June 26, 1956 W. R. HOUGH ET AL 2,752,245

PHOTOGRAPHIC DRAWING METHOD

Filed Nov. 21, 1950 3 Sheets-Sheet 1

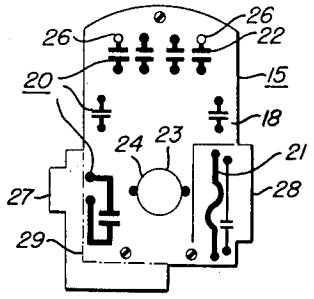


Fig. 1

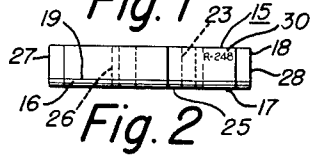


Fig. 2

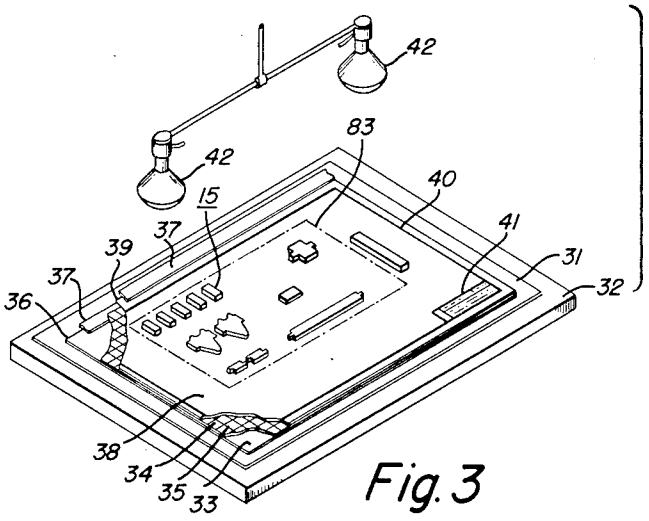


Fig. 3

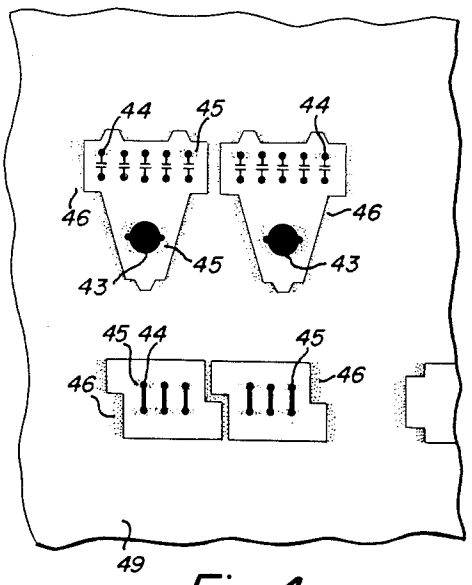


Fig. 4

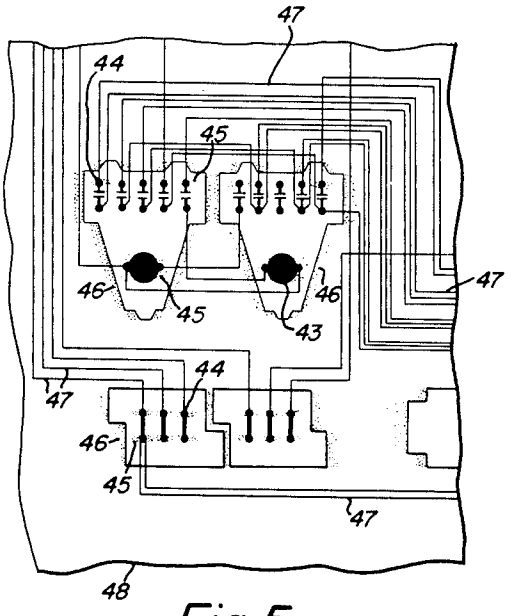


Fig. 5

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PHOTOGRAPHIC DRAWING METHOD

Filed Nov. 21, 1950 3 Sheets-Sheet 2

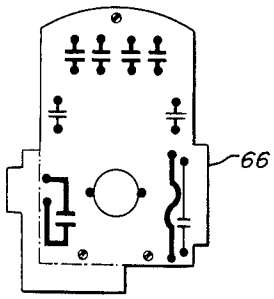


Fig. 6

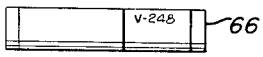


Fig. 7

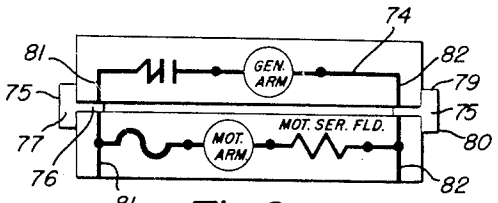


Fig. 9

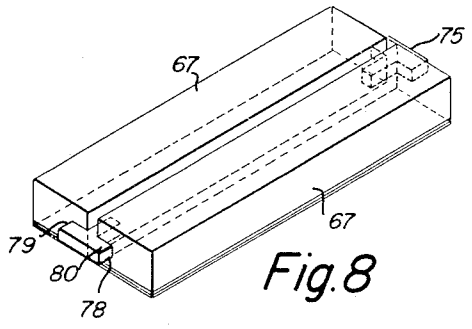


Fig. 8

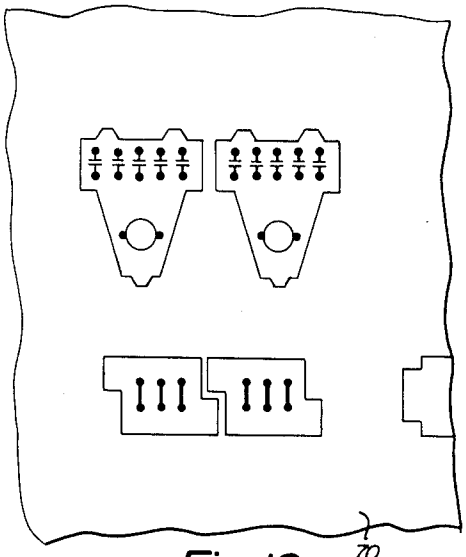


Fig. 12

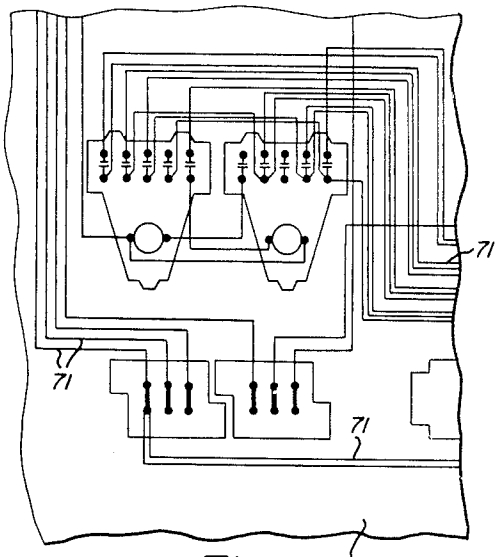


Fig. 13

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PHOTOGRAPHIC DRAWING METHOD

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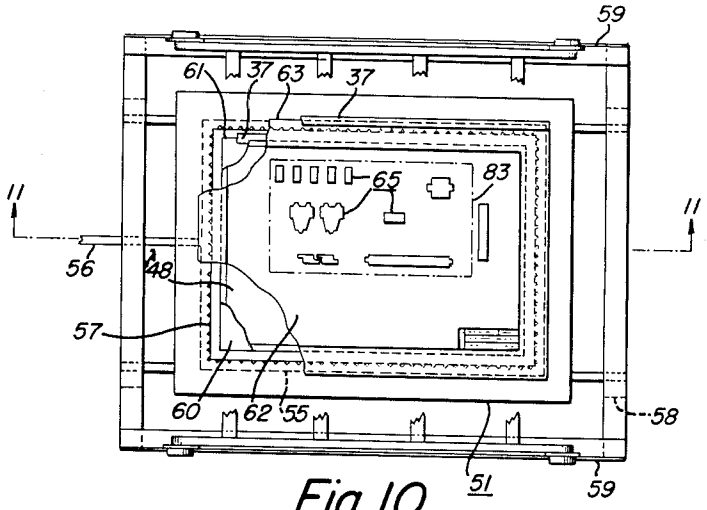


Fig. 10

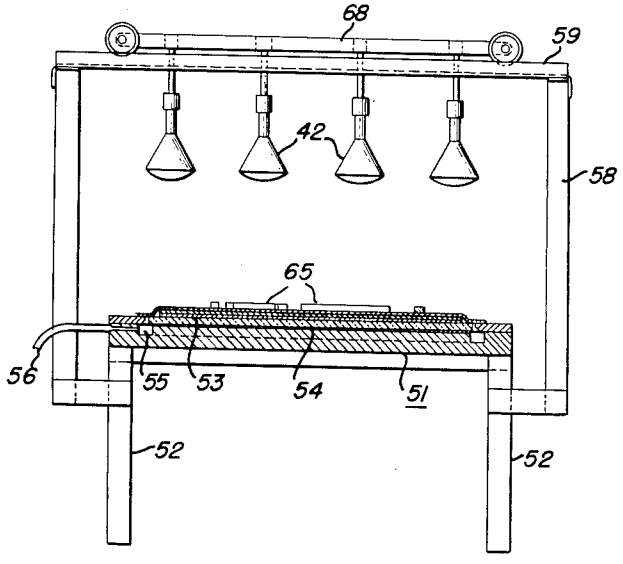


Fig. 11

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PHOTOGRAPHIC DRAWING METHOD

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Application November 21, 1950, Serial No. 196,918

4 Claims. (Cl. 95—5)

The invention relates in general to methods of making a complete master drawing and more particularly to a combination photographic and drafting method of making a complete master drawing or tracing.

A drawing or tracing, generally speaking, consists of an "assembly" of lines on paper or cloth from which copies, generally known as blueprints, can be reproduced. These drawings are usually produced individually with each component line drawn by a draftsman. In drawings of a similar type certain configurations of lines may be required many times, and usually the draftsman produces these each time they are required. In the new method these certain configurations of lines are produced once by a draftsman, they are then fabricated into permanent form subassemblies or templates that can in turn be reproduced exactly as many times as required by photographic means. By this method the draftsman produces a drawing by arranging prefabricated subassemblies to the extent that they are applicable, supplemented with whatever lines he needs to produce by drafting methods to complete the "assembly."

This new method saves time for the draftsman in planning the arrangement of the lines in the "assembly" because the prefabricated elements can be physically rearranged into many possible combinations. This saves time for the draftsman because he does not have to draw the lines that have been established in the templates. This further eliminates errors of comission and omission because each prefabricated subassembly will be reproduced exactly each time it is used. Further, it eliminates the requirement of checking the accuracy of the drawing since the prefabricated subassembly has been checked originally and need not be checked each time it is used.

An object of the invention is to provide a method for making a master drawing wherein a sandwich of sheets of material is used, with this sandwich comprising a photo-sensitized sheet, an opaque mask, a transparent mask, and a plurality of transparent blocks having opaque lines thereon and arranged in a given order to form part of a drawing, and wherein the opaque mask is removed from the sandwich and this sandwich then illuminated to expose the photo-sensitized sheet through the sandwich, the sensitized sheet then developed and lines drawn thereon by drafting methods to connect the image made by the plurality of blocks.

Another object of the invention is to provide a method for making a master drawing by two steps wherein each step is similar to the procedure outlined in the preceding paragraph. The first step utilizes transparent solid blocks having permanent magnets embedded therein so that the blocks adhere to a permeable support, with this first step producing a rough drawing. The second step utilizes the rough drawing as an opaque mask and further utilizes a second set of solid transparent blocks which are substantially the same as the first set of blocks except that the permanent magnets are omitted and these second blocks are arranged in accordance with the images of the first blocks on the rough drawing.

Another object of the invention is to provide a permanent form subassembly or template for use in a combined photo-drafting process wherein the template comprises a transparent block which is relatively inflexible and having a transparent film adhesively secured to one face thereof, and wherein the film has opaque marks thereon as a symbolic representation of a subassembly, wherein the block indicates not only the shape of the physical component which it represents, but also includes terminal points or connection points as part of the marks on the film.

Another object of the invention is to provide a template as described in the next preceding paragraph wherein a permanent magnet is embedded in the template so as to cause the entire template to adhere to a permeable surface.

Another object of the invention is the process of using a template of a solid transparent block wherein the block has opaque marks thereon as a symbolic representation of a device wherein a permanent magnet is embedded in the transparent block and which will cause a shadow to be cast on a photo-sensitized sheet and wherein such shadow is utilized as a part of the marks of said symbolic representation.

Another object of the invention is to provide a process for making a drawing wherein a sensitized sheet of material is placed with the sensitized surface exposed, is next covered by an opaque mask and is next covered by a plurality of blocks having marks thereon indicating a part of a complete drawing and wherein the opaque mask may then be withdrawn for exposure of the sensitized sheet through the transparent blocks.

Another object of the invention is to provide a vacuum printing frame wherein a photo-sensitized sheet is placed inside a rectangular row of apertures leading to a vacuum chamber, a transparent mask covers the sensitized sheet as well as the apertures, and a plurality of transparent solid blocks may be placed on the transparent mask, the entire assembly illuminated from above to expose the sensitized sheet after the underside of the transparent mask has been evacuated by withdrawing air through the apertures, and wherein the customary airtight lid for the vacuum frame is not required.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claim, taken in conjunction with the accompanying drawings, in which:

Figures 1 and 2 are top and front views, respectively, of a solid transparent block with a permanent magnet embedded therein;

Figure 3 is an isometric view of the assembly used to make the rough drawing;

Figure 4 is a drawing depicting the rough drawing produced by the assembly shown in Figure 3;

Figure 5 is a drawing of the rough drawing of Figure 4 wherein the components have been joined by lines;

Figures 6 and 7 are top and front views, respectively of a solid transparent block without permanent magnets therein;

Figure 8 is an isometric view of two solid transparent blocks having interlocking and spacing projections;

Figure 9 is a top view of the blocks of Figure 8;

Figures 10 and 11 are top and front views, respectively, of a vacuum frame;

Figure 12 is a drawing of the final print produced by the vacuum frame of Figures 10 and 11; and

Figure 13 is a drawing of the completed master drawing.

The permanent form subassembly or template used by the layout draftsman is shown generally by the reference character **15** in Figures 1 and 2. This template is made from a solid transparent block **18** of a plastic

material for ease in machining. In Figure 2, which is a front view, the block 15 is shown as having fastened thereto a transparent film 16 which may be an autopositive photographic film having a gelatin coating 17 on the underside thereof. Both the film 16 and the gelatin coating 17 have been shown to an exaggerated thickness in the Figure 2. In the actual templates 15 that have been produced the thickness of the transparent block 18 has been made ¼" thick or ⅜" thick. As a practical matter, the blocks 18 have been made of this thickness merely for rigidity and to prevent warping during use. The film 16 has been found to be about .006" and the gelatin coating 17 is approximately .001" of this .006" thickness. The film 16 is adhesively secured to the lower face 19 of the block 18. The gelatin coating 17 has a photographically developed image 20 thereon, and hence this image is on the lowermost surface of the entire template 15. The image 20 is better shown in Figure 1 and, for purposes of illustration, has been shown as connecting wires 21 and normally open contacts 22. The image 20, therefore, is a standard subassembly or component, in this case an electrical relay which may be used as a part of a complete panel wiring diagram. If the complete layout drawing were to be a hydraulic system, for example, then the image on the template 15 would be some hydraulic component which was frequently used in making up a schematic diagram of a hydraulic system.

The template 15 has embedded therein a small cylindrical permanent magnet 23 which is contained within an aperture 24. The aperture 24 is drilled in the plastic block 18 after the film 16 has been secured to the face 19. The lower pole 25 of the magnet 23 is preferably flush with the gelatin coating 17. The permanent magnet 23 is used in conjunction with and as a part of the image 20, and in this case symbolically represents the coil of the relay. A plurality of small cylindrical permanent magnets 26 is also used at the top of the template 15, and these magnets 26 are likewise placed in the template 15. This may be done either by a snug fit or by some adhesive. It will be noted that the permanent magnets 26 act as terminals or connection points for the contacts 22, and thus they serve a dual purpose.

The transparent film 16 is produced by photographic means in this manner: The draftsman would normally make an ink drawing on paper of the relay coil and the normally open contacts shown by the reference character 22; this drawing of this particular component would then be copied on film such as autopositive transparent film; the autopositive transparency would then have the image of the drawing and this transparency could be used as the transparent film 16. The completed template 15 is then available for use in many possible arrangements and combinations, and it will always be correct to depict this particular type of relay.

The block 18 is shown as having first and second projections 27 and 28 extending beyond the border 29 of the relay which it depicts. These projections 27 and 28 are for the purpose of insuring that this template 15 is physically spaced from any and all other templates or drawing components with which it may be used. The projections 27 and 28 are drawn to scale and indicate that the relay as a physical device has certain projections or protuberances for which space must be allocated when placing this relay in a panel. It will thus be seen that the completed template 15 indicates the physical space requirements of the actual relay as well as indicating the electrical connection points and clearances thereof for the panel wiring diagram.

The templates 15 are used in contact printing and as a result the image 20, which is on the bottom of the template 15, will be clearly reproduced on a sensitized sheet of material if this material is placed very closely adjacent to the gelatin coating 17. For good contact printing the distance of the image 20 from the sensitized sheet of material should be .010" or less. For this reason it has been found that reference numbers of the templates as shown by the reference character 30 may be placed on the edges or top of the block 18, and these will not print when the template 15 is used in contact printing.

The layout draftsman who uses the templates 15 is provided with a board 32 with a metal surface 31. The metal 31 which is on the surface of this board 32 is permeable so that the magnets 23 and 26 will adhere to this surface. The layout draftsman will first place upon the board 32 a photo-sensitized sheet 33 with the sensitized surface up. This sensitized sheet may be that which is commonly used in a blueprint process, and hence may have a relatively long exposure time. The sensitized sheet should be fastened to the board 32 at the upper edge 36 by adhesive tape 37. The layout draftsman next will cover the sensitized sheet 33 with an opaque mask 34, and this opaque mask preferably has grid lines 35 thereon. This opaque mask 34 is not fastened down to the board 32. Next, a transparent border mask 38 is placed over the opaque mask 34 and is fastened at the upper edge 39 thereof by adhesive tape 37. The transparent border mask has a border line 40 thereon and a title block 41. This transparent mask 38 may also have other standard notes and information 83 thereon. The transparent mask 38 used in this process is a flexible sheet only .003" thick. It has a mat surface so that ink lines may easily be drawn thereon. Since it is so thin it does not matter particularly on which side the lines are drawn for good contact printing. The layout draftsman will next take his templates 15 and arrange them on top of the transparent mask 38. The draftsman will have a wide selection of templates 15 which represent many standard components used in the panel wiring diagram, such as line resistors, contactors, relays, solenoids, terminal strips, etc. The templates 15 may also represent various components in an "across-the-line" type of schematic wiring diagram and series field thereof. The Figure 3 shows only a few of the templates 15 arranged on the board 32. However, in actual practice frequently two or three dozen may be used, depending, of course, on the complexity of the wiring diagram. The layout draftsman must use some skill and experienced judgment in determining the best arrangement of the components depicted by the templates 15. He must later draw connecting wires between these various components, and hence these components should be placed so that the connecting wires are as short as possible with a minimum of crossovers. The templates 15 are arranged by using the grid lines 35 as a guide to arrange the particular templates. When the layout draftsman believes that he has a satisfactory arrangement of components, he will remove the opaque mask 34 and then illuminate the sensitized sheet 33 by any suitable means, which in this case is shown by the reflector lamps 42. The sensitized sheet 33 may then be removed from the board 32 and the image thereon developed by the suitable photographic process to produce a preliminary rough drawing 49, shown in Figure 4. The layout draftsman will then take the sensitized sheet with the developed image thereon to his desk and attempt to draw the connecting wires between the various components. If he finds that the arrangement which he has is not the best possible he may again go through the steps outlined above to produce another developed image on a sensitized sheet with a different arrangement of templates. The developed image on the sensitized sheet will be similar to that shown in Figure 4. It will be seen that the permanent magnets 26 and 23 have outlines which designate the terminal points and relay coil, respectively. In Figure 4 the image of a permanent magnet 23 is shown by the reference character 43 and the image of the magnets 26 is shown by the reference character 44. It may also be seen in Figure 4 that the image on the template 15 is faithfully reproduced on the developed sensitized sheet 33.

The magnets 23 and 26 will cast a shadow as shown at 45, Figure 4, and the transparent block 18 itself will cast a shadow shown at 46 since the lamps 42 remain in one position relative to the board 32 during exposure of the sensitized sheet 33. These shadows 45 and 46 are not objectionable since this is only a rough drawing. The Figure 5 depicts the rough drawing 48 or a part of this rough drawing after the draftsman has completed the connecting lines 47 joining the components. For speed in execution these connecting lines 47 may be drawn in pencil. When the layout draftsman is satisfied that he has a workable and satisfactory arrangement of components he may proceed on the next step toward producing the final master drawing. For this master drawing a vacuum frame 51 is used, shown in Figures 10 and 11. The vacuum frame 51 is mounted on legs 52 so that the vacuum frame is at convenient tabletop height. The vacuum frame 51 has a horizontal upper surface 53, which, in this case is achieved by a panel of plate glass. The upper surface 53 should preferably be light absorbent for contact printing, and hence a light absorbent sheet 54 is placed beneath the plate glass 53. The frame 51 is therefore relatively rigid to support the horizontal upper surface 53. An annular vacuum chamber 55 is provided in the frame 51, and an air exhaust outlet 56 is provided for this chamber 55. A row of apertures 57 is provided in a rectangle which communicates with the vacuum chamber 55 and the upper surface 53. For convenience, these apertures 57 are adjacent to the edge of the plate glass used as the upper surface 53. A vacuum may be created in the vacuum chamber 55 by a vacuum pump, not shown, by the expedient of closing a switch or opening a valve.

The vacuum frame 51 also includes an upper support 58 having a track 59. A wheeled carriage 68 rides on the track 59 and carries a plurality of reflector lamps 42. The track 59 and wheeled carriage 68 are for the purpose of relatively moving the light source and vacuum frame 51.

The vacuum frame 51 is used by the operator thereof to produce the master drawing. A sheet of photo-sensitized material 60 is placed on the frame 51 with the sensitized surface up. This sheet 60 is inside the rectangular row of apertures 57. The sheet 60 is fastened down at the upper edge 61 by adhesive tape 37. On top of the sensitized sheet 60 is placed the rough drawing 48 as an opaque mask, and this rough drawing 48 is not fastened down to the frame 51. On top of the rough drawing 48 is placed a transparent border mask 62 which may be the same as the transparent mask 38 used in preparing the rough drawing 48. The border shown on the transparent border mask 62 is lined up with the image of the border on the rough drawing 48. The transparent boarder mask is sufficiently large to cover all the apertures 57 and is fastened at the upper edge 63 thereof to the upper surface 53 by adhesive tape 37.

The operator of the vacuum frame 51 will have available to him a plurality of templates 65. These templates 65 are similar to the template 66 shown in Figures 6 and 7, or the template 67 shown in Figures 8 and 9. It will be noted that these templates 66 and 67 are constructed in a manner similar to the construction of the templates 15 except that no permanent magnets are embedded therein. The templates 65 are then arranged on the transparent mask 62 in accordance with the images of the templates 15. Naturally, templates 65 are chosen which are duplicates, as far as the electrical components are concerned, of the images 20 shown on the templates 15. Thus the operator of the vacuum frame 51 will make a sandwitch of blocks or templates 65 and the transparent mask 62 which have marks or indicia thereon which are exactly the same as the developed image on the rough drawing 48. The rough drawing 48 therefore serves as a guide for lining up the templates 65 and the transparent mask 62. When the templates 65 are all correctly arranged and aligned, the rough drawing 48 is carefully removed from the vacuum frame 51 by sliding it forward. The vacuum chamber 55 is next evacuated by any suitable means which draws the transparent mask 62 into tight contact with the upper surface 53.

The reflector lamps 42 in the carriage 68 may next be turned on to expose the sensitized sheet 60. This sheet 60 may be either paper or cloth and may have a relatively short photographic exposure time. Also, this sheet 60 may have an autopositive coating. The wheeled carriage 68 is moved back and forth on the track 59 during exposure of the sensitized sheet 60. This movement of the lamps 42 eliminates any shadow which might otherwise be caused by the edges of the templates 65. After exposure of the sensitized sheet 60 it next is photographically developed and results in a preliminary master drawing 70, shown in Figure 12. This preliminary master drawing may be made from the sensitized sheet 60 by either a one step or a two step process. If the sensitized sheet 60 has an autopositive coating, it will be a one step process, and an image with black lines on white will appear on the developed sheet 60. If the sheet 60 has a "negative coating," a "positive" of black lines on white will next be made from this negative on a second sensitized sheet, resulting in a two step process. In any event, from the exposed sensitized sheet 60, a sheet is produced with photographically developed images thereon. It will be noted that this preliminary master drawing 70 differs from the preliminary rough drawing 49, of Figure 4, by the elimination of any shadows caused by the transparent blocks. These shadows are eliminated by the fact that the lamps 42 are moved during exposure of the sensitized sheet 60. The draftsman will then take the preliminary master drawing 70 and draw in connecting lines 71 in accordance with the arrangement of the connecting lines 47 on the rough drawing 48. These connecting lines 71 may be drawn in pencil or in ink depending upon the degree of permanence desired. When the connecting lines 71 have been drawn, the result is a master drawing 72, shown in Figure 13. The master drawing 72 will be substantially identical to the rough drawing 48, shown in Figure 5, except that the master drawing 72 will be neater and clearer. From this master drawing 72 any number of reproductions may be made, such as blueprints for use by the production department and/or customers. The master drawing 72 will then be a drawing which is produced partly by photographic means and partly by drafting means, and will take the place of the standard master drawing or tracing customarily produced entirely by drafting means.

Figures 8 and 9 show two templates 67 which have images 74 thereon depicting a part of an "across-the-line" diagram. The templates 67 are provided with spacers 75. These spacers are generally T-shaped. The T-shaped spacer has a stem 76 and an upper crossbar 77. The thickness of the template 67 is ⅜" which is a vertical dimension as these templates are usually used. The spacers 75 have a thickness of ⅛" in the same direction. The spacers 75 have a lower surface 78 which is placed ⅛" vertically above the lower face of these templates 67. The spacers 75 have been vertically removed from the lower face of the templates 67 in order to aid in the elimination of shadows from these spacers. Also, they have been placed midway vertically on the ⅜" thick blocks and at the top of the ¼" thick blocks so that these blocks of different thicknesses may be used interchangeably. One arm 79 of the crossbar 77 is adhesively secured to the upper template 67, and the width of the stem 76 insures a spacing between adjacent templates 67. The other arm 80 of the crossbar 77 acts as an interlocking projection for such adjacent template. Spacers 75 will be placed on both ends of the template 67 and this insures that the lines 81 and 82 of the "across-the-line" diagram will be clearly aligned. The spacers 75 thus perform a dual function of keeping the templates aligned as well as spaced apart. This spacing function, which is accomplished by the width of the

stem 76, eliminates the shadows between adjacent templates when the preliminary master drawing 70 is made. If edges of adjacent templates were permitted to touch or be too close together, the light from the lamps 42 could not easily get between these blocks, and hence a shadow might result.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. The method of making a master drawing comprising, placing a first sheet of photo-sensitized material with sensitized surface up on a support, placing a plurality of first transparent blocks on said first sheet, said blocks being smaller in area than said sheet and having opaque lines thereon, illuminating the sheet and blocks to expose the first photo-sensitized sheet, developing the image on said photo-sensitized sheet to produce a rough drawing, placing a second sheet of photo-sensitized material with the sensitized surface up on a support, placing said rough drawing as an opaque mask on top of said second sensitized sheet, placing a transparent mask on said rough drawing, said transparent mask having opaque lines thereon, placing a plurality of second transparent blocks on said transparent mask using the images of said first blocks as a guide, said second blocks being substantially identical in shape to said first blocks and having opaque lines thereon, removing said rough drawing, illuminating the remaining sheets and second blocks to expose said second photo-sensitized sheet, developing the image on said second photo-sensitized sheet to produce a sheet having photographically developed images thereon, and connecting said images by producing lines on said last-mentioned sheet to complete said master drawing.

2. The method of making a master drawing comprising, placing a first sheet of photo-sensitized material with sensitized surface up on a permeable support, placing a transparent border mask on said sheet, said transparent mask having opaque lines thereon to indicate a border and title block, placing a plurality of first solid transparent blocks on said transparent mask, said blocks being smaller in area than said sheets and having opaque lines thereon to indicate by drawing symbols a plurality of components for said master drawing and having permanent magnets embedded therein to adhere to the permeable support by magnetic attraction, illuminating the sheets and blocks to expose the first photo-sensitized sheet, developing the image on said photo-sensitized sheet to produce a rough drawing, placing a second sheet of photo-sensitized material with the sensitized surface up on a vacuum frame inside a peripheral row of vacuum air inlets thereon, placing said rough drawing as an opaque mask sheet on top of said second sensitized sheet, said two last-mentioned sheets being of substantially equal size, placing a transparent border mask on said rough drawing, said transparent mask having opaque lines thereon to indicate a border and title block, said transparent mask being of larger area than said other sheets to overlap same on said vacuum frame and cover said peripheral row of vacuum air inlets thereon, placing a plurality of second solid transparent blocks on said transparent mask using the images of said first blocks as a guide, said second blocks being substantially identical in shape to said first blocks and having opaque lines thereon to indicate by drawing symbols a plurality of components for said master drawing, removing said rough drawing, producing a partial vacuum in said vacuum frame to cause atmospheric pressure to urge said sheets and second blocks tightly against said vacuum frame, illuminating the remaining sheets and blocks to expose said second photo-sensitized sheet, developing the image on said second photo-sensitized sheet to produce a sheet having photographically developed images thereon, and connecting said images by producing lines on said last-mentioned sheet to complete said master drawing.

3. The method of making a master drawing comprising, placing a first sheet of photo-sensitized material with sensitized surface up on a support, placing a plurality of first transparent blocks on said first sheet, said blocks being smaller in area than said sheet and having opaque lines thereon, illuminating the sheet and blocks to expose the first photo-sensitized sheet, developing the image on said photo-sensitized sheet to produce a rough drawing, placing a second sheet of photo-sensitized material with the sensitized surface up on a support, a placing said rough drawing as an opaque mask on top of said second sensitized sheet, placing a transparent mask on said rough drawing, said transparent mask having opaque lines thereon, placing a plurality of second transparent blocks on said transparent mask using the images of said first blocks as a guide, said second blocks being substantially identical in shape to said first blocks and having opaque lines thereon, removing said rough drawing, illuminating the remaining sheets and second blocks to expose said second photo-sensitized sheet, and developing the image on said second photo-sensitized sheet to produce a sheet having photographically developed images thereon to complete said master drawing.

4. The method of making a master drawing comprising, placing a first sheet of photo-sensitized material with sensitized surface up on a permeable support, placing a transparent border mask on said sheet, said transparent mask having opaque lines thereon to indicate a border and title block, placing a plurality of first solid transparent blocks on said transparent mask, said blocks being smaller in area than said sheets and having opaque lines thereon to indicate by drawing symbols a plurality of components for said master drawing, illuminating the sheets and blocks to expose the first photo-sensitized sheet, developing the image on said photo-sensitized sheet to produce a rough drawing, placing a second sheet of photo-sensitized material with the sensitized surface up on a vacuum frame inside a peripheral row of vacuum air inlets thereon, placing said rough drawing as an opaque mask sheet on top of said second sensitized sheet, said two last-mentioned sheets being of substantially equal size, placing a transparent border mask on said rough drawing, said transparent mask having opaque lines thereon to indicate a border and title block, said transparent mask being of larger area than said other sheets to overlap same on said vacuum frame and cover said peripheral row of vacuum air inlets thereon, placing a plurality of second solid transparent blocks on said transparent mask using the images of said first blocks as a guide, said second blocks being substantially identical in shape to said first blocks and having opaque lines thereon to indicate by drawing symbols a plurality of components for said master drawing, removing said rough drawing, producing a partial vacuum in said vacuum frame to cause atmospheric pressure to urge said sheets and second blocks tightly aaginst said vacuum frame, illuminating the remaining sheets and blocks to expose said second photo-sensitized sheet, and developing the image on said second photo-sensitized sheet to produce a sheet having photographically developed images thereon to complete said master drawing.

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