This invention deals with copying and engraving machines of the type capable of performing three-dimensional work or relief work, sometimes called profiling machines.

Another object of the invention is the provision of a machine in which a pantograph is movable, guided for movement in a plane always parallel to a given fixed plane, and in which the mass inertia of the pantograph is utilized for damping vibrations of the tool spindle or of the tracing stylus in a direction perpendicular to the plane of operation of the pantograph, as well as vibrations in the direction of such plane.

Still another object is the provision of a machine of the kind just mentioned, in which approximately the same mass is available for damping vibrations in a direction perpendicular to the plane of operation of the pantograph, as for damping vibrations in the direction of such plane.

A further object is the provision of a pantograph engraving machine capable of doing relief work, in which the pantograph always operates in a plane parallel to a given fixed plane and in which a more rigid construction and especially a more rigid support for the tool spindle is provided, than in previous machines of this kind.

A still further object is the provision of a pantograph machine of this kind in which the extent to which the end of the cutting tool projects from the plane of the pantograph operation is constant, thus avoiding the unfavorably great projection from the pantograph plane, present in certain prior machines.

To these and other ends the invention resides in certain improvements and combinations of parts, all as will be hereinafter more fully described, the novel features being pointed out in the claims at the end of the specification.

In the drawing:

1. A side elevation of a machine constructed in accordance with a preferred illustrative embodiment of the invention;

2. A plan thereof;

3. A side elevation of a fragment of the machine, showing the connection between the tool holder and the bar which guides vertical movements of the parts, and Fig. 4 is an end view of the construction shown in Fig. 3, with the bar illustrated in section.

The same reference numerals throughout the several views indicate the same parts.

In the machine here shown as an illustrative embodiment, a standard or frame 11 supports a pattern table 13 and a work table 15, both of these tables being mounted, as usual, on various slides and provided with feeding mechanism so that they can be moved to various positions relative to each other and to the frame 11.

An upward extension 11 on the frame is provided with a substantially vertical guideway along which is movable a carrier 19. On this carrier 19 is the so-called main pivot 21 (arranged approximately vertically) of a pantograph linkage of the lazeung type, the pantograph linkage including members 23, 25, 27, and 29 pivoted to each other and to the main pivot 21 in known manner. The pantograph linkage may be said to operate in a plane which is perpendicular to the main pivot 21 from which the pantograph mechanism is supported. The plane of operation of the pantograph linkage does not tilt, since no provision is made for tilting the main pivot 21, but the pantograph linkage as a whole can be moved upwardly or downwardly by sliding the carrier 19 upwardly or downwardly along its guideway on the standard 11. Thus the pantograph linkage may operate in any one of an infinite number of operating planes, each one of which, however, is parallel to each other plane and to any given fixed reference plane (such, for example, as the plane of the table 13 or 15) which is perpendicular to the main pivot 21.

On the member 27 of the pantograph linkage is a tool holder indicated in general at 33, which tool holder has the usual bearings for a tool spindle 35 arranged perpendicularly to the plane of operation of the pantograph linkage, and which carries at its lower end a cutting tool 37. The spindle 35 may be driven in any suitable manner, such, for example, as an electric motor driving a belt 41 which in turn drives a belt 43 running over one or another of the pulleys 45 on the spindle 35.

On the pantograph member 25 near the outer end thereof, is a socket 51 in which is vertically slideable a stylus holder 53 carrying at its lower end a tracing stylus 55. The pantograph member 25 may also have an operating handle 57 projecting from the socket 51, which handle may be grasped by the operator to assist in operating the parts. The stylus holder 53 is accurately guided in the socket 51 so that it may not be displaced laterally therein, but may move freely in a longitudinal direction through the socket.

As usual, the pantograph linkage members 23, 25, 27, and 29 are adjustable relatively to each.
other to vary the ratio of reduction or enlargement, and the tool holder 33 is adjustable along the member 21 on which it is mounted, so that, whenever the linkage members are changed to a different adjustment the tool holder may be set to proper position so that it and the stylus holder 88 and the main pivot 21 all lie in the same plane passing longitudinally through the pivotal axis 21.

The pantograph linkage controls the proper ratio of movement of the tool relatively to the stylus, in directions parallel to the operating plane of the pantograph. For controlling the ratio of movement in directions perpendicular to the pantograph, there is provided a bar 61 connected to the machine frame, the tool holder, and the stylus holder. Any one of these three connections may be a fixed pivot connection, the other two connections being slidable along the length of the bar in order to permit movements of the parts in the plane of the pantograph linkage. In the illustrative form here shown, the fixed pivotal connection is between the bar 61 and the stylus holder 88, as indicated at 88. The pivotal connection 65 between the bar and the tool holder 33 is slidable along the bar, and the pivotal connection 67 between the bar and the machine frame is likewise slidable along the bar, so that these two named connections do not interfere with movements of the stylus holder toward or away from the main pivot 21, since during such movements the bar 61 may slide longitudinally relatively to the pivotal connections 65 and 67.

A preferred form of such slidable pivotal connections is shown in Figs. 3 and 4. The bar 61 is preferably of substantially I-beam shape, as shown in Fig. 4. On each side of the bar is a triangular plate 71, and between these two plates are the pivots of three rollers 73, 75, and 77, two of which roll on one edge of the bar and the other of which rolls on the opposite edge of the bar. Extending upwardly from the top of the tool holder 33 is a shaft 79 mounted in bearings at the top of the tool holder so as to be capable of turning relatively to the tool holder about its own axis (which coincides with the rotary axis of the spindle 35), but held against axial or longitudinal movement relatively to the tool holder. At its upper end this shaft 79 is forked at 80 to form two arms extending upwardly on opposite sides of the triangular plate 71 in embracing relationship thereto, and the pivots 65 extend inwardly from the arms 81 into the plates 71, to form a pivotal connection between the plates and the arms.

With this arrangement the bar 61 may slide freely in the direction of its own length and across the rotary axis of the spindle 35, and the tool holder 33 may turn relatively to the bar 61 about the axis of rotation of the spindle, but the tool holder and the bar are prevented from moving relatively to each other in a direction longitudinally of the rotary axis of the spindle, or in any direction transversely of the length of the bar.

A similar arrangement may be provided for the pivotal connection 67 between the bar 61 and the machine frame, the triangular side plates 71a which carry the three rollers preferably being reversed as shown in Fig. 1, and the forked arms 81a being connected to a shaft 79a which extends upwardly and which is rotatably mounted in a bracket 82 at the top of the spindle 17 of the machine frame, but which is held against axial or longitudinal movement therein.

It is important that the axis of the pivot 61 intersect the axis of the pivot 21 and that the center of rotation of the shaft 79a be in alignment with the axis of the main pivot 21, in order that the reduction or enlargement ratio for vertical movements in a direction perpendicular to the plane of operation of the pantograph linkage, may be the same as the reduction or enlargement ratio for movements in directions parallel to such plane. Also, of course, the pivot 65 intersects the rotary axis of the spindle 35, and the pivot 67 intersects the axis of the stylus 88. The pivotal arrangements above described constitute, in effect, universal joints whereby the bar 61 is connected to the tool holder 33 at a point in alignment with the rotary axis of the tool spindle, and whereby the bar 61 is connected to the machine frame at a point in alignment with the main pivot 21 of the pantograph linkage, the pivots 65, 67, and 61, also being all in a straight line with each other.

As above indicated, the pivot 61 between the bar and the machine frame may be the fixed pivot, and the pivots 65 and 67 may both be slidable along the bar, or the pivot 65 may be the fixed pivot and the pivots 65 and 67 may both be slidable along the bar 61, the pivotal axis of which three pivots is fixed to the bar, so long as the other two are slidable. Indeed, all three could be made slidable along the bar, so far as correct operation of the machine is concerned, so long as some means is provided for preventing the bar from escaping endwise from one of the pivots.

Suitable means is provided for counterbalancing the weight of the vertically movable carrier 19 and of the pantograph linkage and other parts supported therefrom. Such means may be in the form of a counterweight or a spring balancing means, such as the spring 81, the tension of which is adjustable by a hand wheel 39 operating with a threaded rod at the lower end of the spring. The upper end of the spring is connected with a band or cord 85 which extends upwardly over a pulley mounted to turn about a fixed axis, within the machine frame 17, and thence downwardly to a suitable connection with the carrier 19.

In the machine of the present invention, the pantograph linkage is mounted so as to be capable of movement in directions transverse to its own plane (that is, by moving the carrier 19 upwardly or downwardly on the frame 17) and only one of the two holders (tool holder 33 and stylus holder 88) is movable relatively to the pantograph linkage in a direction transverse to the plane of operation of the pantograph, the other of such holders being fixed against movement in a direction transverse to the plane. Thus, when the plane of operation of the pantograph linkage is substantially horizontal as here disclosed for the sake of convenience, either the tool holder 33 or the stylus holder 88 is made vertically movable relatively to the pantograph linkage, but the other of such holders is vertically fixed relatively to the linkage. In the preferred form of construction, it is the tool holder 33 which is fixed against vertical movement relatively to the pantograph linkage on which it is mounted, and the stylus holder 88 is mounted 70 for vertical sliding movement through the socket 81.

These arrangements have substantial advantages over the arrangement where both the tool holder and the stylus holder are fixed on the 75
pantograph linkage against movement in a direction perpendicular to the plane of operation of the linkage. When neither of these two holders is mounted, the movement perpendicular to the plane of the pantograph linkage, then if the machine is to perform relief work, it is necessary that the pantograph linkage be mounted for tilting movement, and such tilting movement is disadvantageous because it causes the tracing stylus and the cutting tool to assume different angular positions with respect to any given fixed plane or surface of the pattern and work, whereas it is frequently advantageous to keep the tool and the tracing stylus always parallel to themselves in all positions of movement, so that they do not tilt, as this assists in cutting certain kinds of surfaces on the work.

Also, the present arrangements are far superior to a known prior arrangement in which both the stylus holder and the tool holder are mounted for movement in a direction substantially perpendicular to the plane of operation of the pantograph linkage, because in such prior construction, during travel over different elevations of the pattern or work, the tool projects to different extents from the plane of operation of the pantograph linkage, and at times, when projecting to a maximum extent from such plane, the end of the tool may be relatively far from the guiding or supporting means on the pantograph linkage, with the result that adequate lateral support for the tool is not attained.

The present constructions provide a much more rigid and satisfactory support for the tool to hold it against lateral deflection, because it never projects very far beyond the plane of the pantograph linkage and thus forces tending to displace the end of the tool laterally from its proper position do not act with any great lever arm, but always with a constant and relatively small lever arm. Of course, if it is the stylus holder rather than the tool holder which is fixed against movement substantially perpendicular to the plane of the linkage, then the same remarks as to the advantage of this construction apply to the stylus holder, and the stylus is never projected very far from the plane of the pantograph linkage, so that it is held more rigidly against lateral deflection.

Another advantage in the present construction, particularly if it is the tool holder which is fixed against movement perpendicularly to the plane of the linkage, is that, since no provision need be made for sliding movement in a direction axially of the tool spindle, the bearings for the tool spindle can be arranged more satisfactorily, with greater rigidity and less chance for lateral play.

Still another and very important advantage of the arrangement described, is that, when the tool holder is fixed against movement in a direction perpendicularly to the plane of the pantograph linkage, the entire mass inertia of the pantograph linkage is available for damping or reducing vibrations of the tool and tool spindle in a direction axially thereof. Thus substantially the same mass inertia is available for damping vibrations axially of the tool spindle, as the mass inertia which damps vibrations in a direction transverse to the tool spindle, and fatigue of the operator caused by vibrations axially of the spindle is greatly reduced.

In the machine constructed as shown in the drawing, the tool 31 will be moved correspondingly in all directions to the movements of the stylus 55, but on a reduced scale, so that the work on the work table 15 will be a reduced scale reproduction of the pattern on the pattern table 13, the degree or ratio of reduction being changeable by changing the setting of the pantograph linkage. If it is desired to make an enlarged reproduction rather than a reduced one, then the work is placed on the table 13 and the pattern is placed on the table 15, and the tool holder 33 and stylus holder 53 are interchanged from the positions shown in the drawing, the sockets in which they are mounted preferably being of the same size so as to allow for such interchange when desired. Preferably, in that case, the tool holder when mounted in position over the table 13 is clamped against movement in a direction transverse to the plane of operation of the pantograph linkage, while the stylus holder, now placed over the table 15, is mounted for such movement in a direction substantially perpendicular to the plane of operation of the linkage.

If it is desired to transform the machine temporarily into an ordinary engraving machine for engraving on substantially flat surfaces, rather than for making relief reproductions, then the stylus holder 53 is preferably clamped in the socket 51 so as to be incapable of vertical movement therein. Any suitable clamping means may be provided, such as the set-screw 57 threaded into the socket 51 and bearing against the holder 53 when screwed inwardly to prevent movement of the holder in the socket. When such clamping means is used, the part at the top of the holder 53 which carries the pivot 63 is swiveled or pivoted on the holder 53 so as to be capable of rotating about the vertical axis of the holder.

If it is desired to transform the machine into an engraving machine for a longer period of time, then the holder 53 may be clamped in the socket 51 by the clamping means 97, as above indicated, and the bar 61 may be entirely removed from the machine.

The socket in the pantograph linkage 27 which holds the holder 33 is preferably also provided with clamping means similar to the clamping means 97 of the socket 51, so that whenever desired, either holder may be clamped against axial movement in its socket and the other holder may be left loose so as to move axially for relief work, or may also be clamped against axial movement for flat engraving work.

In the form of construction here shown, the axis of the main pivot 21 is substantially vertical and the plane of operation of the pantograph linkage is substantially horizontal and is substantially perpendicular to the main pivot axis. This is usually the most convenient arrangement of the parts, though it must be understood that the pivot axis, plane of operation, etc., may be placed in any direction or position in space, so long as the various pivotal axes and planes maintain the proper relation to each other above set forth.

While one embodiment of the invention has been disclosed, it is to be understood that the inventive idea may be carried out in a number of ways. This application is therefore not to be limited to the precise details described, but is intended to cover all variations and modifications thereof falling within the spirit of the invention or the scope of the appended claims.

I claim:
1. A relief copying machine including a frame, a pantograph linkage mounted on said frame for
movement relatively thereto in a direction substantially perpendicular to the plane of operation of said linkage and held against tilting movement relative thereto, a tracing stylus holder mounted on said pantograph linkage, a tool holder also mounted on said pantograph linkage, one of said holders being mounted for movement relatively to said linkage in a direction substantially perpendicular to said plane of operation of said linkage, the other of said holders being held against movement relative to said linkage in said perpendicular direction, and a member pivotally connected to said frame, said tool holder, and said stylus holder, for transmitting to one of said holders a proportionate part of the movements of the other of said holders in a direction substantially perpendicular to said plane of operation of said pantograph linkage.

2. A relief copying machine including a frame, a pantograph linkage mounted on said frame for movement relatively thereto in a direction substantially perpendicular to the plane of operation of said linkage, a tool holder mounted on said pantograph linkage and held against movement relatively thereto, a tracing stylus holder mounted on said pantograph linkage for movement relatively to said linkage in a direction substantially perpendicular to said plane of operation of said linkage, a tool holder mounted on said pantograph linkage and held against movement relatively thereto in a direction transverse to the plane of operation of said linkage, and a relatively rigid elongated member pivotally connected to said stylus holder, tool holder, and frame in such a manner that movements of said stylus holder relatively to said frame in a direction substantially perpendicular to said plane of operation of said linkage will cause corresponding proportional movements in said direction of said tool holder relatively to said frame and of said pantograph linkage bodily with said tool holder.

3. A profiling machine including a frame, a carrier mounted on said frame for movement back and forth along a substantially straight path, a main pivot mounted on said carrier and having a pivotal axis substantially parallel to said path, a pantograph linkage mounted on said main pivot to swing thereon in a plane of operation substantially perpendicular to said main pivot and to said path, a tool holder mounted on said pantograph holder also mounted on said pantograph linkage, the axes of said tool holder and stylus holder both lying substantially in a common plane passing axially through said main pivot, one of said holders being mounted for sliding movement relatively to said pantograph linkage in a direction along said common plane and substantially perpendicular to said plane of operation of said pantograph linkage, the other of said holders being held against movement relatively to said pantograph linkage in said common plane, a pivotal connection between said bar and said stylus holder, another pivotal connection between said bar and said tool holder, and a third pivotal connection between said bar and said frame, said third pivotal connection lying substantially on the axis of said main pivot, and said bar being slideable longitudinally with respect to said frame.

4. A profiling machine including a frame, a carrier mounted on said frame for movement back and forth along a substantially straight path, a pantograph linkage pivotally mounted on said carrier to swing about a main pivot axis substantially parallel to said path in a plane of operation substantially perpendicular to said main pivot axis and to said path of movement of said carrier, a tool holder mounted on said pantograph linkage and held, during normal operation, against movement relatively thereto in a direction transverse to said plane of operation of said linkage, a stylus holder also mounted on said linkage for movement relatively thereto in a direction substantially perpendicular to said plane of operation of said linkage, said tool holder and stylus holder both having axes lying substantially in a common plane passing axially through said main pivot axis, a relatively rigid bar lying substantially in said common plane, means pivotally connecting said bar to said stylus holder, universal pivot means slidably longitudinally along said bar for connecting said bar to said tool holder, and universal pivot means slidably longitudinally along said frame for connecting said bar to said frame at a point substantially in alignment with said main pivot axis.

5. A construction as described in claim 4, in which said universal pivot means for connecting said bar to said frame includes a member pivotally mounted on said frame to turn about an axis substantially coinciding with said main pivot axis, said member having two arms extending in the general direction of said axis and spaced from each other on opposite sides of said axis, two plates spaced from each other on opposite sides of said bar and received between said two arms of said member, pivot means connecting said two plates to said two arms for movement relatively thereto about a pivotal axis substantially intersecting and substantially perpendicular to said axis on which said member turns on said frame, a roller mounted on said two plates and located between them for rolling on one edge of said bar, and another roller mounted on said two plates and located between them for rolling on an opposite edge of said bar.

6. In an engraving and copying machine of the type including a bar to be pivotally connected to a part for universal pivotal movement in all directions relatively thereto and to be slideable longitudinally along said bar, said part for turning movement relatively to said part about an axis transverse to the length of said bar, a frame, a roller mounted on said frame and rolling along one edge of said bar, a pair of rollers mounted on said frame in spaced relation to each other and both rolling along an opposite edge of said bar, and pivot means for connecting said frame to said member about a pivot axis substantially intersecting the center line of said bar so that said frame in said common plane turns relatively to such member about an axis substantially intersecting and substantially perpendicular to the axis about which said member turns relatively to said part.

7. A construction as described in claim 4, further including means for clamping said stylus holder against movement relatively to said linkage in a direction substantially perpendicular to said plane of operation of such linkage, to transform said profiling machine into a machine for engraving substantially flat surfaces.

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