

UNITED STATES PATENT OFFICE

2,311,547

PROCESS FOR PRODUCING ACCURATE REPLICAS AND PRODUCT

Miller Reese Hutchison, New York, N. Y., assignor
to Mock-Up Incorporated, a corporation of New
Jersey

Application July 12, 1941, Serial No. 402,128

6 Claims. (Cl. 95-5)

This invention relates to a process for producing accurate replicas of pictorial representations, line drawings, documents or the like and to the product thereof.

While the present invention is capable of broad application, it has special merit in the manufacturing industry, particularly in the production of punching and forming dies, jigs and templates, i. e., tools and dies used chiefly in mass-production methods. By way of example, the invention has been illustrated in connection with the manufacture of templates and, more specifically, templates of the character used in aircraft manufacture, since the advantages, inherent in the improved process, more readily will be appreciated when compared with practices presently prevailing in that industry.

Unlike automobile models, which remain of fixed design for a period of a year or more, enabling substantially all of the sheet metal elements to be blanked out and punched, the airplane, at the present time, is in a stage of rapid development; so much so, that most types would be obsolete in the time required to fabricate the necessary tools and dies for manufacturing them by standard, mass-production methods.

A modern plane chiefly is composed, as to fuselage and wings, of aluminum alloy sheets, shaped as required by their individual locations and riveted to each other and to the frame. The rivets must freely pass through holes in the sheets, which attach to other sheets and to the frame, requiring that the holes be drilled with considerable care and accuracy. Considering that a fighter-plane contains over 150,000 individual rivets and a bomber over 400,000, it is obvious that it would be impracticable to fabricate each of the many individual sheets by hand and, accordingly, the procedure heretofore followed has been, to prepare a template, or pattern, of the part to be fabricated from and by means of which a number of aluminum alloy replicas, quickly can be produced. The template is prepared by first laying out a sheet of steel, about $\frac{1}{4}$ inch thick, slightly longer and wider than is the part of the plane to be fabricated. One side of the sheet steel is painted a dull red, or brown, so that when a sharp, steel scriber is drawn across the surface, a contrasting bright line will be produced. The line must be deeply scratched into the surface of the metal, which requires that the scriber be used with considerable pressure. The process is very fatiguing, both to the hand and eyes of the workman and, should a mistake be made, it cannot be erased,

as could a pencil mark but, instead, must be eliminated by peening the surface, to render it smooth again, whereupon it must be recoated and the correct marking made. The process is exceedingly tedious and slow, since accuracy is absolutely necessary.

Some idea of the time, required to make a template, may be gleaned from the fact that some templates are over 10 feet long and over 6 feet wide, having one row of small rivet holes made parallel, each with the edges of the greater dimension and two rows near the ends, the holes being pitched only about $\frac{3}{4}$ of an inch apart. The center of each of these holes must be accurately scribed into the metal. In addition, there are many other holes, through which rivets must pass, to attach the sheet to the frame, as well as the weight-reducing, embossed and cut-away portions, etc., which must be located and designated. Then, there must be hand-stamped, by a hammer and individual letter or numeral punches, such information as, the sizes of holes to be drilled: the places where band sawing, milling machine profiling, sanding, etc., must be done, so as to give the machinist all the information necessary for fabricating the template. The whole process is time-consuming and, indeed, the operation of laying out one such template often requires weeks of time by expert, highly paid men.

When the template has been completed, it is placed on top of a number of like-size-to-template aluminum alloy sheets, all of which, including the template, are tightly clamped together so as to guard against relative movement. If the external periphery is of irregular shape, it is milled or band-sawed to conform to the shape of the template. The template then acts as a guide for the drilling of the holes through the pile of sheets. The drill, itself, is guided by a sleeve, the bottom end of which accurately fits into the holes that previously were drilled through the template: so that the drill, itself, is not in contact with the template, thus enabling the integrity of the template holes to be retained. Each aluminum alloy sheet, thus fabricated, is an exact replica of the template.

Laying out the templates is a "bottleneck" in aircraft production and anything which even slightly increases the speed of this operation is of great value.

According to the present invention, the template design originally is laid out accurately to scale in pencil, on drawing paper, which has been immunized against dimensional variations by

backing it with sheet metal in a manner herein-after described, or drawn upon aluminum foil, the surface of which has been prepared to take pencil. According to one procedure the metal, used for backing the paper, is template stock and, when the design of the template has been completed on the paper, together with all of the necessary information as to hole sizes, operations, etc., that must be imparted to the machinist, a reflex negative photographically is produced of the drawing and, from the reflex negative, a positive is printed on photographic paper, which likewise is immunized against dimensional variations, by properly being secured to a backing of thin sheet metal; or printed on thin aluminum foil, the surface of which has been sensitized to receive photographic impressions. These positives are retained as file copies and, since they will not be subject to dimensional variations, may again be used to prepare duplicate templates, by making reflex negatives of them, from each of which a positive is made on template stock which has been surfaced with photographic paper in a manner which later will be described.

After the file copies have been prepared, so that all the information will be available for future reference, the original drawing which, as will be recalled, was prepared in pencil, on paper, backed up by the template stock, is turned over to the machinist for fabrication, in accordance with the design and the instructions appearing thereon: so this becomes the template which is then employed in the usual manner in the fabrication of the aluminum alloy sheets for the airplane parts.

According to another procedure that may be followed, an original full scale drawing of the template is made in pencil, upon drawing paper, immunized against dimensional variations by a backing of thin sheet metal or the drawing may be made upon aluminum foil that has been treated to take pencil. All of the information required, for the fabrication of the template, is written upon these original drawings, which become the file copies from which any number of templates can be made. A template is made by preparing a reflex negative of the original drawing and a positive, from the reflex negative is printed onto photographic paper, backed up by template stock, which thus insures the photographic paper from dimensional changes. When the positive has been developed, it will be an accurate replica of the original full scale drawing and will enable a machinist to fabricate the template from the information that appears on the photographic reproduction, which is affixed to the template stock.

The advantages of drawing with a pencil on paper, or upon aluminum foil treated to take pencil, are obvious. It is quicker and less fatiguing to hand and eyes than is scribing lines into the surface of a piece of metal. Mistakes, which are prone to occur, easily are erased and corrected. However, ordinary drawing paper, tracing cloth, photographic paper, etc., are hygroscopic, i. e., they absorb atmospheric moisture. Thus, on damp days, such materials expand, whereas on dry days, they contract. Therefore, two points or lines, located several feet apart, on such materials, will be located further apart on a wet day, than on a dry day. But for this, a layout could be made on drawing paper and, when completed, the paper could be adhered to a sheet of template stock, so that machinists, by following the lay-out, could fabricate the template as

well as if the information had been scribed into the surface of the metal. However, paper can be used, if rendered invulnerable to dimensional changes and that is just what is done, in the instant process, to the paper on which the template lay-out appears at any time, whether it be on the drawing paper or on the photographic paper backed, either by template stock or by thin sheet metal, for filing, according to which procedure is followed. Of course where metal foil is used, in the process for the file copy, either as the medium upon which the template lay-out originally is pencil drawn or upon which the template lay-out photographically is reproduced, no dimensional changes will occur from variations in atmospheric moisture. It is important, too, that the reflex negative, which is made as an intermediate step of the process, also be immunized against dimensional variations. In a word, it is essential that the integrity of the template design be maintained at all stages in the process, as well as in the file copies that are retained for future use; otherwise inaccuracies would appear in the ultimate airplane parts which would render them useless.

According to the present invention, the drawing paper, or the photographic paper, as the case may be, is attached to one side of the template stock, or to one side of the thin sheet metal for the file copy, in such manner that each part of the surface of the paper firmly is affixed to the adjacent part of the metal surface and, assuming that the paper is very thin and properly applied and that the proper type of plastic is used as an adhesive, changes in atmospheric moisture will have no effect upon the paper, insofar as expansion or contraction is concerned, with the result that there will be no variations in the distance between any two points, or lines, appearing on the paper. A better understanding of the invention may be had from the following description, when read in conjunction with the accompanying drawing wherein

Fig. 1 is a sectional view, greatly enlarged, depicting a portion of a sheet of drawing paper, backed with sheet metal such as is used in practicing the present invention;

Fig. 2 is a sectional view, greatly enlarged, depicting a portion of a sheet of paper having a thermo-plastic coating, prior to being backed with metal;

Fig. 3 is a sectional view, greatly enlarged, of a portion of a metal sheet which has been given a thermo-plastic coating, prior to being faced with paper;

Fig. 4 is a diagrammatic view illustrating the manner in which the thermo-plastic coated paper and metal sheet, of Figs. 2 and 3 are adhered;

Fig. 5 is a sectional view, greatly enlarged, and depicting a portion of a sheet of photographic paper thermo-plastically adhered to a sheet of metal;

Fig. 6 is a sectional view, greatly enlarged, and depicting a portion of a sheet of photographic paper thermo-plastically adhered to a sheet of glass, for use in making a reflex negative;

Fig. 7 is a diagrammatic view of the frame in which there are made the reflex negatives and the positives, therefrom; and

Fig. 8 is a sectional view, greatly enlarged, depicting a portion of a sheet of paper coated, on one side, with a photographic emulsion and, on the opposite side, with a thermo-plastic.

Reference first will be made to the template stock which is faced with paper, on which the original template design is drawn and which ultimately is fabricated into the template, after a file copy has been made from a reflex negative of the template design. As shown in Fig. 1, a sheet of drawing paper A is adhered to a sheet of metal B (template stock) by an intermediate thin layer of thermo-plastic C. The drawing paper A must have certain characteristics to render it suitable for the function it has to perform. First, the paper should be very thin, preferably not more than five-thousandths of an inch thick, in order that the punch will not "walk" when it is struck by a hammer to indent the centers of the holes to be drilled. Where the paper is too thick, the punched center-mark, in the metal, will not be made directly under the point of intersection of the two lines on the paper, denoting the center of the hole to be drilled, unless indeed, the machinist holds the punch absolutely vertically with reference to the surface of the paper-covered template sheet. The paper also must be very smooth, otherwise the pencil point quickly will be dulled, making the lines of varying width; this despite the fact that a special pencil of extreme hardness is recommended for this type of work. It is essential that all of the pencil-drawn lines be thin and sharply defined since, in this work, dimensions accurate to a thousandth of an inch are being dealt with. Toughness also is a requisite, because erasures must be made and also because, during the machining of the template stock, the saws, sanders and millers tend to pull the paper apart, which would result in destroying the integrity of the lines at the point of machining.

The thermo-plastic must also have special characteristics. It must be insoluble in water, so as to be unaffected by dampness and its melting point must be greater than are the temperatures generated by sawing, sanding or milling the template, in fabrication, or the paper would separate, at the point of machining, from the metal and thus destroy the integrity of the design. A thermo-plastic having a softening point of about 300° F. is recommended for this purpose. Thermo-plastics, having such characteristics, currently are on the market.

Care must be exercised, in the process of adhering the paper to the template stock, to insure a surface free of lumps and to insure, also, that there be an entire absence of air or gas pockets between the paper and the metal; otherwise, the integrity of the drawing would be destroyed, since the dimensions of the paper on and in the vicinity of the air or gas pockets, would vary with changes in atmospheric conditions, for reasons previously pointed out. To obtain a good product, it is preferred to coat one surface of the metal with thermo-plastic, as well as that surface of the paper which, in the completed stock, will be adjacent the metal, since two thermo-plastic surfaces more intimately will form a firm bond, than can possibly be secured if only one of the two surfaces is coated. A coating of thermo-plastic may be applied to the paper by looping the latter transversely and drawing it over the surface of liquid thermo-plastic, as is done when coating paper with photographic emulsion. If the paper then is drawn over a roller, past a scraper located at a fixed distance from the coated surface of the paper, the surplus plastic will be scraped off leaving a coating of definite thickness upon the paper. Figs. 2 and 3 illus-

trate, respectively, a sheet of paper A and a sheet of metal B, both coated with thermo-plastic C and before being joined together.

The manner in which the paper and template stock, both previously covered with thermo-plastic, are adhered together, is illustrated in Fig. 4. The necessary apparatus consists of a frame, somewhat similar to a vacuum printing frame, in that it includes a base member D and a top flexible member E capable of being brought together to define a compartment F, from which air can be exhausted. The base D is capable of being heated, preferably by electricity, in order that the temperature may be accurately controlled. The template stock B is laid, coated surface up, on the base plate D and the paper, coated surface down, on top of the template stock. In other words, the plastic layers, on the paper and on the template stock, are placed in contact, after the base plate D has been heated.

When the template stock and paper are in position, the frame is closed. Heat is applied to bring the temperature up to the melting point of the thermo-plastic (i. e., about 300° F.) and the air is exhausted from the chamber F, until a vacuum of about thirty inches of mercury is obtained. These conditions are held, for about five minutes, during which period not only is all the air and whatever gas may be given off by the melted thermo-plastic extracted from what otherwise would be the space between the metal and the paper, but the paper is firmly pressed, throughout its entire area, to the surface of the metal, by the action of the vacuum-actuated flexible member E. When the thermo-plastic thus has been cured, the bond is complete and the template paper-coated stock is ready for laying out the template design.

The paper coated metal stock, for use in the alternate procedure, that is, where the original drawing of the template design is maintained as the file copy and the template produced photographically, may be made in the same way. It too, consists of a layer of paper A and a thin sheet of metal B, joined together by a thin layer of thermo-plastic C (Fig. 1).

The paper used must possess some of the attributes that are possessed by the drawing paper which is applied to the template stock, in that it must present a smooth surface, so as not unduly to wear the pencil and also must have the required toughness to withstand erasures. It could, without harm to the process, lack certain of the tough qualities possessed by the paper used in conjunction with the template stock since, of course, it does not have to be subjected to a machining process. The metal backing member B need not be as heavy as the template stock, but its surface must possess the same smoothness and character, so that the plastic layer will be correspondingly smooth and not form lumps beneath the paper. The thermo-plastic could be of a lower melting point, if desired, since it would not have to withstand the temperatures generated by machining, as does the paper coated template stock.

In Fig. 5 there is shown a sheet of paper G, surface-coated with a photographic emulsion H and adhered to a metal backing I by an intermediate layer of plastic J. This figure pictorially represents template stock faced with photographic paper and to which the template design photographically would be transferred, in accordance with one of the procedures previously outlined; or a thin metal sheet, faced with photo-

graphic paper and to which the template design photographically can be transferred, for use as a file copy, in the event the other procedure is followed. Where the stock is for template use, it must have certain special qualities to render it suitable for the purpose intended. Thus, repeating, for sake of emphasis, the paper must be very thin, so that the punch will not "walk" when indenting the centers for the holes, to be drilled and must have a smooth surface, especially on the side to which the photographic emulsion is to be applied. It must also possess toughness, so as to guard against pulling apart during the fabrication of the template. The template stock I is identical to that used for the paper-faced template stock previously described. The thermo-plastic, in addition to possessing all of the qualities of that used for adhering the drawing paper to the template stock must, in addition, be acid and alkali-proof, in order that the bond will survive the developing process.

The procedure followed, in applying the photographic paper to the template stock, is the same as that used in applying the drawing paper to the template stock.

A sheet of paper T coated, on one side, with a thermo-plastic U, and on the opposite side, with a light sensitive emulsion V, in itself, is believed to be new and is one of the features of the instant invention (Fig. 8). Special care must be exercised in preparing the paper before it is adhered to a backing element which is immune to dimensional variations. Thus, the thermo-plastic U should be applied before the emulsion V and allowed to dry if applied in cold, liquid form; or to set if applied in heated form. This sequence is desirable since light sensitive emulsion easily is contaminated and also, since the thermo-plastic tends to stiffen the paper which is very thin—around three thousandths of an inch—thus making it easier to apply the emulsion when the paper loop is moved into and out of contact with the surface of the emulsion in the applying trough. Also, since photographic emulsions are sensitive to infra red rays, as well as to visible light, an emulsion is used, the sensitivity of which initially is much higher than is required for printing; one being selected of such character that, after it has been subjected to the heat required to cure the thermo-plastic, during the application of the sensitized paper to the template stock, nevertheless will have a final sensitivity correct for printing. Since the heat retained in the template stock, after the cure of the thermo-plastic has been completed, would continue to effect the sensitivity of the emulsion, it is preferable that the product be cooled as expeditiously as possible and for this purpose suitable refrigerating means may be employed.

To be more specific, in adhering the photographic paper to its base, the heating unit must be brought to a definite temperature which is held for a definite period to effect a proper cure of the thermo-plastic. With that as a consideration, a light sensitive emulsion is selected having an initial sensitivity gaged to permit a reduction to the proper value for printing at the conclusion of the plasticizing process. At the conclusion of the cure the plasticized unit immediately is removed from the heating frame and placed in a refrigerating chamber. In other words, it is essential that the reduction in sensitivity accurately be controlled: otherwise, in the subsequent printing there would be no way of

accurately determining the light intensity and exposure time required for proper exposure.

A similar procedure can be followed in preparing the metal backed photographic stock for use as a file copy. The paper used for this stock may lack some of the toughness of the photographic paper attached to the template stock since, of course, it will not have to undergo the rigors of machining. The metal stock may be thinner than is the template stock.

Before describing the process of producing the reflex negatives, a description first will be given of the element on which the reflex negative is made. As shown in Fig. 6, the element includes a sheet of plate glass K and a sheet of photographic paper L, adhered to the glass by means of a thin layer of thermo-plastic M. The paper is applied to the glass in the same manner as is the photographic paper applied to the template stock and which previously has been described. Here, too, the paper must be attached to the surface of the glass, over its entire area, since it must be immune to dimensional changes, in order to maintain the integrity of the template design, throughout the process. The thermo-plastic, in addition to being water, acid and alkali-proof, must also be transparent, to permit the passage of light. There is also followed the same procedure of using an emulsion of originally higher sensitivity than is required for printing, since here, too, the sensitivity of the emulsion suffers as a result of the heat applied during the curing of the thermo-plastic, to attach the paper to the glass. In other words, the initial sensitivity of the emulsion is such that, after it has been in the heating frame for the length of time required to cure the thermo-plastic, say about five minutes, the sensitivity will have dropped to the desired point for printing. It is also preferable, in this connection, to use a photographic emulsion which will not require a dark room for handling; in other words, one which will not be particularly sensitive to ordinary factory illumination, if quickly handled in that light.

While photographic paper, is preferred as the medium for making the reflex negatives, other materials having the requisite properties will suffice.

A commercial type of vacuum printing frame, such as illustrated in Fig. 7, is utilized in preparing the reflex negative from the original template drawing and for making the positive from the reflex negative. Such frames consist of a ground glass base plate N having an overlying compartment O which, when the frame is closed, is defined, at the top, by a flexible member P and with means for extracting the air from the compartment O. A compartment, Q underlying the ground glass plate N, houses a source of orange light for printing negatives and a source of white light for printing positives, suitable timing devices being employed to regulate the periods of exposure: or all the lights may be white if an orange filter is interposed when printing the negative.

The reflex negatives are made as follows: With the printing frame open, a glass plate R, previously faced with photographic paper in the manner described, is laid upon the ground glass plate N, with the photographic paper facing upward (Fig. 7). On this element there is laid the metal-backed drawing of the template design, i. e., the drawing on the paper coated template stock or the drawing on the paper coated thin metal file copy or on the aluminum foil file copy,

according to which procedure is followed, as previously described. In other words, the emulsion side of the glass plate and the drawing side of the design, are in contact. The vacuum frame is then closed, the vacuum applied, and the unit exposed for a few seconds, to orange light. When the glass plate is removed and its photographic surface developed and fixed, there will be found, on its surface, a reflex negative of the template design, i. e., the lines will be white (semi-transparent) and the blank spaces opaque. The glass plate, with the paper reflex negative still attached to its surface, is now returned to the vacuum printing frame and again placed upon the ground glass base, with the paper reflex negative face upward. Template stock, coated with photographic paper of the type previously outlined, or thin metal stock coated with photographic paper as previously outlined, or metal foil, the surface of which photographically has been sensitized, according to which procedure is followed, is placed, emulsion side down, on the reflex negative. The frame is then closed and the unit exposed to white light for the proper number of seconds, after which the exposed template stock, thin metal stock, or metal foil, as the case may be, is developed and, on the newly developed surface, there will be an exact replica of the original template design, with all the information, required by the machinist, on it and which may be used as previously outlined. In other words, if the photographic replica is on template stock, the indicated holes will be center punched and the template then drilled and machined, preparatory to making the aluminum alloy airplane parts from the template. Or, where the photographic replica is made on paper coated thin metal stock, or upon aluminum foil from an original design on paper coated template stock, such photographic replicas will be used as the file copies from which a replica, on template stock, photographically may be prepared, at any future time. The paper reflex negatives, upon serving their purpose, may be removed from the glass backing element, by a suitable solvent for the thermo-plastic, enabling the glass to be re-faced with photographic paper in the manner described, for use in making other reflex negatives.

In addition to the advantages possessed by this instant invention, some of which have been set forth and others of which will be apparent to those skilled in the art, there are strategic points which, under present conditions, in which time is the essence in aircraft production, are of great value.

Under present practices, when detailed scale drawings of a new design of plane passes from engineering to mold loft of an aircraft factory, templates are laid out and made for parts requiring such for their fabrication. This requires much time and it is months before the first model can be tested for final adoption, even if no mistakes have been made in design of some parts, invariably apparent when assembly is in order.

It is difficult and usually impossible to alter a completed template: so new templates must be made, occasioning further delay. Then, too, when the plane is tested, it may be rejected, in which event the time and money spent in fabricating the templates, etc., are lost.

A much quicker and more economical procedure will be to lay out the template designs on paper covered thin sheet metal or aluminum foil,

the former being preferred, and make reflex negatives from them. From the reflex negatives, positive prints would be made on the Duralumin sheets which will constitute the airplane, the sheets having previously been prepared to take the positive prints either by sensitizing the metal or by adhering the metal to photographic paper. The Duralumin sheets then would be fabricated in accordance with the design printed upon them and used in custom-making the first airplane. If then, it is found necessary to make any changes in design, it would be but the work of a few hours to erase and correct the design on the original paper covered thin sheet metal, prepare new reflex negatives from which the design would be photographically transferred, as before, to new Duralumin sheets. These sheets, of course would be fabricated in accordance with the design and built into the plane. When the plane is accepted, the templates would be made in the manner previously described using the same reflex negatives. Going into production, by this system, greatly would be advanced and much money would be saved.

If reasonably sure of the acceptance of the plane, when the first model is tested, production time could be cut down by laying out all the templates, making reflex negatives therefrom, printing the positive onto the sensitized sheet metal to compose the plane and, while the plane is in custom fabrication, fabricate the templates of parts which are least apt to be changed. Such designs as must be changed can be, as to defective details, erased from the paper on the template stock and fabrication of the templates carried on. By this plan, by the time the plane would be completed, many of the templates will have been made and, on acceptance, mass production shortly can be begun.

Another advantage of the invention resides in the ease with which any number of replicas of the original drawing can be made. Thus, under the present practice, where there are a number of duplicate parts in a single ship, a corresponding number of duplicate submaster templates are made in order to keep the production in step. Instead of drilling the submaster templates from the master template as now, a practice which may result in submaster templates of less accuracy than the original because steel and not aluminum alloy is the material, the duplicate submasters can be made photographically in the manner described and individually fabricated, so that each submaster will be as accurate as is the original.

Then, too, the system may be used to reproduce whatever drawings are required of the original and for whatever purpose intended. Thus, insofar as Government work is concerned, the Government requires a replica on tracing cloth, of all parts of a ship or device made for it. With the present system, such replicas photographically can be made on commercially available waterproof tracing cloth, through the use of the reflex negative of the original template drawing.

In the accompanying drawing, the invention has been illustrated merely in preferred form and by way of example, but obviously many variations and modifications may be made therein which will still be comprised within its spirit. It is to be understood, therefore, that the invention is not limited to any specific form or embodiment, except insofar as such limitations are specified in the appended claims.

I claim:

1. A process for producing templates which includes placing a photo-sensitive surface, presented by a backing sheet of light transmitting material, in face contact with a surface presenting the template layout accurately to scale and which is immune to longitudinal and transverse dimensional variations due to atmospheric moisture, exposing the photo-sensitive surface to light transmitted through the backing sheet and reflected from the surface presenting the template layout, processing the exposed photo-sensitive surface to produce a reflex negative of the template layout, locating the reflex negative in face contact with a photo-sensitive surface presented by a sheet of template stock, exposing said last mentioned photo-sensitive surface to light passing through the light transmitting backing sheet and the reflex negative to produce, after processing said photo-sensitive surface, an accurate replica of the template layout on the template stock, and thereafter fabricating the template stock in accordance with the layout photographically transferred thereto, the backing sheet of light transmitting material and the template stock being such as to maintain their respective photo-sensitive surfaces immune to longitudinal and transverse dimensional variations throughout the processing steps and immune also to longitudinal and transverse dimensional variations due to changes in atmospheric moisture.

2. A process for producing templates which includes making an accurate layout of the template on a surface immune to longitudinal and transverse dimensional variations from changes in atmospheric moisture, placing a photo-sensitive surface, presented by a backing sheet of light transmitting material, in face contact with the surface presenting the template layout, exposing the photo-sensitive surface to light transmitted through the backing sheet and reflected from the surface presenting the template layout, processing the exposed photo-sensitive surface to produce a reflex negative of the template layout, locating the reflex negative in face contact with a photo-sensitive surface presented by a sheet of template stock, exposing said last mentioned photo-sensitive surface to light passing through the light transmitting backing sheet and the reflex negative to produce, after processing said photo-sensitive surface, an accurate replica of the template layout on the template stock, and thereafter fabricating the template stock in accordance with the layout photographically transferred thereto, the backing sheet of light transmitting material and the template stock being such as to maintain their respective photo-sensitive surfaces immune to longitudinal and transverse dimensional variations throughout the processing steps and immune also to longitudinal and transverse dimensional variations due to changes in atmospheric moisture.

3. A process for producing a template which includes placing a sheet of photo-sensitized paper, adhered to a backing sheet of glass, in face contact with a surface presenting the template layout accurately to scale and which is immune to longitudinal and transverse dimensional variations due to atmospheric moisture, exposing the photo-sensitized paper to light transmitted through the glass backing sheet and reflected from the surface presenting the template layout, processing the exposed surface to produce a reflex negative of the template layout, locating the reflex negative in face contact with a photo-

sensitive surface presented by a sheet of template stock, exposing said last mentioned photo-sensitive surface to light passing through the glass backing sheet and the reflex negative to produce, after processing said photo-sensitive surface, an accurate replica of the template layout on the template stock, and thereafter fabricating the template stock in accordance with the layout photographically transferred thereto, the photographic paper being adhered to the glass backing member by a thermo-plastic which maintains their union intact throughout the processing step.

4. A process for producing a template which includes placing a photo-sensitive surface, presented by a backing sheet of light transmitting material, in face contact with a surface presenting the template layout accurately to scale and which is immune to longitudinal and transverse dimensional variations due to atmospheric moisture, exposing the photo-sensitive surface to light transmitted through the backing sheet and reflected from the surface presenting the template layout, processing the exposed photo-sensitive surface to produce a reflex negative of the template layout, locating the reflex negative in face contact with a sheet of photo-sensitized paper adhered to a sheet of template stock, exposing the photo-sensitized paper to light passing through the light transmitting backing sheet and the reflex negative to produce, after processing the photo-sensitized paper, an accurate replica of the template layout on the paper coated template stock, and thereafter fabricating the template stock in accordance with the layout photographically transferred thereto, the photographic paper being adhered to the template stock by a thermo-plastic which maintains their union intact throughout the processing steps and which resists softening during the fabrication of the template.

5. A process for producing a template which includes placing a sheet of photo-sensitized paper, adhered to a backing sheet of glass, in face contact with a surface presenting the template layout accurately to scale and which is immune to longitudinal and transverse dimensional variations due to atmospheric moisture, exposing the photo-sensitized paper to light transmitted through the glass backing sheet and reflected from the surface presenting the template layout, processing the exposed surface to produce a reflex negative of the template layout, locating the reflex negative in face contact with a sheet of photo-sensitized paper adhered to a sheet of template stock, exposing the photo-sensitized paper to light passing through the glass backing sheet and the reflex negative to produce, after processing the photo-sensitized paper, an accurate replica of the template layout on the paper coated template stock, and thereafter fabricating the template stock in accordance with the layout photographically transferred thereto, the photographic paper being adhered to the template stock and to the glass backing member by a thermo-plastic which maintains their respective unions intact throughout the processing steps, and which, as regards the paper coated template stock, resists softening during the fabrication of the template.

6. A process for producing templates which includes making an accurate layout of the template on paper which has been adhered to a backing of metal stock in a manner to render the paper immune to longitudinal and transverse

dimensional variations due to atmospheric moisture, placing a photo-sensitive surface, presented by a backing sheet of light transmitting material, in face contact with the surface presenting the template layout, exposing the photo-sensitive surface to light transmitted through the backing sheet and actually reflected from the surface presenting the template layout, processing the exposed photo-sensitive surface to produce a reflex negative of the template layout, locating the reflex negative in face contact with a photo-sensitive surface presented by a sheet of template stock, exposing said last mentioned photo-sensitive surface to light passing through the

5 light transmitting backing sheet and the reflex negative to produce, after processing said photo-sensitive surface, an accurate replica of the template layout on the template stock, and thereafter fabricating the template stock in accordance with the layout photographically transferred thereto, the backing sheet of light transmitting material and the template stock being such as to maintain their respective photo-sensitive surfaces immune to longitudinal and transverse dimensional variations throughout the processing steps and immune also to longitudinal and transverse dimensional variations due to atmospheric moisture.

MILLER REESE HUTCHISON.