relationship between development time and certain visual density characteristics of the comparator and test patches which are used to control processing. The guide is designed to give an operator controlling the developing operation a visual standard of comparison between three comparator densities or tones and the density or tone of the gray monotone. The ideal effective visual density value of comparator patch **74** is designated by zero (0) with upper and lower limits designated minus (−) and plus (+) in patches **72** and **76** to aid the operator in making an evaluation. The operator stops the developing step when the density of the monotone test patch **78** appears to have a density between the plus and minus extremes of the reference patch tones **72** and **76** with the objective of achieving a visual match **88,** FIG. **6,** between the monotone test patch **78** and comparator patch **74,** at which time the film is transferred to a stop bath and then a fixing bath.

The visual densities of the halftone comparator patches are stable over a wide time period of the development cycle, as indicated by respectively labelled curves **80, 82** and **84.** The visual density or tone of gray monotone sample patch **78** slowly increases during development; the development process is stopped when a visual tone match is achieved between the tone of sample patch **78** and comparator patch **74.** Observation of this guide is made under low visibility condi-

tions, namely: reflectance from the emulsion while in the developer solution under safe light illumination. Thus the visual relationship between the monotone patch **78** and the comparator patches **72, 74** and **76** is not the same as their measured transmission densities, as illustrated in FIG. **6.** It has been determined that the observed patch **78** appears denser during development by approximately 0.20 than its actual density. This apparent increase in visual density of the monotone patch over the actual measured value of the critical transmission density is consistent throughout the development process and thus requires no other correction in the comparator and test patches of the visual processing guide than an initial adjustment of the black to white ratio in the original half-tones to increase the apparent density by about 0.2. Thus the halftone comparator patch **74** should have a measured transmission density of 0.50, which is ⅔ opaque to ⅓ clear, to match effectively a monotone density of 0.30. The ratio of opaque to clear portions in halftone patches **72** and **76** should be about 1.5:1 and 3:1 respectively. With reference to the halftone patterns of the comparator patches of the processing guide, it should be noted that a line frequency of about 50 lines per inch is about the minimum which the operator sees as an effective visual tone without resolving the lines under manual processing conditions.

FIG. **3** illustrates typical comparator patches incorporated in a visual processing guide for machine processing of the film carrying the master grid layout sheet. The guide differs from that of FIG. **2** because it is used as a standard of comparison after completion of processing, and provides the operator with an evaluation useful in machine adjustments (speeds and temperature) and chemistry changes (developer aging, additions or replacement) to control the development of film subsequently fed into the processor. More than three comparator patch density values are used because the magnitude of deviation should be evaluated to aid an operator in making the adjustments noted above. In FIG. **3,** seven patches **90–96** are used with the center patch **93** providing a visual density match with the critical gray monotone density. A table of ratios of opaque to clear portions of these half-tone patches is set out below. It should be understood that these values are disclosed as examplees, and are not intended to be limiting in any way.

Patch 90	0.43:1
Patch 91	.56:1
Patch 92	.785:1
Patch 93	1:1
Patch 94	1.22:1
Patch 95	1.5:1
Patch 96	1.85:1

It should also be noted that the automatic film processing guide is viewed under better conditions than the guide used in tray processing methods. Therefore, the line frequency of the automatic processing guide of FIG. **3** should be higher to prevent visual resolution. A line frequency of about 65 per inch is about minimal. Further, the apparent visual density of the test patch **78** as observed is more nearly identical to its actual transmission density so that no adjustment (as for the manual processing guide of FIG. **2**) need be made. In fact, a densitometer may actually be used.

While a particular embodiment of this invention is shown above and described, and particular methods of utilization are described with respect thereto, it will be understood, of course, that the invention is not to be limited thereto, since many modifications may be made. It is contemplated, therefore, by the appended claims, to cover any such modifications as fall within the true spirit and scope of this invention.

I claim:

1. A method of producing master grid layout sheets on a light sensitive material having a known gamma up to a predetermined light saturation level, said sheets including a pattern of gray monotone effects comprising the steps of

a. exposing said light sensitive material through a desired pattern to represent said pattern of gray monotone effects, said material being exposed to light such that said pattern is substantially uniformly exposed to an amount of light substantially less than said saturation level,

b. placing said light sensitive material in a developing fluid to develop said exposed areas,

c. terminating said developing step when said gray monotone areas have a predetermined optical density,

d. fixing said sensitive material to prevent any further development thereof, and

e. said predetermined optical density being sufficient to be visible in the sheet but having a sufficiently low optical density that said pattern will not be present when said sheet is subsequently photographically reproduced.

2. The method of claim **1** wherein the pattern is visually monitored during the development step to terminate said development step when said pattern attains said predetermined optical density.

3. The method of claim **2** wherein said material is further exposed to a visual process control guide comprising an auxiliary pattern of small unexposed areas and adjacent areas exposed to saturation to form a halftone which develops to a final effective visual density bearing a predetermined known relationship to said predetermined optical density more quickly than said monotone pattern will so develop, and comparing said optical density to said effective visual density to terminate said development step at the optimum time.

4. The method of claim **3** wherein the visual process control guide includes a plurality of comparator test patches, including a first patch having visual density appearing equal to the predetermined optical visual density of said monotone pattern, a second patch having a visual density greater than said predetermined optical density, and a third patch having visual density less than said predetermined optical density, said second and third patches establishing upper and lower limits for the monotone pattern.

5. The method of claim **14** including the steps of placing an effectively opaque pattern on said material following said development step, and photographically reproducing the pattern on said material whereby only said effectively opaque pattern will be present in the photographic reproductions.

6. The method of claim **1** wherein said desired pattern is on a first area of a master negative and an appropriate pattern to produce an effectively opaque pattern is, on a second area of said negative, including the steps of

f. exposing said light sensitive material through said master negative to a first light source,

g. placing a mask over a portion of said light sensitive material exposed to said desired pattern, and

h. exposing said material to a second light source, the duration and intensity of said light source in each of said exposing steps being related whereby said monotone and effectively opaque patterns are reproduced respectively on said material.

7. The method of claim **6** wherein the ratio of the intensity of said second light source to the intensity of said first light source is about ten to one and the exposure interval for said first light is substantially the same as the exposure interval for said second light source.

8. The method of claim **4** wherein said optical density of said monotone pattern is critically fixed within a range of about 0.25 to about 0.35 above the density of unexposed sensitive material after said fixing step.

9. The method of claim **14** wherein said optical density of said monotone pattern is critically fixed within a range of about 0.2 to about 0.4 above the density of unexposed sensitive material after said fixing step.

10. The method of claim **1** wherein said monotone pattern and an effectively opaque pattern are introduced on a negative for exposing said material and the relative exposures of said monotone pattern and said effectively opaque pattern are controlled, whereby the ratio of the density on said material after said fixing step of said monotone pattern to the density of said material underlying said effectively opaque pattern is ten to one and the portion of said material not underlying either of said patterns is exposed to about the saturation level.

11. The method of claim **1** wherein said desired pattern is on a first area of a master negative and an appropriate pattern is on a second area of said negative to produce an effectively opaque pattern on the master grid layout sheet, said method including the steps of placing a light controlling mask over said first area, and controlling the exposing step of said method whereby the duration and intensity of said exposure of said light sensitive material is controlled whereby said monotone pattern is produced thereon in said first area and said effectively opaque pattern is produced in said second area.

12. The method of claim **11** wherein the ratio of total incident light exposure of said first area to the total incident light exposure of said second area is one to ten.

* * * * *