

Sept. 14, 1965

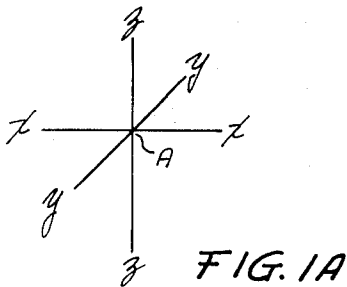
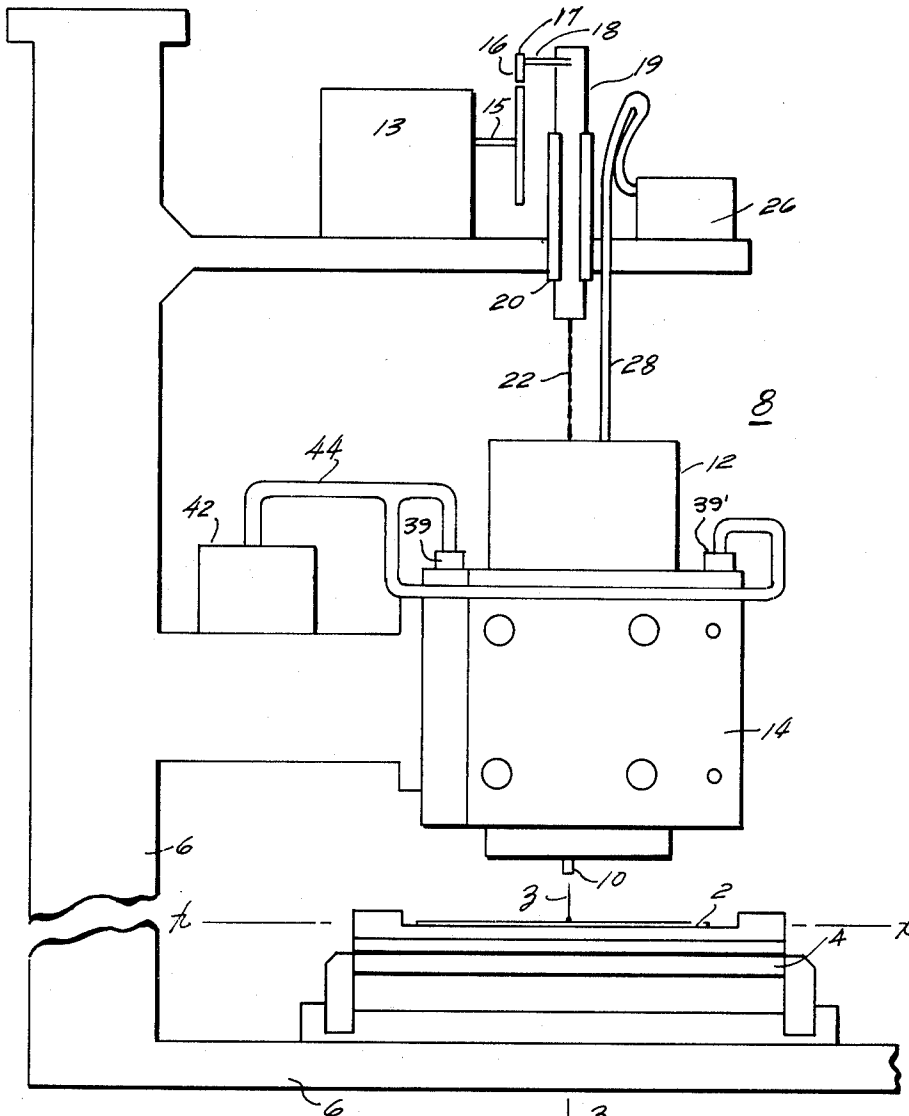
R. F. KILBURN

3,205,587

PHOTOGRAMMETRIC DEVICE

Filed July 1, 1963

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

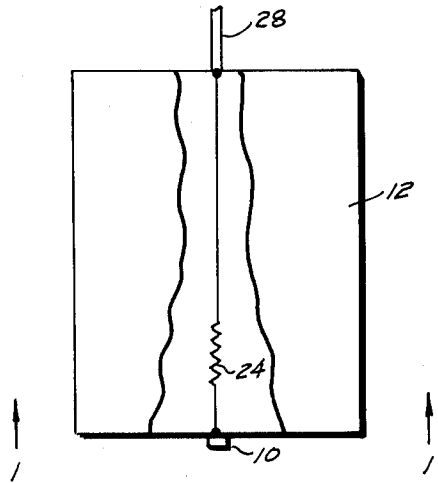


FIG. 2

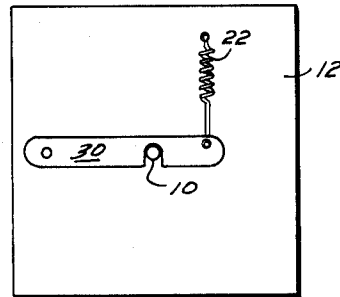


FIG. 2A

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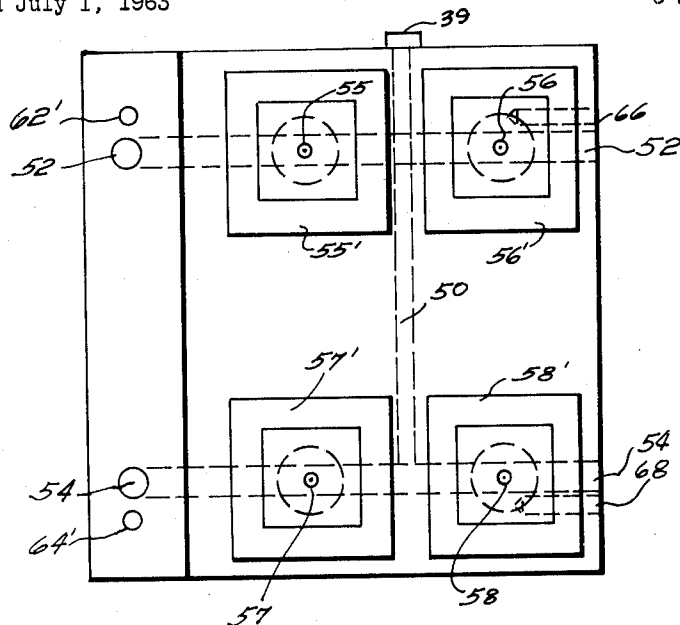


FIG. 3B

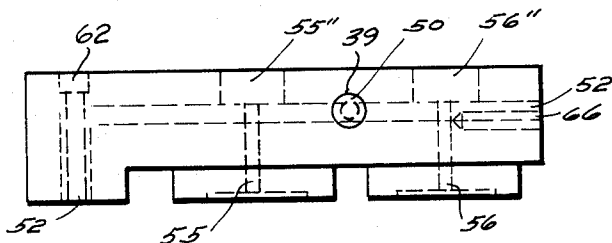


FIG. 3C

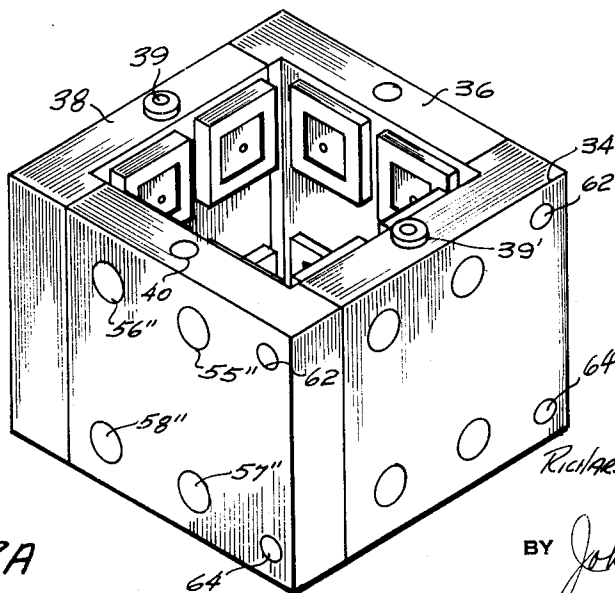


FIG. 3A

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PHOTOGRAMMETRIC DEVICE

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12 Claims. (Cl. 33—189)

This invention relates to a photogrammetric device, and more particularly to an improved system for accurately and permanently marking photographic emulsions.

In assembling a mosaic, i.e., a compilation of aerial photographs, it is necessary to identify and mark the location of identical objects, or positions, on two or more photographic emulsions. The conventional marking techniques heretofore generally employed in marking the photographic emulsions forming the mosaic, i.e., drilling an extremely fine hole in the emulsion with a spade drill, or indenting the emulsion by impressing a small steel ball thereon, are deficient in several respects. For example, neither of the methods recited above remove, to a sufficient extent, any of the emulsive substance when marking the emulsion, so that there is a tendency of the emulsion to heal itself. That is, if the photographic emulsion is subjected to vibration or excessive handling, the plastic substance comprising the emulsion flows into the evacuated area, refilling the hole and destroying the mark. This self-repairing characteristic of the emulsion is a severe limitation on the longevity of the mark, and leads to a very great expense in the packaging and storing of the emulsions. A further limitation inherent to both of the above indicated methods is, in general, that the distinctive form of the mark cannot be varied to a great extent, but is limited to the circular style corresponding to the general configuration of the imprinting device, i.e., the spade drill or ball.

It, therefore, has become necessary to devise a method and apparatus for marking photographic emulsions, such that the mark will be both permanent and prominent regardless of the handling techniques and storage methods employed, as well as being permanent and prominent for an extended period of time. What has been discovered, and this is an important advantage of the present invention, is that a thermal evacuation of the emulsive substance is effective to permanently mark the photographic emulsion at a selected index point. In a preferred embodiment of the invention, to be hereinafter described in detail, a die, having an area equal to the area of the desired mark, is electronically heated, and, upon command, is plunged into contact with the indexed region of the emulsion, burning and vaporizing the emulsive substance, thereby creating a permanent mark. And, further, by using distinctive dies, and this is an important feature of the invention, the style of the mark is made prominent and easily distinguishable from other features present upon the emulsion.

A still further severe limitation of conventional marking systems, is the repeated accuracy with which the marking apparatuses can be guided to the indexed region of the emulsion. It is readily obvious, that from the scale of aerial photographs normally employed in assembling a mosaic, small deviations in the location of identical marks on separate photographs, or photographic emulsions, is extremely critical. Thus, for marking apparatus to be effective in analytical aerotriangular work, the index marks must be reproduced with an accuracy that is measured in microns, a micron being approximately one twenty-five thousandths of an inch. The point marking system of the present invention, and this is a

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major advantage, repeatedly positions the marking die within a few microns of the selected index point.

Basically, the point marking system of the present invention consists of six major assemblies; a coordinate drive system, a point marking die, a die heater and holder assembly, an air guidance bushing, a main frame assembly, and a die holder vertical drive system. In operation the photogrammetric emulsion is secured on the coordinate drive system, and the object, or position, to be marked is selected, either manually or electronically, and placed under the point marking die. The die and the die heater and holder, which are suspended from the frame and positioned with the air guidance bushing by a flexible chain, as more particularly hereinafter described, is then plunged, upon command, manually or automatically, momentarily into contact with the emulsion, and then withdrawn, to thereby permanently and prominently mark the object selected and positioned at the index point.

It is an object of this invention, therefore, to provide an improved photogrammetric device.

It is another object of this invention to provide an apparatus for permanently marking a photographic emulsion.

It is a further object of this invention to provide an apparatus which will prominently and distinctively mark a photographic emulsion.

It is still a further object of this invention to provide a marking system which will accurately index as emulsion or photograph.

It is another further object of this invention to provide a guidance system which will accurately locate the index mark.

These and other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings which disclose, by way of example, the principle of the invention and the best mode which has been contemplated of applying that principle.

In the drawings:

FIG. 1 is a front view of a preferred embodiment of the photogrammetric device of the invention, with the point marking system shown on an enlarged scale and the precision position apparatus shown on a reduced scale.

FIG. 1A is a diagram of the geometric axes of the device shown in FIG. 1.

FIG. 2 is a view of the die heater and holder assembly, with portions thereof broken away for clarity.

FIG. 2A is a bottom view of the die heater and holder taken along line 1—1 of FIG. 2.

FIG. 3A is an isometric view of the air guidance bushing employed in the preferred embodiment illustrated in FIG. 1.

FIG. 3B is a front view of one quadrapad of the air bushing illustrated in FIG. 3A.

FIG. 3C is a top view of the quadrapad illustrated in FIG. 3B, taken along lines 3—3 of FIG. 3B.

Referring now to the drawings, FIG. 1 illustrates a preferred embodiment of the present invention, and, as shown, a photographic emulsion 2 is placed on a precision positioning apparatus 4, secured to a frame 6 in order to locate the exact position of the object to be marked. Precision positioning apparatus 4 is a servo driven X-Y coordinate measuring device, as shown, by way of example, in copending application Serial Number 229,962, filed October 11, 1962 on behalf of John Whitmore, and assigned to the assignee of the present invention, and, inasmuch as the positioning apparatus, per se, does not constitute a portion of the inventive aspect of the present invention, it will not be described in detail herein. Thus, photographic emulsion 2 is positioned manually by a human operator, utilizing a precision microscope, or the like, to control an X-Y servo drive system of precision posi-

tioning apparatus 4, until the object on photographic emulsion 2 to be marked is positioned under a centering mark in the viewing field of the microscope. The emulsion, therefore, is now in position to be marked.

The point marking device 8 is also secured to frame 6, and is positioned to be operationally symmetrical about an axis z shown in FIG. 1, axis z being perpendicular to the x and y axes of precision positioning apparatus 4 as shown in FIG. 1A; the point of intersection of the mutually perpendicular axes defining the selected marking point A.

Point marking device 8 consists of a point marking die 10, a die heater and holder 12, an air guidance bushing 14, and a servo drive motor 13; air bushing 14 and motor 13 being rigidly secured to frame 6.

Servo motor 13 is selectively operable to drive an output shaft 15, to which a truncated cam 16 is secured. A cam follower 17 engages cam 16 and the resultant movement thereof is transmitted to a vertically movable member 19 by a shaft 18, movable member 19 being positioned within a vertical guide 20 of frame 6. The above assembly is effective to convert the rotary motion of shaft 15 into a reciprocating vertical motion of shaft 19 along the z axis, upon the energization of motor 13 as follower 17 rides on the contour of cam 16. Attached to vertical shaft 19 is a flexible chain 22, rigidly secured to holder 12, the point of attachment lying on axis z, which normally is the longitudinal axis of holder 12, as more particularly hereinafter explained.

Die heater and holder 12 is a precision rectangular block, the four external longitudinal surfaces of which are positioned parallel to the z axis, each of the surfaces being flat and highly polished in order to provide a first bearing surface when positioned within air guidance bushing 14, bushing 14 providing the second bearing surface of an area air bearing to provide precise alignment of holder 12 within bushing 14. Secured within holder 12 is an electrical heating element 24, see FIG. 2, electrically connected to a voltage source 26 by means of a cable 28. Attached to the lower portion of holder 12 is die 10, to which element 24 is physically connected in heat-transferring relationship. Thus, heater 24 operates to maintain die 10 at a predetermined temperature, such as, by way of example, 500 degrees. Die 10 is positioned in holder 12 by a lock 30 and a spring 32 (see FIG. 2A). It should be understood, and this is another important advantage of the invention, that a number of dies may be fashioned to have various distinctive configurations, and further, each of these dies may be replaceably secured to holder 12, depending upon the configuration of the mark desired.

As above described, die heater and holder 12 are suspended by chain 22 within air guidance bushing 14, bushing 14 being rigidly and symmetrically supported by frame 6 about the z axis. Although the external surfaces of heater and holder 12 form one of the bearing surfaces of the area air bearing, holder 12 is positioned within bushing 14 with a clearance many times that of the marking precision required which may be, by way of example, ± 4 microns. This tolerance ensures minimum heat transfer from holder 12 and, additionally, is effective to minimize friction between holder 12 and bushing 14, since bushing 14 and holder 12 are maintained out of contact by a supply of air pressure, as hereinafter explained. Thus, the function of air guidance bushing 14 is, first, to accurately position holder 12 while maintaining friction at a minimum and, second, to prevent any appreciable transfer of heat from the die to other elements of the system.

Air guidance bushing 14, as shown in FIGS. 3A, 3B and 3C consists of four identical L shaped quadrapads 34, 36, 38 and 40, united to form a hollow cube. Two of the quadrapads, 34 and 38, are connected to a source 42 (see FIG. 1) of a low pressure fluid, such as air, by a tubing 44 connected to inlet orifices 39 and 39'. The corresponding inlet orifices of the remaining quadrapads being plugged in the preferred embodiment now being de-

scribed. It should be noted, that a single inlet orifice, or all four orifices, could be used to supply the low pressure air to the quadrapads. However, it has been found that dual inputs, 39 and 39', are sufficient to ensure that the pressure in each of the quadrapads is equal, in order to maintain the outlet pressure therefrom equal, as will be better understood as the described proceeds. Since each of the four quadrapads are identical, only one will now be described in detail. Referring again now to FIGS. 3B, 3C, each quadrapad includes a vertical air passage 50 one end of which terminates in inlet orifice 39. Passage 50 intersects two vertically displaced horizontal air passages, 52 and 54, which supply low pressure air to four outlet orifices 55, 56, 57 and 58, orifices 55, 56, 57 and 58 being recessively centered in associated bearing pads 55', 56', 57' and 58', respectively. The outlet orifices are recessed within their respective pads, to ensure that each will not be blocked, should die holder 12 inadvertently engage the outer peripheral bearing edge of pads 55-58' during marking. Each outlet orifice 55 through 58 also has an individual, oppositely positioned, external access plug 55'' through 58'' see FIG. 3A, each of which allows the removal of any debris, which may become lodged therein. The four quadrapads are affixed in pairs, one to the other, by a pair of bolts 62 and 64, which extend through openings 62' and 64' (see FIG. 3B) of a first quadrapad, and are secured in threaded apertures 66 and 68, of a second quadrapad, thereby aligning the first and second quadrapads.

In operation, referring now again to FIG. 1, the operator positions the point of photographic emulsion 2 to be indexed under the centering mark A, which as stated above, is the intersection of the x, y and z axes, shown in FIG. 1A. This is accomplished by manually energizing an X-Y servo drive of precision-positioning apparatus 4. Next, the operator manually energizes motor 13, the initial operation of which is effective to move heated die 10 vertically downward, until die 10 engages and burns the indexing mark into photographic emulsion 2 and then removes the die from contact with the emulsion in accordance with the reciprocating motion above described. Thus, a mark is permanently engraved in and through the emulsion, and, further, it being remembered that this is an important aspect of the invention, this engraving operation prevents the emulsion from later reflowing into the mark since the heated die not only burns and vaporizes a portion of the emulsion, but also seals the periphery of the resultant hole. It should be pointed out at this time, that the emulsion 2, marked by the apparatus of the present invention, requires no special handling techniques or expensive packaging and storing equipment, other than that required for high quality photographs, due to the permanency of the mark impressed therein.

As stated hereinbefore, it is essential that die 10 be repeatedly repositioned at point A, within a tolerance of ± 4 microns. The use of an area air bearing, and this is another important feature of the invention, is operable to repeatedly reposition die 10 at point A, within this tolerance. As stated previously, air guidance bushing 14, holder 12, and die 10 are normally symmetrically positioned about the z axis, in order to perfectly position the index mark upon the photographic plate. This alignment is maintained, during a marking operation, since, as holder 12 and die 10 are lowered, any lateral displacement of holder 12 from the z axis results in a differential pressure being exerted on holder 12 to restore it to its normal position about the z axis. For example, if holder 12 is laterally displaced along the y axis, that is, towards quadrapad 38 and away from quadrapad 34, the pressure exerted upon the longitudinal planar surface of holder 12 nearest quadrapad 38 increases proportionally with the displacement of holder 12 along the y axis, while, simultaneously, the pressure exerted upon the longitudinal planar surface of holder 12 nearest quadrapad 34 correspondingly decreases. The resulting difference in pressure applied to

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these opposed surfaces is effective to restore holder 12 to its normal position, so that it remains symmetrically positioned about the z axis. The use of the above described novel area air guidance bushing further maintains friction at a minimum since metal to metal contact is avoided, and, additionally, prevents any appreciable heat transfer from die 10 to the surrounding surfaces of bushing 14.

Thus, a point marking system which is effective to permanently and prominently mark an emulsion, and, further, repeatedly indexes the emulsion of a specific location within predetermined tolerances has been described. Further, it should be noted that, through the use of a heated die, accurately positioned about a selected axis by a novel area air bearing, an improved photogrammetric device has been disclosed.

While the invention has been shown and described with respect to a preferred embodiment, it will be understood that various changes and modifications may be made therein without departing from the spirit of the invention, and it is intended therefore to be limited by the scope of the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A point marking system for indexing a selected region of an emulsion comprising, support means for supporting said point marking system, said support means defining three mutually perpendicular axes; positioning means mounted on said support means for movement along two of said axes and controllable to position a selected region of said emulsion at a preselected point, said point being at the intersection of said three axes; fluid guidance means fixedly secured to said support means and symmetrically positioned about the third one of said axes; thermal point-marking means suspended from said support means symmetrically about said third axis and isolatively suspended within said guidance means; and drive means carried by said support means for selectively providing a reciprocating motion to said marking means and operable to index the selected region of said photographic emulsion positioned by said positioning means at the point defined by the intersection of said three axes.

2. A device according to claim 1 wherein the guidance means comprises fluid pressure means and a bushing; said bushing including at least one inlet orifice and a plurality of outlet orifices; said inlet orifice being connected to said fluid pressure means and said outlet orifices coacting with said marking means to maintain said marking means suspended within said bushing symmetrically aligned with said third one of said axes by fluid pressure.

3. A device according to claim 1 wherein said thermal marking means comprises, a source of electrical energy; an electrical heating element; means connecting said element to said source of energy; a thermally conductive die; and means connecting said die to said heating element; effective to heat said die to a predetermined temperature sufficient to burn an index mark in said selected region of said emulsion when said die is brought into contact therewith.

4. A point marking system for indexing a photographic emulsion, including a thermal marker and a marker guidance system, comprising a base member and a support means vertically attached thereto; fluid pressure means fixedly secured to said support means; and a marker guidance bushing fastened to said support means positioned about said marker and operatively associated with said fluid pressure means, said bushing having a plurality of fluid pressure outlet orifices coacting with said marker tending to maintain said marker symmetrically positioned within said bushing and isolated therefrom.

5. In a point marking system for indexing a photographic emulsion, a marker guidance system comprising

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support means retaining said marking system and defining three mutually perpendicular axes, a guidance bushing fixedly secured to said support means symmetrically positioned about a first one of said axes, and arranged normal to the plane defined by the intersection of the second and third axes; thermal marker means isolatively suspended within said bushing from said support means; the longitudinal axis of said marker means being parallel with said first one of said axes; and fluid pressure means coacting with said bushing to maintain said longitudinal axis of said marker means aligned with the first one of said axes.

6. A device according to claim 5 wherein said bushing includes at least one inlet orifice coacting with said fluid pressure means; and a plurality of outlet orifices operatively associated with said inlet orifice and symmetrically positioned about said first one of said axis to maintain said longitudinal axis of said marker means aligned with said first one of said axis by said fluid pressure emanating from said individual outlet orifices acting on said marker means.

7. A device according to claim 5 wherein said bushing includes at least one inlet orifice coacting with said fluid pressure means and a plurality of outlet orifices symmetrically positioned on the inner surface of said bushing about said first one of said axes and operatively associated with said inlet orifice to maintain said longitudinal axis of said marker means aligned with said first one of said axes by said fluid pressure exerted on said marker means by said individual outlet orifices.

8. A photogrammetric device which will indelibly mark a photographic emulsion at indexable region comprising, means securing said photographic emulsion to a precision position table operable in response to control signals to locate said indexable region at the intersection of three mutually perpendicular axes; a thermally heated die reciprocally mounted above said indexable region symmetrically about a vertical one of said axis; first means selectively operable to cause said heated die to contact and withdraw from said emulsion to both sear and cure an indelible mark on said emulsion; second means cooperating with said first means for isolatively guiding and maintaining said die symmetrically about said vertical axis and; said second means including a plurality of fluid bearings each of which is adjacent with at least one vertical side area of said die, whereby displacement of said die from said vertical axis results in a pressure differential operable to reposition said dye symmetrically about said vertical axes.

9. The device of claim 8 wherein said fluid is air.

10. A photogrammetric device comprising, a photographic emulsion an indexable region of which is to be indelibly marked; means for positioning said indexable region at the intersection of three mutually perpendicular axes, one of said axis being normal to said emulsion; a thermally heated die; means yieldably securing said die above said emulsion in alignment with said normal axis; means selectively operable to cause said die to momentarily contact said emulsion; and means cooperating with said last named means for aiding said yieldable means in maintaining said die in alignment with said normal axis, including an area air bearing isolatively surrounding said die.

11. The device of claim 10 wherein said area air bearing comprises, first and second area air bearing surfaces; said first surface including the outer surfaces of said die; said second surface including the inner surfaces of a bushing device; said inner surfaces having a geometrical configuration corresponding to the outer surfaces of said die; said bushing device including a plurality of air outlet cavities recessed therein; and means coupling a source of low pressure air to all of said plurality of outlet cavities; said last named means effective to maintain the air pressure at each of said cavities equal.

12. The device of claim 10 including a plurality of dies of predetermined configurations; and means for securing a selected one of said plurality of dies in said photogrammetric device.

References Cited by the Examiner

UNITED STATES PATENTS

1,424,941	8/22	Pirwitz	33—189
2,209,498	7/40	Wittman	33—189

2,295,186	9/42	Schwarzmayr	33—189
2,669,642	2/54	Menges.	
2,827,699	3/58	Schultze	33—189 X
2,900,726	8/59	Hentz	33—189 X

FOREIGN PATENTS

896,233	4/44	France.
934,471	10/55	Germany.

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