Aug. 8, 1967 W. F. DELP 3,334,541

PRECISION ART WORK MACHINE

Filed July 28, 1964

FIG. 1

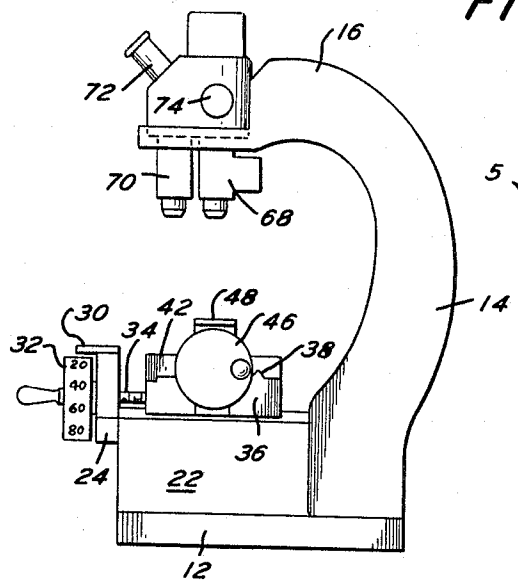
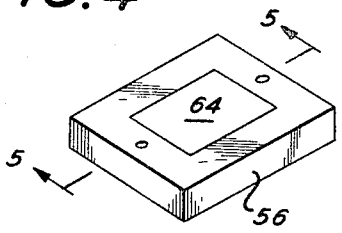


FIG. 4



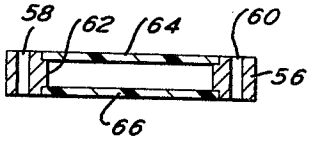
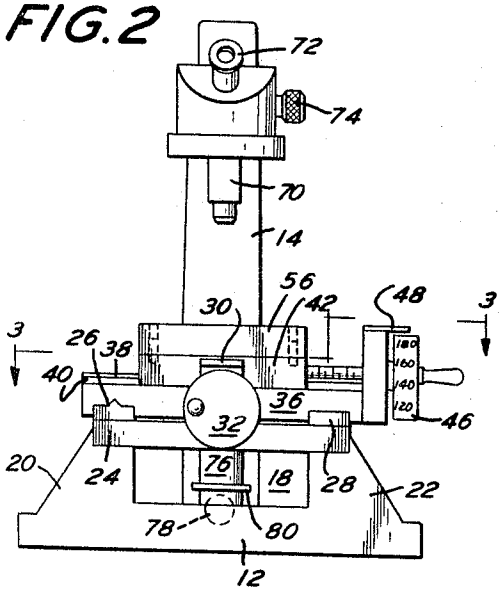


FIG. 5

FIG. 2



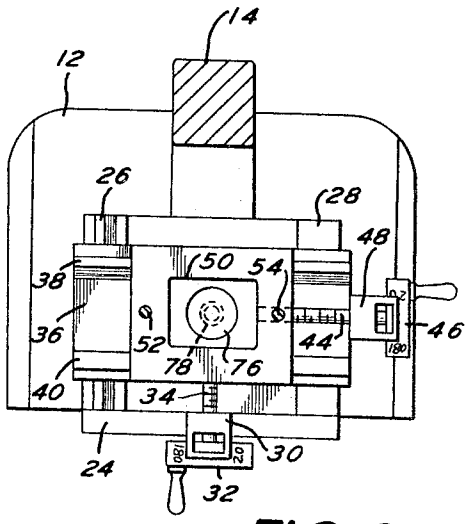
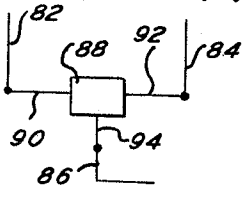


FIG. 3

FIG. 6



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PRECISION ART WORK MACHINE

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This invention relates to a precision art work machine, and more particularly, to a machine for producing any number of art work patterns with identical accuracy and with a higher degree of accuracy known heretofore in connection with similar machines.

The machine of the present invention is adapted to reproduce art work orientated with respect to a master pattern with identical accuracy up to plus or minus .1 micro inch. Direct focusing of art work patterns before an exposure is made is provided for in the machine of the present invention thereby eliminating or overcoming the trial and error methods utilized heretofore. Such direct focusing of the image is preferably accomplished by reading through a microscope.

The machine of the present invention may include a high speed photoelectric microscope constructed for automated operation so that it can repeat itself observing a line section of 10 micro inches, and will automatically trigger the reduction printer. The high speed photoelectric microscope may be coupled with an interferometer for automated indexing. The reduction printer is located below and facing upwardly toward the sensitive surface of a mask plate regardless of the type of microscope. This relationship is an important feature of the present invention.

The precision art work of the master pattern may assume a wide variety of configurations and is adapted for wide variety of uses. One use of the master pattern is a miniaturized printed circuit. Other types of art work and uses for the same will be readily apparent to those skilled in the art to which the present invention pertains.

It is an object of the present invention to provide a novel precision art work machine for producing art work orientated with respect to a master pattern with high identical accuracy.

It is another object of the present invention to provide a precision art work machine which provides for direct focusing of the art work image before an exposure is made.

It is another object of the present invention to provide a precision art work machine wherein any error in the image is constant for all reproductions.

Other objects will appear hereinafter.

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a side elevation view of the machine of the present invention.

FIGURE 2 is a front elevation of the machine of the present invention.

FIGURE 3 is a sectional view taken along the line 3—3 in FIGURE 2.

FIGURE 4 is a perspective view of a plate holder.

FIGURE 5 is a sectional view of the plate holder taken along line 5—5 in FIGURE 4.

FIGURE 6 is a schematic illustration of art work.

Referring to the drawings in detail, wherein like numerals indicate like elements, there is shown in FIGURE 1 a precision art work machine of the present invention designated generally as **10**.

The machine **10** includes a generally flat horizontally disposed base **12** having an upright column **14**. Column **14** extends upwardly from the base **12** along a back side thereof and terminates in a generally horizontally disposed arm **16**. The base **12** is provided with upright support members **20** and **22** spaced from each other so as to provide a recess **18** therebetween, see FIGURE 2.

A brace plate **24** extends between the members **20** and **22**. A gib **26** and a guide **28** extend along the upper surface of the members **20** and **22** in a direction perpendicular to the direction of the plate **24** and above the plane of the plate **24**.

The plate **24** supports a vernier **30** and a hand wheel **32** having graduations on its periphery. Hand wheel **32** is connected to a shaft **34** which in turn is connected to a plate member **36**.

Plate member **36** is contoured on its lowermost surface to mate with the gib **26** and guide **28**. Plate **36** is reciprocated toward and away from the column **14** by rotating hand wheel **32**. Such reciprocation of plate member **36** is guided by the gib **26** and guide **28**.

The uppermost surface of plate member **36** is provided with a gib **38** and a guide **40** along opposite sides thereof. A plate holder support **42** is provided with surfaces which mate with the gib **38** and guide **42**. The support **42** is guided by gib **38** and guide **40** for reciprocation in a direction perpendicular to the direction of reciprocatory movement of the plate member **36**.

Reciprocation of plate holder support **42** is effected by a hand wheel **46** having graduations thereon. Hand wheel **46** is supported by plate member **36** by means of an upright support terminating at its upper end in a vernier **48**. Hand wheel **46** is coupled to support **42** by means of shaft **44**. Hereinafter, elements **26–48** inclusive may be referred to as an X–Y axis stage.

The support **42** is provided with a centrally disposed generally rectangular aperture **50**. Upright pins **52** and **54** are provided on the support **42** on opposite sides of the aperture **50**. Support **42** is adapted to have mounted thereon a plate holder **56**. Plate holder **56** is provided with spaced holes **58** and **60** adapted to receive the pins **52** and **54**, respectively. The pins **52** and **54** may be of different size or contour to mate with corresponding shaped holes **58** and **60** to assure proper positioning and orientation of the plate holder **56**.

The plate holder **56** is provided with a centrally disposed aperture **62** which corresponds in size and configuration to the aperture **50**. The plate holder **56** is provided with a peripheral recess to the aperture **62** on its upper surface and within which is supported a master pattern substrate **64** so as to be flush with the upper surface of plate holder **56**. Substrate **64** may be made from any transparent material such as glass, plastics, etc. on which a master pattern may be provided in accordance with any conventional process. For example, a printed circuit may be engraved on the substrate **64**.

On its lowermost surface, the plate holder **56** is provided with a peripheral recess around the aperture **62**. A mask plate **66** is disposed within the recess and overlies the aperture **62**. The mask plate **66** is provided with its photosensitive surface visible when viewing the mask plate **66** from below. Adjustable means such as screws, clips or pins (not shown) are provided to assemble holder **56**, plate **66** and substrate **64**.

The arm **16** is provided with a high speed photoelectric microscope **68** and a conventional manual microscope **70**. The microscopes **68** and **70** may be manually indexed so as to be positioned on a center line with and over the master pattern on the substrate **64**. An adjustable eye piece **72** is supported by the arm **16** for observing the focus of the image on plate **66**. Adjustment of focus of

said image is accomplished by adjusting the nob 74. Nob 74 moves the microscopes up or down as desired.

A reduction printer 76 is supported in the recess 18 by the base 12 below the plane of the plate member 36. Hence, the reduction printer 76 will be below the mask plate 66 when the plate holder 56 is supported by the plate holder support 42. The reduction printer 76 is diagrammatically illustrated and is provided with a negative holder 80. The printing light source means is illustrated at 78 and includes two light sources of different intensities.

An interferometer is an instrument which utilizes the phenomenom of interference of light waves for the measurement of small distances. Interferometers may assume a wide variety of forms, however in most cases two or more beams of light travel separate paths, determined by a system of mirrors and plates, and are finally united to form interference fringes. Substantially any commercially available interferometer may be coupled to the microscope 68 and the camera 76 to trigger the camera when the image is orientated and in focus if greater accuracy is desired.

In FIGURE 6, there is illustrated schematically a portion of the master pattern on substrate 64. Said portion of the master pattern includes lines or conductors 82, 84 and 86. The art work to be exposed on mask plate 66 and orientated with respect to the master pattern may include element 88 representative of a transistor, for example, and its lines or condutcors 90, 92 and 94.

The operation of the machine of the present invention is as follows:

Let it be assumed that the substrate 64 has etched or engraved thereon a master pattern in any conventional manner, the pattern including printed circuitry having conductors 82, 84 and 86. Let it be assumed that the negative in the negative holder 80 has been prepared with art work corresponding to element 88 and its conductors 90, 92 and 94 which are to be exposed on the mask plate 66. The present invention enables the art work on the negative to be exposed on the mask plate 66 and orientated with respect to the art work on the master pattern with extreme accuracy so that conductor 90 will properly be orientated with conductor 82, conductor 92 will be properly orientated with condutcor 84, and conductor 94 will be properly orientated with respect to conductor 86.

The mask plate with its photosensitive surface facing downwardly is releasably connected to the plate holder 56. The substrate 64 is likewise releasably coupled to the plate holder 56. In accordance with conventional practice (not shown), a mask is provided to prevent exposure of the photosensitive surface on the mask plate 66. Thereafter, the plate holder 56 is orientated with respect to the pins 52 and 54 which are aligned with the holes 58 and 56 respectively. Thereafter, the mask over the photosensitive surface on the mask plate 66 is removed.

Thereafter, the image of the art work of the negative projected on the photosensitive surface of the mask plate 66 is observed by focusing the microscope and viewing the image through the eye piece 72. The focal plane of the microscope 70 includes substrate 64 and plate 66, due to the close spacing thereof. When the image is in focus and being observed, the hand wheels 32 and 46 of the X–Y axis stage are adjusted to properly orientate the image on plate 66 with respect to the master pattern. When this orientation and focusing is being accomplished, the very low intensity light source of the printing light source means 78 is being utilized so as not to expose the photosensitive surface on the mask plate 66. When focusing and orientation have been accomplished, the high intensity light source is activated by a switch (not shown) to expose the image projected from the negative in the negative holder 80 onto the photosensitive surface of the mask plate 66. Thereafter, the plate holder 56 is removed from its operative disposition, mask plate 66 is removed from its disposition on the plate holder 56, and thereafter the mask plate 66 is developed in a conventional manner. A new mask plate may be provided on the plate holder 56 and exposed by activating the high intensity light source. This step may be repeated to expose any number of such mask plates.

The art work on the negative in the negative holder 80 may be of such a nature which is an addition to the art work on the master pattern properly orientated with respect thereto or may contain art work which is to be a substitute for a portion of the art work on the master pattern. Any error in the art work of the negative and exposed on plate 66 is constantly repeated. Hence, adequate compensation may be provided at some other point in the system which uses the art work to correct for the uniform error. The provision of a machine which produces a constant error is a distinct advantage over devices used heretofore which are subject to error, which errors are variable and therefore difficult or impossible to compensate for. Since the negative has art work thereon which is to be projected on to the mask plate 62, it in itself may be considered a substrate having a master pattern thereon. The negative of course will be stored when not being reproduced. After a predetermined number of mask plates have been made with a particular art work thereon, the negative being used may be readily removed and a different negative substituted therefor. When a negative has been changed, it will be necessary to refocus and reorientate the image on the mask plate with respect to the art work on the master pattern. The reduction printer 76 has is own adjusting nob (not shown) for adjusting the focus of the art work on the negative with respect to the image projected on to the mask plate 66. If the above sequence of steps are accurately performed, an accuracy of .1 micro inch may be attained. The microscopes, reduction printer, interferometer, are per se commercially available items known to those skilled in the art and therefore need not be described in detail.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

It is claimed:

1. Apparatus for producing precision art work comprising means for supporting a substrate adapted to have a master pattern thereon, means for supporting a mask plate juxtaposed to said substrate and below said substrate, a reduction printer means below the means for supporting the mask plate, said reduction printer means facing upwardly toward said last mentioned means, and means for simultaneously moving each supporting means as a unit relative to said printer means for orientating the mask plate.

2. Apparatus for producing precision art work comprising a holder for supporting a substrate having a master pattern thereon, a mask plate, means for supporting the mask plate juxtaposed to the substrate and below the substrate, a reduction printer means below the holder and facing upwardly toward the supporting means for the mask plate, said reduction printer means including means for supporting a negative having art work adapted to be projected on to a photosensitive surface of the mask plate, means for focusing the image of the art work on the negative on to the photosensitive surface of the mask plate, means for adjusting the mask plate supporting means so that the image projected on to the mask plate is orientated in a predetermined manner with respect to the master pattern, and a light source means for exposing the image from the negative on the photosensitive surface of the mask plate.

3. Apparatus in accordance with claim 2 wherein the holder for the substrate is an annular readily removable member, said holder also constituting the means for supporting the mask plate.

4. Apparatus for producing precision art work comprising a plate holder for supporting a substrate adapted to have a master pattern thereon and for supporting a mask plate juxtaposed to the substrate, a reduction printer, the reduction printer facing toward the mask plate, said reduction printer being adapted to have a negative on which art work is provided and adapted to be projected on to a photosensitive surface of the mask plate, a X–Y axis stage device for orientating the mask plate and master pattern with respect to the printer and a microscope positioned to facilitate viewing the master pattern whereby said orientation may be accomplished with accuracy.

5. Apparatus for producing precision art work comprising a base, a column supported by said base and extending in an upright direction, the upper end of said column having an arm extending over said base, a microscope supported by said arm, means associated with said microscope for adjusting the position thereof with respect to said arm, an eye piece for said microscope, a X–Y stage device on said base for supporting the substrate adapted to have a master pattern thereon and for supporting a mask plate below the substrate, a reduction printer on said base below said device, said printer facing upwardly so that it is directed toward the plane in which the mask plate is to be supported, said microscope and eye piece being structurally interrelated in a manner to facilitate viewing of the image on the mask plate and the master pattern, said reduction printer being adapted to have a negative on which art work is to be projected on to the mask plate, a light source means on said base and below the negative, said light source means being

adapted to present a light source of low intensity for focusing the image of the art work from the negative on to the mask plate and a light source of high intensity for exposing the image on the mask plate.

6. A method of reproduction precision artwork on a mask plate orientated in a pre-determined manner with respect to a master pattern comprising the steps of providing a master pattern on a transparent substrate, providing artwork to be reproduced so that the artwork is orientated with respect to the master pattern in a predetermined manner, projecting the image of the artwork onto a photo-sensitive surface of the mask plate, simultaneously viewing the mask plate and master pattern, orientating the mask plate with respect to the artwork, and then exposing the orientated image on the mask plate and then developing the mask plate having the exposed orientated image thereon.

7. A method in accordance with claim 6 including producing additional exposed and properly orientated mask plates by individually substituting unexposed mask plates and exposing them, whereby a large number of identical mask plates may be produced.

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