M. C. HOPKINS.

PHOTOSCULPTURE.

APPLICATION FILED OCT. 18, 1919.

1,382,978. Patented June 28, 1921.

3 SHEETS—SHEET 1.

Fig. 1.

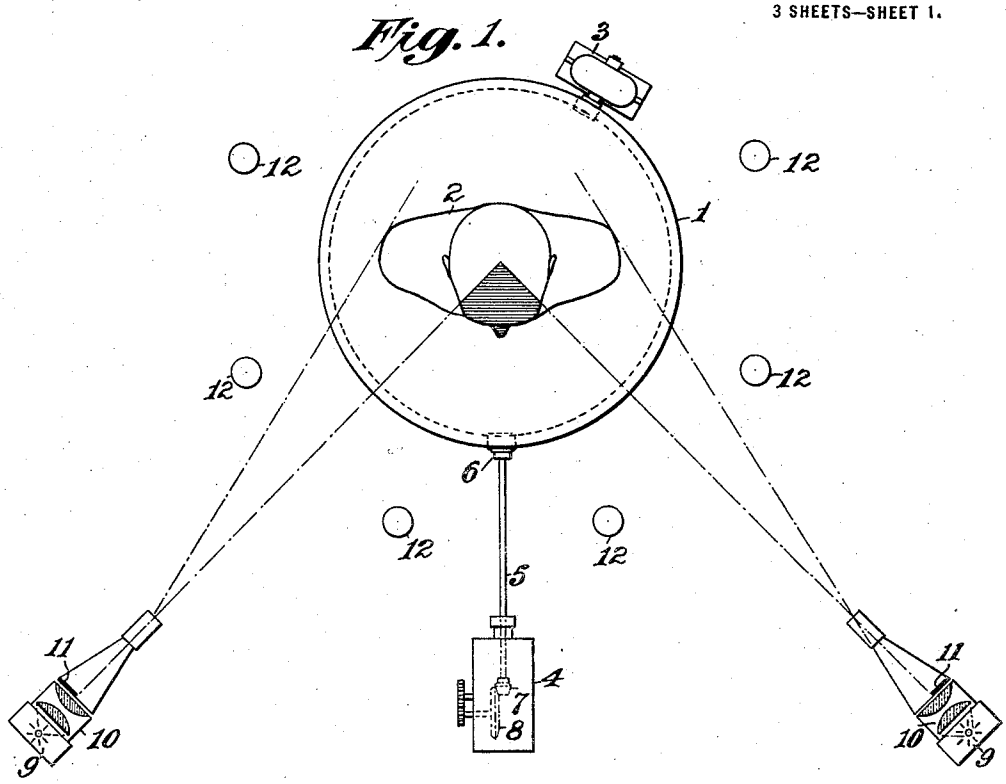
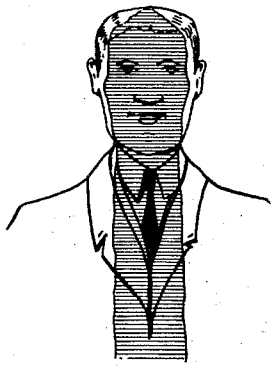


Fig. 2.



Inventor

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By his Attorney

Frank L. Hyer

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3 SHEETS—SHEET 2.

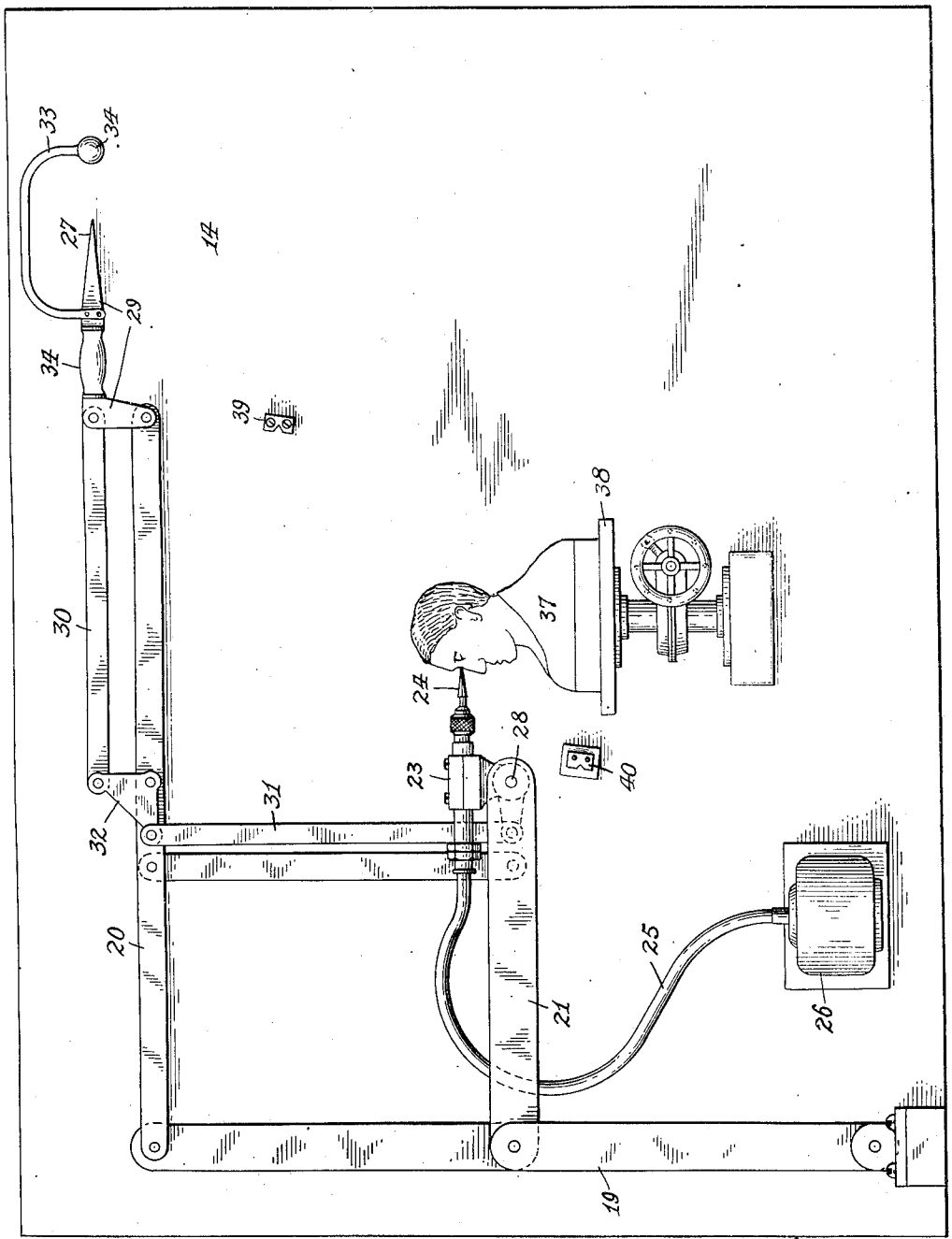


Fig. 3.

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3 SHEETS—SHEET 3.

Fig. 4.

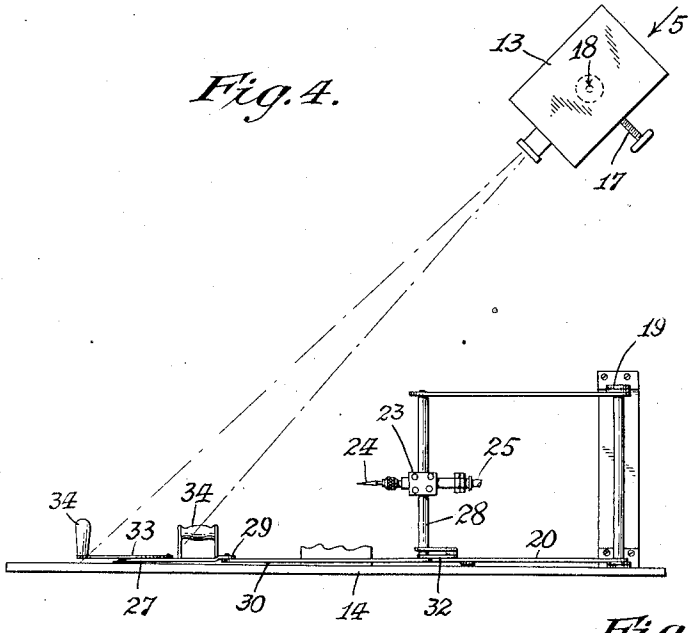


Fig. 5.

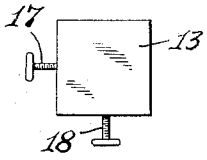


Fig. 6.

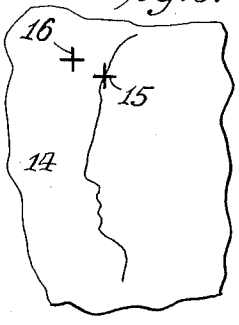
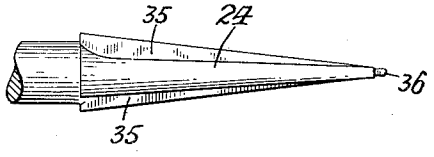


Fig. 7.



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UNITED STATES PATENT OFFICE.

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PHOTOSCULPTURE.

1,382,978. Specification of Letters Patent. Patented June 28, 1921.

Application filed October 18, 1919. Serial No. 331,584.

To all whom it may concern:

Be it known that I, MARCUS C. HOPKINS, a citizen of the United States, residing at Falls Church, in the county of Fairfax, State of Virginia, have invented certain new and useful Improvements in the art of Photosculpture, of which the following is a specification.

My invention relates to the art of photosculpture or the art of making accurate reproductions of three dimensional objects photographically. By means of my invention, instead of a flat photograph of a person, it becomes possible to make a complete bust of the head and shoulders, or, if desired, of the entire figure. The photographic record is a permanent one, so that at any time further reproductions can be made of the original object.

In carrying the invention into effect I make practically a photographic record of the contour of the object to be reproduced at closely adjacent points or lines and from which record the completed copy can be made by any suitable process. Preferably I make the three dimensional copy from the two dimensional photographic images by tracing the images or projected impressions thereof successively by means of a pantograph, causing a cutting tool to trace the contour line corresponding to each image, whereby when all the lines have been traced, representing the complete circumference of the object, an original master will be secured, from which, after suitable retouching, if necessary, any desired number of duplicate copies in a permanent material can be obtained, as is now done in making copies of clay models produced by sculptors.

As compared to a bust made in the old way, my improved art possesses the very practical advantage that the photographic images can be made in a few seconds, and hence the bust when completed may represent the desired expression which is to be secured just as is done in photography. Also with the new art, the busts are photographically accurate, although if desired they may be suitably retouched or softened to give the desired artistic effect. Busts made in this way are very much cheaper than those produced by hand by a sculptor. The saving of time in securing the original photographic record, as compared with the present practice of many sittings while the sculptor models the image in clay, is a further important consideration.

Various ways may be employed for securing successive photographs of the contour lines of the three dimensional object to be reproduced, but I prefer to do this by casting a very sharply defined shadow on the object by means of a projecting lantern, the beam of which is masked centrally by a sharp edged diaphragm. This shadow line is then caused to travel completely around the object, either by maintaining the object stationary and swinging the lantern circumferentially around it or by maintaining the light stationary and turning the object pivotally with respect to the same. As the shadow is thus caused to travel over the entire surface of the object to be reproduced, the shadow when viewed at an angle of 90° from the axis of the beam of light will present an accurate sectional contour of the object at all points. If the attempt were made to take successive photographs of the shadow line at an angle of 90°, the resulting images would not be so sharply defined or so satisfactory for the purpose as when viewed at an angle of less than 90°. Therefore I prefer to take successive photographs of the shadow line at a considerable angle less than 90° from the axis of the light beam, said photographs being taken successively as the shadow lines travel with respect to the object. An ordinary moving picture camera is well suited for this purpose, and since the shadow line is very sharply defined the time of exposure can be made very brief, so that although there is relative movement of the camera and the shadow line while the film is being exposed the image will be sufficiently sharp for the purpose. This result is accomplished by using a shutter, the aperture of which is only a few degrees in extent. If the object is sta-

tionary, the camera travels circumferentially around it concurrently with the light beam, but if the object is rotated then the camera is fixed with respect to the source of light. As many photographs are thus taken as may be necessary to give a sufficient number of contour lines to represent the characteristic details of the object which is to be copied. In case of the human head, photographs taken one degree apart will ordinarily be sufficient, making 360 photographs on the moving picture film for the entire record.

In order to overcome the difficulty of securing satisfactory photographs of contour curves of certain difficult portions of the face to be reproduced, such, for example, as the angle of the nose and the deep depression of the eye adjacent to the nose, I prefer to make use of two beams of light casting two shadow lines on the object to be reproduced, said shadow lines being 90° apart and the moving picture camera being mounted midway between the beams so as to simultaneously take photographs of the two shadow lines. In this way the pantograph, which cuts the contour curves in the material, can first trace successively one of the shadow lines of each image and then retrace the other shadow line of each image, the work in process of manufacture being obviously shifted through an arc of 90° with respect to the tracing point of the pantograph before commencing the tracing of the second set of shadow lines. By thus tracing two sets of shadow lines, any defects or difficulties existing with one set of shadow lines will be corrected when tracing the other set. Obviously, viewing the shadow line from an angle less than 90° involves elements of error; the resulting photographic images are not accurate contour lines; in other words, the curves are flattened or foreshortened. This error may be corrected by projecting the images of the successive photographs onto the surface from which they are traced by the pantograph at the same angle at which the photographs were taken; that is to say if the photographs are taken at an angle of 45° from the axis of the light beam, they are projected on the tracing surface at an angle of 45° with respect to the same. The pantograph, which may be used for the purpose of tracing the contour lines, may be of any suitable character, carrying a tracing point which traces the projected images of the contour lines on one of its elements and carrying a suitable cutting tool on another of its elements partaking of the same movements as the tracing point. The pantograph may be arranged to give any desired relationship between the movements of the tracing point and the cutting tool, and the desired size of bust may be secured by properly projecting the contour lines on the tracing surface to give the desired size thereof. It is of course important that the enlargement of the projection should not be too great to destroy the desired sharpness of the projected image and prevent accurate tracing of the contour lines.

With an ordinary motion picture camera very great accuracy is possible, but nevertheless it sometimes happens that the successive images of the contour lines may not precisely coincide on the tracing surface, and if this occurs there may be objectionable variations in the action of the cutting tool, certain of the cuts in the material being too deep or too shallow, forming circumferential scorings in the resulting copy. To overcome this defect I prefer to place adjacent to the object being photographed a suitable mark or indication, for instance, two cross lines which will be photographed concurrently with each image, and on the tracing surface I employ a similar mark. When the image is projected, if the two marks coincide, the operator knows that the projected image is properly located, but if the marks do not coincide, means are provided for adjusting the projecting lantern so as to bring them into coincidence and thus do away with this possibility of error.

In making a photographic record of a human head, if the projected shadow line is brilliantly illuminated on one side and non-illuminated on the other, there is likelihood of the subject winking or shrinking from the light glare during the photographic operation, whereas entire steadiness is necessary. I therefore prefer to employ several sources of non-actinic illumination for lighting the object and thus reducing the contrast between the light and shadow of the shadow line. In other words, in a physiological sense the subject does not appreciate the contrast between the shadow and light passing across the eye, but in a photographic sense the contrast is as conspicuous as possible in order that the shadow may be very sharply defined.

In order that my invention may be better understood attention is directed to the accompanying drawings forming a part of this specification, and in which—

Figure 1 is a diagrammatic plan view of a suitable apparatus for making the photographic record of the head and shoulders of a man seated on a rotating platform, so that the object rotates with respect to the motion picture camera and the lanterns for casting the two shadow lines, the projecting lanterns being shown diagrammatically.

Fig. 2, a front view of the object being photographed showing the shadow cast thereon and illustrating the two shadow lines constituting contour lines which comprise the photographic record.

Fig. 3, a view illustrating suitable mecha-

nism for tracing from the projected contour line and cutting the desired replica in the solid material.

Fig. 4, a view showing the pantograph and projecting lantern for throwing the contour lines on the projecting surface at an angle to correct the foreshortening of the contour lines in the photographic record.

Fig. 5, a section illustrating a conventional adjusting mechanism for adjusting the position of the projected contour line on the projecting surface.

Fig. 6, a detailed view showing one of the projected contour lines and purposely illustrating the same as incorrectly located, requiring adjustment to bring it into the proper position prior to being traced, and

Fig. 7, an enlarged view of the end of a suitable rotating cutting tool.

In all the above views corresponding parts are represented by the same reference numerals.

Referring first to Fig. 1, I illustrate the turn table 1 mounted in rigid bearings so as to turn smoothly in a horizontal plane, and on which is seated a man 2 whose face and shoulders are to be reproduced in the form of a bust. In order that the subject may be absolutely immovable it is desirable to support the head by means of brackets, such as were formerly used in taking photographs by the daguerreotype process. The platform 1 is rotated in any suitable way, as by an electric motor 3, so that it turns with a steady movement making a complete rotation. Facing the subject to be photographed is a motion picture camera 4 of any suitable type, which takes a series of photographs equally distantly spaced on a long strip of photographic film as is well known. Preferably the speed of operation should be quite high, say in the neighborhood of 30 per second, and the exposure opening of the shutter is made relatively small so that the period of exposure will be extremely slight. In this way, although the object being photographed is in motion during the exposure of the film, the period of exposure is so slight that the relative movement of the image is inconsiderable and the resulting photographs are therefore sharply defined. The camera 4 is operated in any suitable way so that the number of photographs being taken will bear a definite relation to the turning movement of the object. In practice a large number of photographs are taken, for instance, 360 for a complete rotation, and the operating mechanism for the camera is so proportioned as to cause the same to take the desired number of photographs as the object makes a complete rotation in front of the camera. A convenient mechanism for operating the camera is a shaft 5 operated by gear 6 from the turn table 1 and rotating a pinion which engages the gear 8 on the operating shaft of the camera. This coupling up of the camera to the turntable is important as it is necessary that the photographs shall represent contour lines a given distance apart for the entire circumference of the object. These contour lines (two being preferably used) are formed by projecting lanterns comprising lights 9—9 and lenses 10—10, each beam of light being intercepted by a diaphragm 11 so as to throw on the object a very dark shadow (in a photographic sense) as shown in Figs. 1 and 2, the lines marking the edges of the shadow thus forming the contour lines of the object. If these contour lines are viewed at an angle of 90° to the axis of the light beam, they will represent true sectional contours of the object, but since the contour lines are taken by the moving picture camera at a considerably less angle than 90°, as shown, they are obviously foreshortened and this error has to be corrected in tracing from such lines. Lights 12 are located around the object and are non-actinic, so as to have little appreciable effect, if any, on the photographic film. These non-actinic lights illuminate the object and make the shadow less conspicuous so as to reduce the danger of the person, whose photographic record is being made, being disturbed by the glare of the light beam as it passes over either eye, as would be the case if the only sources of illumination were the lights 9—9. The subject to be photographed is placed on the turn table 1, illuminated by the lights 9—9 and the shadow lines are photographed by the motion picture camera as the subject is given a complete rotation with respect to the camera.

The resulting record will be a series of photographs, viewing the object in successive circumferential positions and the contour lines representing successive contours of the face and shoulders to be copied. Such motion picture negative is now developed in the ordinary way and may be employed directly from which to obtain the copy, or, as is preferable, a positive print is made therefrom. By using a positive print, in case the same should be damaged, another copy can be readily obtained and such a positive print has a further advantage of more accurately guiding the operator since the shadow cast on the projecting surface is positive and not negative.

Having obtained this photographic record, I now proceed to utilize the same in making a complete bust of the original subject by means of the mechanism illustrated in Figs. 3 to 7 inclusive. The photographic film is mounted in a projecting machine 13, which is like an ordinary motion picture projecting machine arranged to feed the film step by step to successively expose the pictures. Its gearing, however, is so adjusted

that when one image is projected it will remain stationary on the projecting surface until the shadow line has been traced, whereupon another picture is projected and so on. Therefore the source of illumination should be so chosen as not to injure the film during the periods of rest. This projector projects the successive images on the surface 14 of any suitable character on which the shadow line will show up as conspicuously as possible. It will be observed that the images are projected on the surface 14 at an angle corresponding to the angle at which the shadow line is viewed by the taking camera 4, so that in this way the foreshortening of the contour lines will be corrected.

Referring to Fig. 6, it will be observed that the shadow line shown is provided with an indication 15 in the form of cross lines which are photographed simultaneously with the taking of each picture. This mark is a stationary indication placed upon or adjacent to the subject being photographed to indicate the desired position of each contour line. On the surface 14 is a second mark 16 so placed that when the shadow line is properly located the two marks 15 and 16 will coincide. It will be observed in Fig. 6 that the two marks 15 and 16 do not coincide which indicates that the shadow line shown in the figure does not coincide correctly with the shadow lines which have already been traced. This defect may be due to some aberration in the camera or to some other cause. By means of adjusting screws 17 and 18, as shown in Figs. 4 and 5, the lens of the projector 13 may be adjusted slightly so as to bring the two marks 15 and 16 into coincidence and thus assure the operator that all the shadow lines are all located properly and accurately on the adjusting surface 14.

The shadow lines, representing successive contours of the object, are traced by means of a suitable pantographic device which may be of any suitable type. The pantograph illustrated in the drawings is of a very common form, giving a reduction of two to one and comprising main members 19 and 20 pivoted together, and a secondary member 21 carrying a chuck 23 or cutting tool 24, which tool is operated through a flexible shaft 25 from an electric motor 26. The tracing point 27 is carried by the member 20, so that any movements at this point will be communicated to the tool 24, the movements of which will be one-half as great as those of the tracing point.

I find that in practice, it is desirable in cutting the object, that the tool should at all times be presented to the object as nearly perpendicularly as possible; for instance, in cutting around the point of the chin, if the tool is always horizontal the cut cannot be made as accurately as if the tool is shifted so as to be always presented perpendicularly to the surface that is being cut. To effect this result, I mount the chuck 23 on a pivot 28, and I mount the tracing point 27 on a small angle lever 29 and connect these elements together by links 30 and 31 and the bell crank 32. In this way the operator following the shadow line keeps the tracing point as near as may be perpendicular to the curve at all times, and the tool 24 will be similarly operated so that its angle will correspond to the angle of the tracing point. At the same time this auxiliary movement does not in any way interfere with the following by the cutting tool of the movements of the tracing point.

In order more effectively to handle the tracing point, I prefer to provide the same with an extension 33 thereon, having two handles 34 which may be grasped by both hands of the operator so that the tracing point 27 may follow the projected image of the shadow lines very accurately. The cutter 24 is of any suitable character for cutting fine lines, such, for example, as a shank pointed conically and formed with longitudinal grooves 35 to comprise a small routing tool, as shown in Fig. 7. The extreme cutting end of the cutter is preferably formed as a minute chisel 36, as shown, to make a sharp, clear cut. This tool cuts the contour lines in a block 37 of plaster-of-Paris, or similar material, secured to the turn table 38 and provided with mechanism by which it may be turned through an angle representing the distance between each two of the photographic images. In the assumed case the mechanism for operating the turn table 38 will give the same, 360 successive feed movements for a complete rotation. It will, of course, be understood that at all times the extreme cutting point of the tool 24 should occupy a fixed and definite relationship to the tracing point 27. If this relationship changes for any reason—such as by wear of the tool or a failure to accurately adjust it after sharpening—the work will not be accurate and the cut lines will be either too deep or too shallow. To secure the desired accuracy of relationship, I provide a notched gage plate 39 into which the tracing point may be inserted, and a second gage 40 into the notch of which the tool may be introduced and adjusted back and forth as desired. The notches in the two gages 39 and 40 bear the desired relationship which shall exist between the tracing point and cutter. Therefore, when these two elements line up properly with respect to the two gages, the operator is assured that the cutter is in accurate adjustment, and if out of adjustment, the position of the cutter can be speedily corrected.

In operation, having secured a photographic record as explained, the first image

is projected by the lantern 13, on the surface 14, and the operator then traces the shadow line by means of the tracing point 27. This causes the cutting tool 24 to partake of the same movements, and since the cutting tool is rapidly rotated it will cut out a scoring in the block 37 corresponding in contour to the first contour line. The next photographic image is now projected on the surface 14 and the turn table 38 is moved through one step and the second contour line is traced by the operator, cutting in the block 37 to correspond therewith. This operation is repeated until all the contour lines have been traced, the turn-table 38 being moved one step for each image, so that when the last photograph has been traced the bust will be completed.

By having two sets of contour lines, as explained, certain parts of the bust may be gone over a second time, the tracing point 27 tracing the second contour line, care being taken that the position of the turn table 38 will correspond to the particular photographic image that is being traced. In this way more accurate results are secured in the reproduction of difficult parts of the face, such as the depression of the eye adjacent to the bridge of the nose and the back of the ear.

If care is taken in the reproduction of the bust in the manner explained, the surface will be substantially smooth and will be very slightly grained circumferentially by the successive cutting operations. If desired, this slight graining effect can be overcome by retouching the bust by hand, smoothing out any irregularities or roughness therein, and when this work is done by a skilled person it will substantially add to the artistic character of the completed article. The replica obtained in this way may now be reproduced in solid material, such as marble or bronze by any of the well known processes now used for making such copies from the original plaster masters turned out by the hands of sculptors.

The apparatus shown in the drawings is intended to illustrate only the general principles of the invention. It will be understood, of course, that since it is necessary that the object being photographed shall move relatively to the camera, the object may be stationary and the camera and lanterns be made to turn around it. Also, of course, it is to be understood that instead of projecting the shadow lines on a vertical surface they may be projected on a horizontal surface, in which case the bust being cut will be arranged parallel to the same.

Having now described my invention, what I claim as new therein and desire to secure by Letters Patent is as follows:

1. The art of making plastic reproductions of three dimensional objects, which consists in casting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a series of photographs of the shadow thereby obtaining a series of contour lines representing successive sections of the object, and in making pantographically from these photographs the reproduction desired, substantially as set forth.

2. The art of making plastic reproductions of three dimensional objects, which consists in casting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a series of photographs of the shadow thereby obtaining a series of contour lines representing successive sections of the object, and in actuating a cutter in accordance with said photographs to secure in a solid material the reproduction desired, substantially as set forth.

3. The art of making plastic reproductions of three dimensional objects, which consists in casting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a series of photographs of the shadow as viewed from an angle thereby obtaining a series of distorted lines representing successive sections of the object, in correcting the distortion so secured, and in making pantographically from said photographs the reproduction desired, substantially as set forth.

4. The art of making plastic reproductions of three dimensional objects, which consists in casting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a series of photographs of the shadow as viewed from an angle thereby obtaining a series of distorted lines representing successive sections of the object, in correcting the distortion so secured by projection at a corresponding angle, and in making pantographically from the corrected photographs the reproduction desired, substantially as set forth.

5. The art of making plastic reproductions of three dimensional objects, which consists in casting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a series of photographs of this shadow as viewed from an angle thereby obtaining a series of distorted lines representing successive sections of the object, in correcting the distortion so secured by projection at a corresponding angle and in actuating a cutter in accordance with said corrected photographs to secure in a solid material the reproduction desired, substantially as set forth.

6. The art of making plastic reproductions of three dimensional objects, which consists

in casting two shadow lines circumferentially on the object, in causing the shadow lines to progress successively over the surface of the object, in making a series of photographs of the two shadow lines thereby obtaining two series of contour lines representing successive sections of the object, and in making pantographically from said photographs the reproduction desired, substantially as set forth.

7. The art of making plastic reproductions of three dimensional objects, which consists in casting two shadow lines circumferentially on the object, in causing the shadow lines to progress successively over the surface of the object, in making a series of photographs of the shadow lines thereby obtaining two series of contour lines representing successive sections of the object, and in actuating a cutter in accordance with said photographs to secure in a solid material the reproduction desired, substantially as set forth.

8. The art of making plastic reproductions of three dimensional objects, which consists in casting two shadow lines circumferentially on the object, in causing the shadow lines to progress successively over the surface of the object, in making a series of photographs of the shadow lines as viewed from an angle thereby obtaining two series of distorted lines representing successive sections of the object, in correcting the distortion so secured, and in making pantographically from the corrected photographs the reproduction desired, substantially as set forth.

9. The art of making plastic reproductions of three dimensional objects, which consists in casting two shadow lines circumferentially on the object, in causing the shadow lines to progress successively over the surface of the object, in making a series of photographs of the shadow lines as viewed from an angle thereby obtaining two series of distorted lines representing successive sections of the object, in correcting the distortion so secured, and in actuating a cutter in accordance with said photographs to secure in a solid material the reproduction desired, substantially as set forth.

10. The art of making plastic reproductions of three dimensional objects, which consists in illuminating the object with non-actinic light, in casting a shadow circumferentially on the object by means of actinic light, in causing the shadow to progress successively over the surface of the object, in making a series of photographs of the shadow thereby obtaining a series of contour lines representing successive sections of the object, and in making pantographically from said photographs the reproduction desired, substantially as set forth.

11. The art of making plastic reproductions of three dimensional objects, which consists in casting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a series of photographs of the shadow thereby obtaining a series of contour lines representing successive sections of the object, in simultaneously photographing a mark or indication having a fixed relation to the object, and in making pantographically from these photographs the reproduction desired, substantially as set forth.

12. The art of making plastic reproductions of three dimensional objects, which consists in projecting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a series of photographs of the shadow thereby obtaining a series of contour lines representing successive sections of the object, in simultaneously photographing a mark or indication having a fixed relation to the object, in projecting the photographs successively on a flat surface provided with a mark or indication, in bringing the two marks or indications into coincidence, and in making pantographically from the projected images the reproduction desired, substantially as set forth.

13. The art of making plastic reproductions of three dimensional objects, which consists in casting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a connected series of uniformly spaced photographs of the shadow, thereby obtaining a series of contour lines representing successive sections of the object, in projecting the successive photographs on a plane surface in the order of their exposure, and in making pantographically from the projected images the reproduction desired, substantially as set forth.

14. The art of making plastic reproductions of three dimensional objects, which consists in casting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a connected series of uniformly spaced photographs of the object, thereby obtaining a series of contour lines representing successive sections of the object, in projecting the successive photographs on a plane surface in the order of their exposure, and in actuating a cutter in accordance with the projected images to secure in a solid material the reproduction desired.

15. The art of making plastic reproductions of three dimensional objects, which consists in casting a shadow circumferentially on the object, in causing the shadow to progress successively over the surface of the object, in making a connected series of uni-

formly spaced photographs of the shadow as viewed from an angle, thereby obtaining a series of distorted lines representing successive sections of the object, in projecting the successive pictures in the order of their exposure on a plane surface at the same angle at which they were taken so as to correct the distortion, and in making pantographically from said photographs the reproduction desired, substantially as set forth.

This specification signed and witnessed this sixth day of October, 1919.

MARCUS C. HOPKINS.

Witnesses:
Jos. L. Tepper,
John W. Dyer.