Aug. 3, 1926. 1,594,607

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APPARATUS FOR PLASTICALLY REPRODUCING OBJECTS

Filed June 8, 1922 2 Sheets-Sheet 1

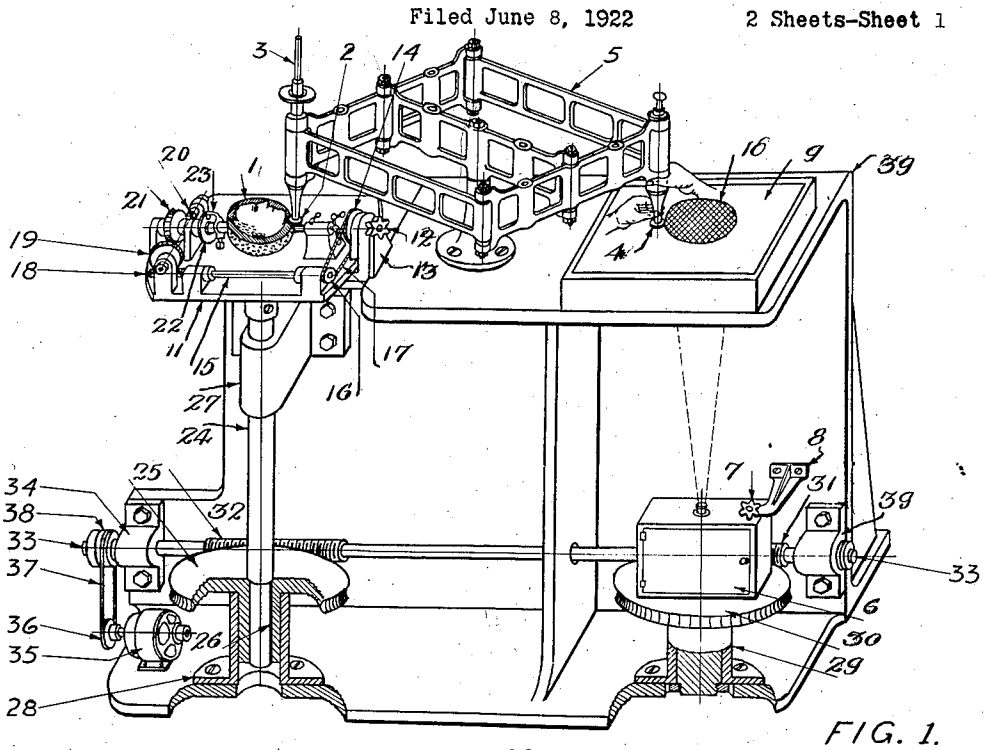


FIG. 1.

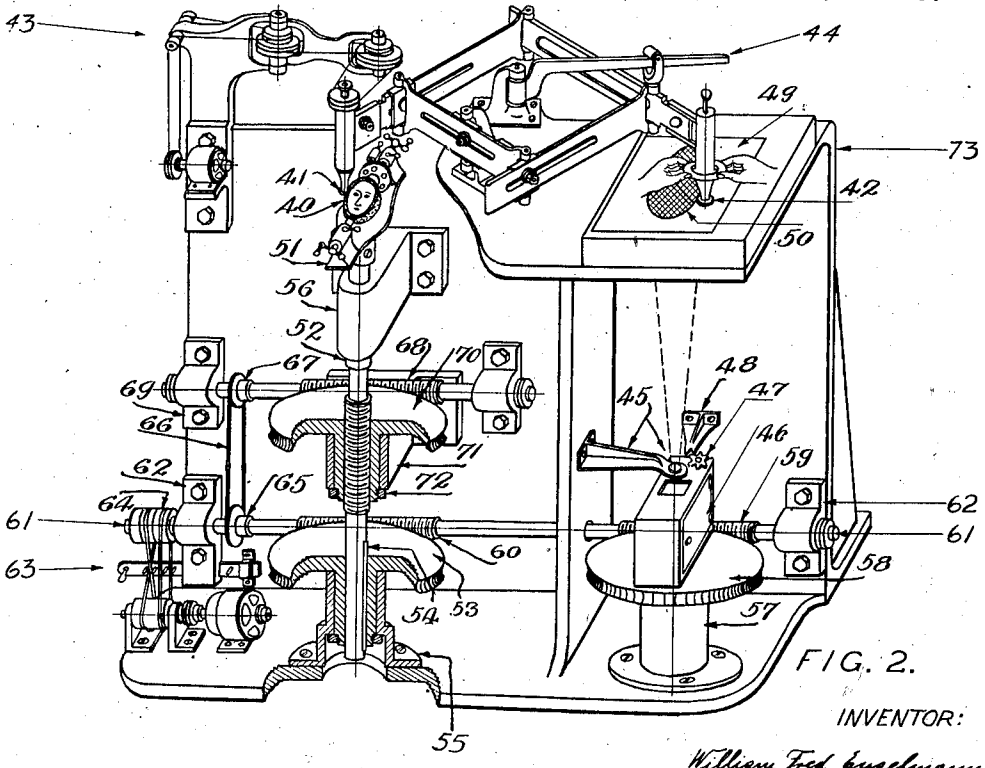


FIG. 2.

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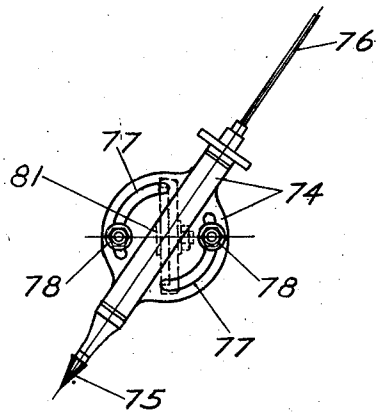


FIG. 3

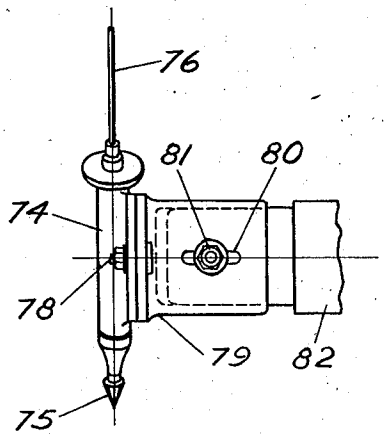


FIG. 4

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR PLASTICALLY REPRODUCING OBJECTS.

Application filed June 8, 1922. Serial No. 566,808.

This application is an addition to the application filed by me December 15, 1921, Series of 1915, No. 522,660.

The invention has for its object to furnish improved apparatus for working out the copy from the finished form record of the object.

With the apparatus illustrated in Figs. 2 and 4 of the last mentioned application the tool which works out the copy is moved in two dimensions, in a plane, and one of the three dimensions of the object is eliminated from the operators consideration. With the apparatus illustrated in Figs. 1 and 2 of this application the tool is moved in one dimension only, along a line, and two of the three dimensions of the plastic object are eliminated from the operator's consideration. Besides these apparatus move the various planes of the material block and the various film images of the form record automatically in their respective working positions.

Figs. 1 and 2 of the accompanying drawing show perspective views of two improved apparatus for working out the copy; Fig. 1 for method "A", and Fig. 2 for method "B". Each view has two portions of the apparatus shown in section. Fig. 3 shows a front view, and Fig. 4 a side view of a modification of a part of the apparatus.

The different forms of apparatus are presented with the purpose in view of showing the principles of the invention as clearly as possible. No particular attention has been paid to show the most suitable design.

Referring to Fig. 1 in detail, numeral 1 represents the material block having the copy partly worked out; 2, the tool for removing the excessive material from the material block; 3, means connecting the tool driving power with the tool; 4, the tracer disk; and 5, any kind of a device for transferring the movements given the tracer disk to the tool in any desired size, with means for removably receiving the various tracer disks and tools used. Numeral 6 represents a projector, in construction similar to a moving picture projector, with a lamp and means for holding and stepwise shifting the film having the various film images. In operation this projector is rotated around its optical axis. Numeral 7 represents a pinion that is part of the film shifting device of the projector. This pinion and with it the film shifting device receives its actuating movement from the pinion, being moved around in a circle by the rotating projector, striking against 8, a stationary actuator. This actuator is rigidly fastened to 39, the stand of the apparatus, and has its free end shaped to suit the teeth of the pinion. The pinion strikes the actuator once during each projector revolution. Numeral 9 represents a ground glass or other suitable screen, and 10 a film image enlarged and thrown upon the screen by the projector. Numeral 11 represents a turn table, which rotates in operation, and which is equipped with a tail stock and, opposite the tail stock, a spindle stock. The material block is held between two centers, of which the one center is part of the tail stock, and the other one part of the spindle of the opposing spindle stock. For each material block plane to be worked out the material block is rotated a very small amount between the two centers by a train of gearing which is part of the turn table, and connected to the spindle of the spindle stock. The spindle stock, together with the train of gearing, serve the same purpose as a dividing head on a milling machine. The spindle of the spindle stock is moved in very small angular steps; each revolution of the continuously rotating turn table causes the spindle to make one step; this takes place at the moment when the pinion 12, which is a member of the above mentioned train of gearing and as such travels around with the turn table, strikes in its circular path the stationary actuator 13 fastened to the apparatus stand 39. The pinion receives thereby a very small rotating movement. This pinion movement is transferred to the spindle and to the material block through the train of gearing, which can be designed in many different ways. It is illustrated by 14, a sprocket, which is fastened to the same shaft the pinion 12 is fastened to, and which together with the pinion 12 straddles the bearing of said shaft; 15, a shaft, that is connected to sprocket 14 by 16, another

sprocket, and by 17, a chain; 18, a worm, that is fastened to shaft 15, and that engages in 19, a worm wheel, which is fastened to 20, a shaft, to which is secured another worm that engages in 21, another worm wheel that is fastened to the spindle; 22, a face plate, that is also fastened to the spindle; and 23, a bent tail dog, which is clamped to the material block and has its bent tail reaching into a slot of the face plate. Numeral 24 represents a vertical shaft. To the upper end of this shaft is adjustably fastened the turn table; the lower end is connected to 25, a worm wheel by means of 26, a key. While the upper portion of this shaft is journaled in 27, an upper bearing, the lower end is journaled through the worm wheel 25 in 28, a footstep or thrust bearing. Numeral 29 represents a bearing similar to bearing 28 in which is rotatably supported 30, a worm wheel, which has with its cooperating worm 31 the same transmission ratio that the worm wheel 25 has with its cooperating worm 32. Both worms are part of or are secured to 33, a horizontal shaft. Numeral 34 represents two bearings for this shaft. Numeral 35 is a motor for rotating the shaft through 36, a motor pulley, 37, a belt, and 38, a friction wheel. The design of this friction wheel is immaterial; as long as it serves its purpose, which is to allow the turntable and the projector to be held stationary by hand, without stopping the motor, when it is desired to spend a comparatively longer time in finishing a more complicated portion of a plane outline. To this end the coefficient of friction between the driving member and the driven member of the friction wheel must be comparatively small.

The running motor rotates the horizontal shaft, which in turn slowly revolves through the worms 31 and 32 and the worm wheels 30 and 25 the vertical shaft, with turn table and material block, and also the projector with the film images of the form record. As the two worm and worm wheel sets have the same transmission ratio, the material block and the projected film image rotate in synchronism. At a fixed moment during the revolution of the turn table the pinion 12 comes in contact with its cooperating actuator, which causes the pinion to make a slight rotary movement. The gearing of the rotating and arresting device is so designed that the material block is caused to move the same angular amount about which the cover with light and camera is moved around the object between the taking of two successive pictures when recording the form of the object. In a similar way the projector pinion 7 coming in contact with its actuator during the revolution of the projector receives a slight rotary movement, which results in a new film image being moved in working position and projected upon the screen. The effect is that with each revolution of the two worm wheels a new material block plane is moved into the working plane of the tool and a new film image projected upon the screen.

Moving the tracer disk on the screen in such a way back and forth in a line that one point of the periphery of the tracer disk always touches the periphery of the slowly revolving film image, causes the quickly rotating and independently driven tool to work out in the plane of the material block an outline which is a perfect duplication of the outline of the film image. As the change from the finished plane to the unfinished plane and the change from the used film image to the unused one is done automatically, the keeping in touch of the periphery of the tracer disk with the film image is all the work required for working out the copy. The connecting device between tracer disk and tool is preferably of a pantograph design, as such a device also allows the tracer disk and tool to be moved in any desired direction.

For making reproductions of different sizes three changes have to be made on the apparatus: The pantograph must be reset, the cutter must be replaced by a new one which has its diameter in correct proportion to the diameter of the tracer disk used, and the vertical distance from the working plane of the cutter to the line connecting the two centers between which the material block is held must be changed. When, for instance, a reproduction of natural size is desired, the pantograph must be set to transfer the movements given the tracer disk to the cutter in full size; a cutter must be inserted into the cutter chuck that has the same diameter as the tracer disk; and the vertical distance from the working plane of the cutter to the line connecting the two centers must be changed to equal the distance from the plane through the edge of the shade of the form recording apparatus used in conjunction with this photo-sculpture method to the center of the rotating ring of said apparatus that carries the camera around. For a reproduction of one quarter the natural size, the pantograph must be set to transfer the movements given the tracer disk to the cutter in one quarter the natural size, a cutter must be inserted into the cutter chuck that has a diameter of only one quarter the size of the tracer disk diameter, and the vertical distance from the working plane of the cutter to the line connecting the two centers must be changed to equal only one quarter the distance from the plane through the edge of the shade of the form recording apparatus to the center of the rotating ring of said apparatus. These values are based upon the assumption that the film images on the screen are enlarged to natural size; if they are enlarged to a

different size, or if other sizes of reproductions are desired, the given values have to be changed accordingly. Depending upon the design the vertical distance between the working plane of the tool and the line connecting the two centers may be changed by either inserting a chuck of different length for holding the various tools used, or by raising or lowering the whole turn table with the actuator as a unit, or by raising or lowering the rotating and arresting device of the material block alone without changing the positions of the pinion with pinion shaft and the sprocket belonging thereto. No means for effecting such raising or lowering is shown, this being easily accomplished as will be readily understood by those versed in the art.

Referring to Fig 2. in detail, numeral 40 represents the material block having the copy partly worked out; 41, the tool for removing the excessive material from the material block; 42, the tracer disk; 43, means for actuating the tool; and 44, any kind of mechanical device for transferring the movements given the tracer disk to the tool in any desired ratio, which device is shown as a pantograph with three of its arms slotted and provided with bolts, nuts and washers, and the tool spindle and the tracer disk spindle held in brackets that are adjustably fastened to their respective pantograph arms, so as to allow the relative positions of the various fulcrums controlling the ratio between the movements of the tracer disk and the tool to be changed, and also held in the changed positions. Numeral 45 represents the objective of a projector held in a bracket; 46, a projector box, being revolved during operation, with a lamp and a mechanism for holding and stepwise moving the film having the various film images; 47, a pinion, which actuates said mechanism, and which receives its actuating movement by the rotating projector box bringing with each rotation the pinion in its circular path once against 48, a stationary actuator. This actuator is fastened to 73, the apparatus stand, and has its free end shaped to fit the teeth of the pinion. Numeral 49 represents a ground glass or other suitable screen, and 50 a film image, enlarged and projected upon the screen. Numeral 51 represents a continuously rotating turn table which is equipped with two tail stocks that oppose each other. The material block is held between the centers of the tail stocks and prevented from rotating by an index plate, that is clamped to the material block, and that cooperates with an index pin slidably held in one of the tail stocks. The index plate has a number of holes arranged in a circle, into which the index pin fits. By bringing a hole of the index plate opposite the index pin and pushing the index pin into this hole, the material block can be held in various positions. This becomes necessary when working out the various sections of the material block. Numeral 52 represents a vertical shaft. To the extreme upper end of this shaft is adjustably fastened the turn table, and to the extreme lower end is fastened 53, a worm wheel by means of 54, a key in such a way that the shaft is free to move longitudinally. The worm wheel together with the shaft is rotatably supported in 55, a bearing; the upper portion of the vertical shaft is journaled in 56, a bearing. Numeral 57 represents a bearing in which is rotatably supported 58, a worm wheel that has with its cooperating worm 59 the same transmission ratio that the worm wheel 53 has with its cooperating worm 60. Both worms are secured to or are part of 61, a horizontal shaft. This shaft is journaled in 62, two bearings and is rotated either clockwise or counter clockwise by 63, the apparatus driving mechanism. The design of this driving mechanism and the kind of power used for it is immaterial, as long as said mechanism allows the direction in which the various parts of the apparatus are driven to be reversed. This apparatus driving mechanism is indicated by a motor with clutch and motor pulley, two belts, one loose and one tight pulley attached to shaft 61, and reverse levers 63 with shifting fork, etc. Numeral 64 represents a friction wheel, which forms the connecting link between the apparatus driving mechanism and the horizontal shaft 61. Its function is to allow the turn table and the projector to be held stationary without stopping the apparatus driving mechanism, when it is desired to spend a longer time on a complicated plane outline. Secured to the horizontal shaft is 65, a sprocket, which through 66, a chain and 67, another sprocket drives 68, a worm journaled in 69, two bearings. This worm engages in 70, a worm wheel which is rotatably mounted in 71, a bearing and prevented from moving longitudinally by 72, a washer secured to the worm wheel. The center hole of this worm wheel is threaded and engages the threaded portion of the vertical shaft.

In the same way as in the previously described apparatus the running motor slowly revolves the material block with its corresponding film image in synchronism, and also automatically changes the film images during the short time the pinion is in contact with its actuator. The changes in the planes of the material block are also automatically made. These changes take place steadily during the revolving of the turn table. They result from a very slow upward movement of the rotating shaft with turn table and material block, and are effected by the faster running lower worm wheel

gradually screwing the threaded portion of the shaft into the threaded center hole of the slower running upper worm wheel. If the speed with which both worm wheels were driven were alike, the vertical shaft would simply revolve without undergoing any longitudinal displacement whatsoever. As soon as the speed of the upper worm wheel lags behind the speed of the lower one, the faster running lower worm wheel screws the threaded shaft into the threaded worm wheel, which raises the shaft, turn table, and the material block. The amount that the shaft is raised during a revolution depends upon the speed difference existing between the upper and lower worm wheels. This speed difference is easily controlled by the number of teeth in sprocket 65 or sprocket 67, or by the transmission ratio of the upper worm and worm wheel. For a full sized copy the apparatus possesses the correct amount of shaft displacement, when the image is enlarged to full size, and the amount of lead belonging to the angle that the upper worm wheel lags behind the lower one during one revolution equals the amount that the cover was moved between the taking of two successive pictures during the form recording. For other copy sizes or for basreliefs the apparatus has to be adjusted accordingly. The turn table is brought back to its starting position by pulling out the reverse lever and letting the motor drive the apparatus in opposite direction.

The apparatus illustrated in Fig. 2 may also be used to great advantage in carving out molds. For this purpose the tracer disk has to be moved inside the projected film image, and the plane having the largest area must be worked out first.

To obtain more accurate copies and to facilitate keeping the periphery of the tracer disk in touch with the periphery of the film image, the film image may be enlarged to such a large size that only a part of it will be visible on the screen.

The use of tracer disks and tools of different diameters is not necessary when the device for transferring the movements given the tracing member to the tool is provided with a tracer pin which tapers out to a point, and a conical endmill which also tapers out to a point. The conical endmill must be so positioned and held in the mentioned device in relation to the tracer pin point that its given movements are transferred to the point of the rotating conical endmill. To reach conveniently into the smallest irregularities of the copy, the means for holding the endmill is preferably made adjustable, to allow the axis of the rotating endmill to be inclined more or less as desired. Using a tracer pin in connection with a conical endmill requires the tracer pin point to be moved along the periphery of the enlarged film image for a perfect duplication of the film image outline on the material block.

Figs. 3 and 4 illustrate one way of making the means for holding the conical endmill adjustable, so as to allow the axis of the conical endmill to be inclined to facilitate the carving out a complicated copy. In these figures numeral 74 represents a spindle housing, holding the cutter spindle; 75, a conical endmill held in the spindle; 76, a flexible shaft for driving the spindle with the endmill; 77, two circular slots cut into the flange of the spindle housing, which in connection with 78, two bolts with washers and nuts, allow the spindle housing with spindle and endmill to be tilted and tightened in the desired position to 79, a flanged bracket. This flanged bracket is provided with 80, an oblong slot, which together with 81, a bolt with a nut and a washer, permits the flanged bracket to be adjustably held on 82, the extreme tool end of the device for transferring the movements given the tracer disk to the cutting tool.

When making very small sized copies, intended for jewelry purposes for instance, it is not necessary to use a projector for enlarging and projecting the film images of the form record upon a screen, as the film images themselves may be used as guides when directing the tracer disk or tracer pin in its movements.

To make a copy of a material which does not yield to milling, but requires other material removing operations, the kind of tool, the means for actuating and for holding the tool must be chosen accordingly.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:—

1. In an apparatus of the character described the combination of a material block holder, a film containing images of the form record, a suitable device with one end of it removably holding the tracer disk, and the other end the tool for transferring the movements given the tracer disk to the tool; and means for revolving material block and film image in synchronism.

2. In an apparatus of the character described the combination of a holder for a material block, a film containing images of the form record, each image corresponding to one of the various planes in which the copy is to be worked out; means for holding the form record and material block and moving each film image with its corresponding plane of the material block in working position a device; a tracer disk and a tool removably held in said device, said device transferring the movements given the tracer disk to the tool; and means for revolving the material block and the film image in synchronism.

3. In an apparatus of the character de-

scribed the combination of a tracer disk and a tool a device removably holding said disk and tool and transferring the movements given the tracer disk to the tool; means for holding the material block and moving the various planes to be worked out in working position; means for holding the form record and moving the various film images in working position; and means for revolving the material block and film image in synchronism.

4. In an apparatus of the character described the combination of a tracer disk and a tool a device removably holding said disk and tool and transferring the movements given the tracer disk to the tool; optical means for enlarging the various film images of the form record and throwing them upon a screen; means for holding the material block and moving the various planes to be worked out in working position; means for holding the form record and moving the various film images in working position; and means for revolving the material block and the film image in synchronism.

5. In an apparatus of the character described the combination of a tracer disk and a tool, a device removably holding said disk and tool and transferring the movements given the tracer disk to the tool; optical means for enlarging the various film images and throwing them upon a screen; means for holding the material block and moving the various planes to be worked out in working position; means for holding the form record and moving the various film images in working position; means for changing the distance between material block and working plane of tool; and means for revolving the material block and film image in synchronism.

6. In an apparatus of the character described the combination of a tracer disk and a tool a device removably holding said disk and tool and transferring the movements given the tracer disk to the tool; means for holding the material block; means for holding the form record and moving the various film images in working position; and means for revolving the material block and film image in synchronism and gradually changing the working planes of the material block.

7. In an apparatus of the character described the combination of a tracer disk and a tool a device removably holding said disk and tool and transferring the movements given the tracer disk to the tool; means for holding the material block and gradually moving the various planes of the material block in working position; means for holding the form record and moving the various film images in working position; and means for revolving the material block and film image in synchronism.

8. In an apparatus of the character described the combination of a device for holding the material block and moving the various planes of the block in working position, with a device for holding the form record and moving the various film images in working position, and means connecting both devices for causing a material block plane and a film image to be moved simultaneously.

9. In an apparatus of the character described the combination of means for supporting a film having a series of film images of the object to be reproduced; a device for supporting a material block; means for actuating said supporting means and said device to cause the film and the block to be shifted and rotated; and means holding at one end a tracer and at the other end a material removing tool for transferring the movements given said tracer to said tool.

10. In an apparatus of the character described the combination of means for supporting a film, having a series of film images of the object to be reproduced and projecting each image upon a screen; a device for supporting a material block; means for simultaneously rotating and shifting a film image and a corresponding material block plane; and means for gearing a tracer adapted to follow the outline of the film image to the material removing tool acting on the material block.

11. In an apparatus of the character described the combination of means for supporting a film having a series of film images of the object to be reproduced and for projecting the images upon a screen; a device for holding the material block and shifting the various material block planes in working position; means for rotating said supporting means and said device; a tracer adapted to follow the outline of the projected image; a material removing tool to act on the material block; and means for gearing said tracer to said tool.

12. In an apparatus of the character described the combination of means for supporting a film having a series of film images of the object to be reproduced and for projecting the images upon a screen; a device for supporting the material block; means for actuating said supporting means and said device to cause the film image and the block to be rotated in synchronism; means for changing the distance between material removing tool and material block for each new image projected; and a suitable device, holding at one end a tracer and at the other end the material removing tool, for transferring the movements given said tracer to said tool.

13. In an apparatus of the character described the combination of means for supporting a film having a series of film images of the object to be reproduced and for pro-

jecting the images upon a screen; a device for supporting the material block; means for actuating said supporting means and said device to cause the film image and the block to be rotated in synchronism; means for changing the plane in which the material block is worked out for each new image projected; and a suitable device, holding at one end the tracer and at the other end the material removing tool for transferring the movements given said tracer to said tool.

In testimony whereof, I have signed my name to this specification.

WILLIAM FRED ENGELMANN.