June 6, 1939. P. M. HENKES 2,161,709

THREE DIMENSIONAL ENGRAVING AND ALLIED PANTOGRAPH MACHINE

Filed June 3, 1938 4 Sheets-Sheet 1

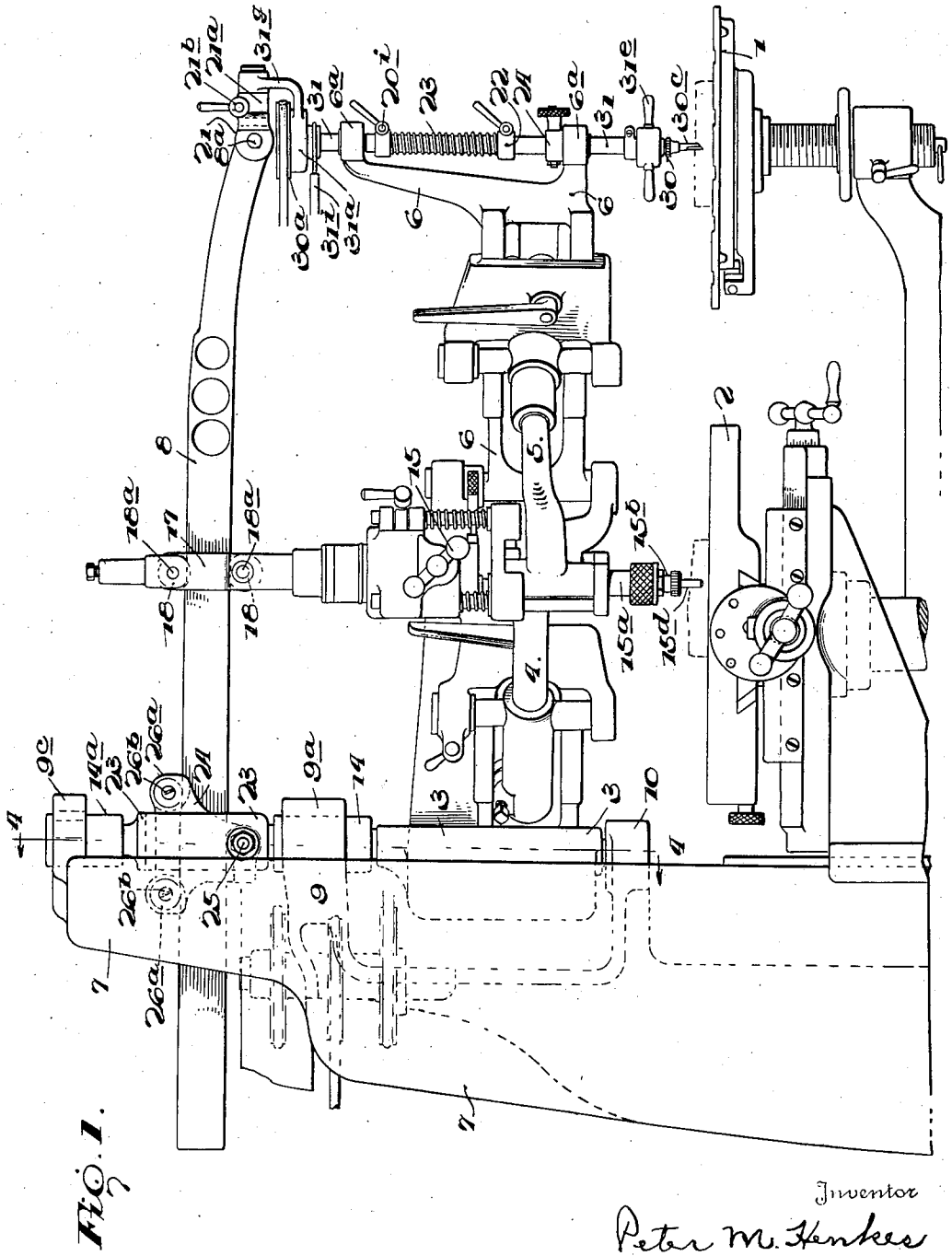


FIG. 1.

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Fig. 2.

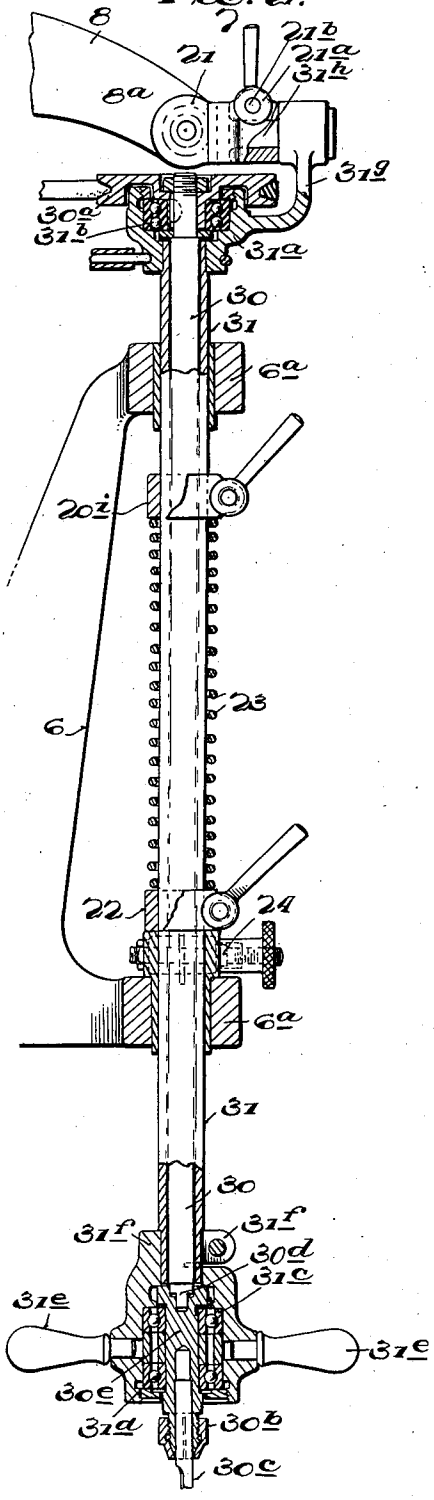
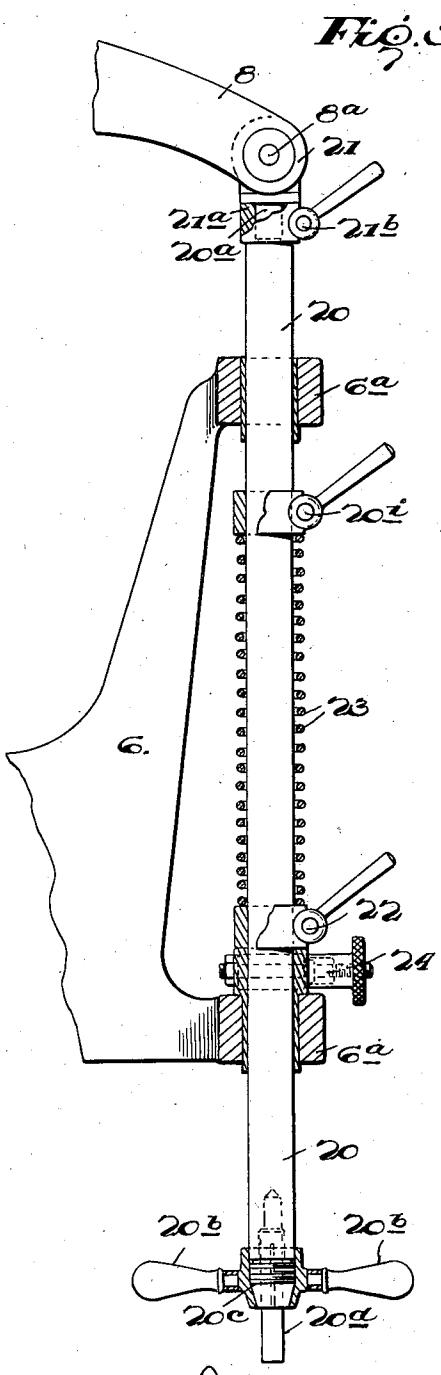


Fig. 3.



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Fig. 4.

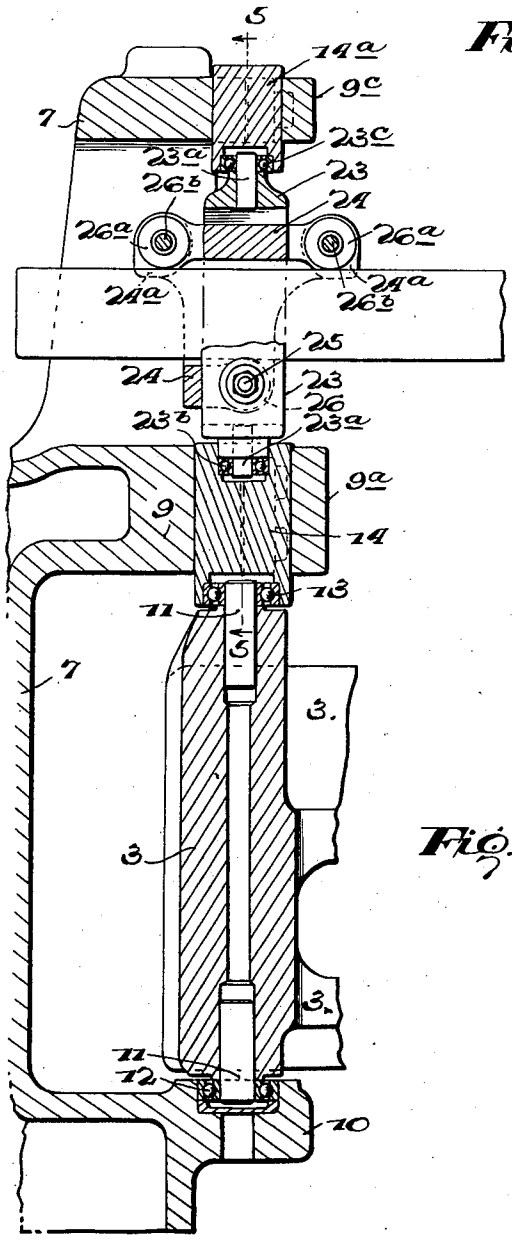
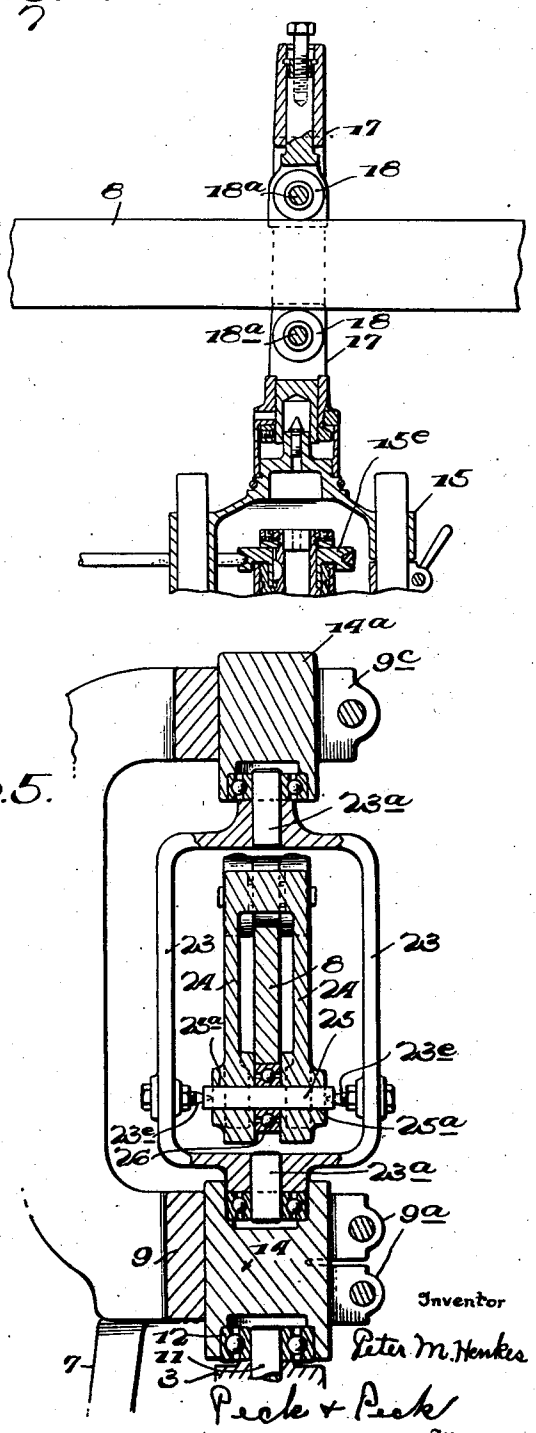


Fig. 5.



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THREE DIMENSIONAL ENGRAVING AND ALLIED PANTOGRAPH MACHINE

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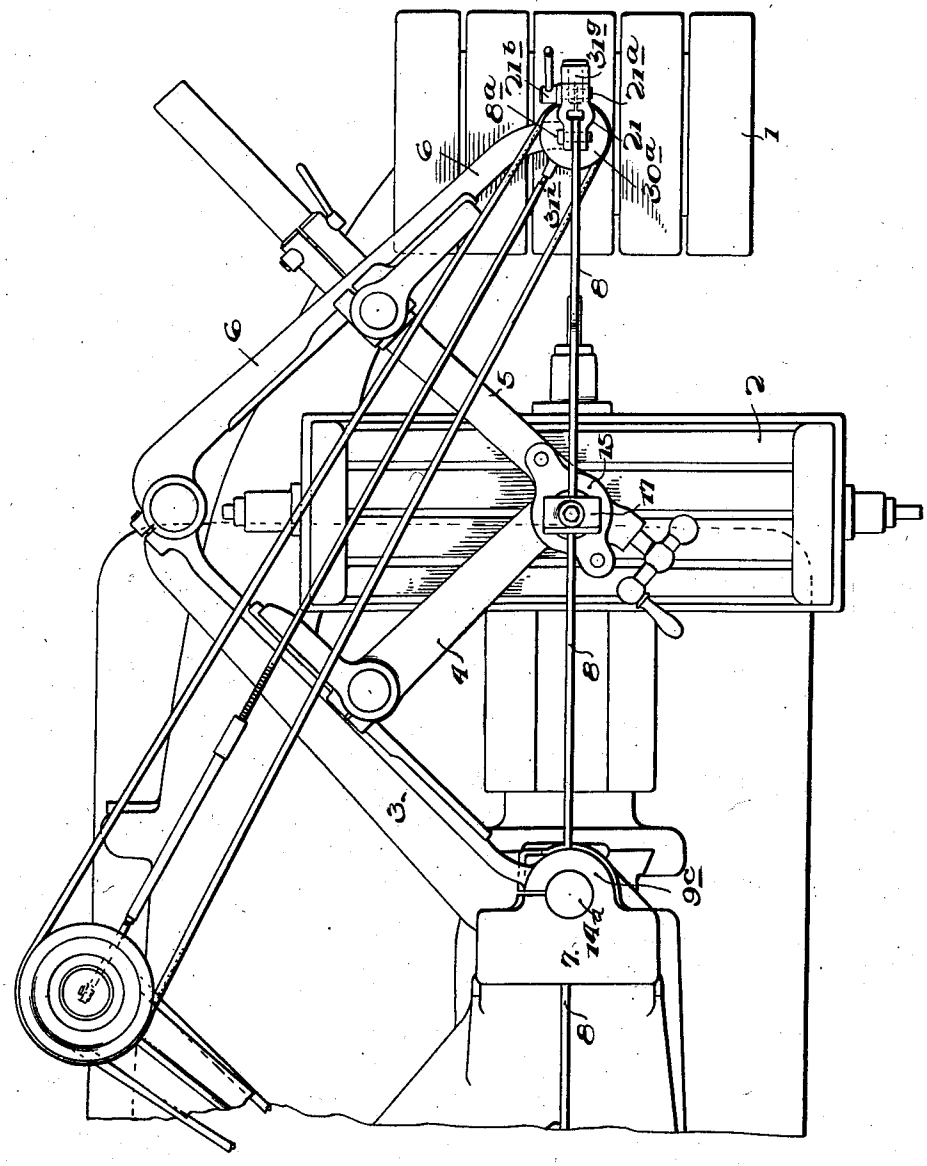


Fig. 6.

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Patented June 6, 1939 2,161,709

UNITED STATES PATENT OFFICE

2,161,709

THREE DIMENSIONAL ENGRAVING AND ALLIED PANTOGRAPH MACHINE

Peter M. Henkes, Racine, Wis., assignor to George Gorton Machine Co., Racine, Wis., a corporation of New Jersey

Application June 3, 1938, Serial No. 211,678

18 Claims. (Cl. 90—13.1)

This invention relates to improvements in and concerning three dimensional engraving and allied pantograph machines, and the term "engraving" is herein employed in a generic sense to include all machines in which my invention can be employed or to which it can be adapted; and the objects and nature of the invention will be understood and made clear from and by the following description of the accompanying drawings that illustrate a mechanical expression or embodiment of an example of my invention for purposes of explanation, from among other constructions, variations, and embodiments within the spirit and scope of the invention.

The invention particularly relates to that type of three dimensional pantograph machines wherein the pantograph is usually hung on a normally-fixed vertical supporting axis holding the pantograph to lateral swing and operation in a normally-fixed horizontal plane, with the vertical tracer or stylus, and the vertical cutter spindle, maintained parallel with the pantograph axis, and controlled and actuated in their lateral movements by the pantograph for scaled lateral dimensional operation; the vertical tracer and cutter spindle being relatively movable longitudinally, with respect to said pantograph for scaled depth dimensional operation; the depth dimensional operation or movements of the cutter spindle being controlled by the depth dimensional movements of the tracer through the medium of a scaling lever, or its equivalent, operatively associated with the tracer and the cutter spindle and being connected to the machine frame, or a normally fixed support, by a suitable swivel coupling, rendering said lever laterally swingable with the pantograph on a vertical axis substantially alined with the axial line of said pantograph axis, and relatively swingable vertically, with respect to the pantograph, on a transverse axis substantially intersecting and perpendicular to said pantograph axis; the pantograph maintaining susbtantially the same usually-reducing reproduction ratio relationships between the parallel vertical axes of the tracer, cutter spindle and pantograph axis, for both lateral dimensional and depth dimensional operations. Organizations of my invention, of the above described type, are disclosed by my pending United States patent applications Ser. No. 693,175, filed October 11, 1933, and Ser. No. 33,611, filed July 27, 1935, now U. S. Patent 2,128,611, August 30, 1938.

An object of the invention is to provide an improved three dimensional pantograph machine of the general type of the disclosures of my above mentioned patent applications, for producing enlarged copies preferably of relatively soft materials, of a pattern or copy, according to a desired enlarging ratio within the capacity of the machine.

A further object of the invention is the production of a three dimensional pantograph machine of the aforementioned type for producing reduced copies of the pattern according to any reducing ratio within the machine capacity, capable of easy conversion into and from, a machine of the same general type, for producing enlarged copies of the pattern, by providing a unit tracer and its mounting easily removable from and applicable to the depth scaling lever and the pantograph, and a unit additional rotary cutter and its mounting, easily applicable to said lever and said pantograph in place of said unit tracer, and easily removable therefrom; and cutter spindle driving means operatively detachable from the permanent cutter spindle and operatively applicable to said additional substitute cutter for driving the same, whereupon a tracer can be fixed to the permanent cutter spindle on removal of the cutter therefrom.

Another object, is the production of a novel removable and applicable rotary cutter spindle and its mounting as a unit, for application to the depth scaling lever and the pantograph of such three dimensional pantograph machines, in place of the regular tracer that is employed in such machines for producing reduced copies of the pattern, whereby a tracer can be substituted in the cutter spindle of the permanent cutter head, for tracing a pattern fixed on the work table, while a cutter carried by the cutter spindle unit substituted for the regular tracer, can operate on work fixed on the pattern table, with said last named cutter driven by the regular drive operatively disconnected from the permanent cutter head.

And a further object is the production of certain improvements in three dimensional pantograph machines of the type hereinbefore described with the end in view of increasing the efficiency and accuracy thereof, whether or not such machines are adapted for producing reduced copies of the pattern or enlarged copies of the pattern.

With the foregoing and other objects in view, that will become apparent from the following explanations, the invention consists in certain novel features and organizations and in combinations and arrangements as more fully herein-

after set forth, and specified by the appended claims.

Referring to the accompanying drawings, forming a part hereof:

Fig. 1 is an elevation of a three dimensional pantograph machine embodying my invention, and organized for producing enlarged copies of the pattern, the work being indicated on the pattern table and the pattern being indicated on the work table, the removable and applicable auxiliary cutter spindle and its mounting unit, being operatively coupled to the depth scaling lever and located in the pantograph in place of the regular tracer, and a tracer being substituted for a cutter in the chuck of the regular cutter spindle in the permanent cutter head.

Fig. 2 is a detail view showing the auxiliary cutter unit partially in longitudinal section, coupled to the vertically swingable lever, and mounted in the pantograph, the eyes of which are shown in vertical section.

Fig. 3 is a detail view showing the normal tracer spindle mounted in the pantograph and to the vertically swingable lever, certain parts being shown in vertical section.

Fig. 4 is the vertical section on the line 4—4, Fig. 1, being the axial line of the vertical axis of the pantograph, a portion of the vertically swingable lever being shown, together with a portion of the operative connection between said lever and the vertically floatable normal cutter spindle.

Fig. 5 is a detail vertical section on the line 5—5, Fig. 4.

Fig. 6 is a top plan, in part, of the organization of Fig. 1.

In the three dimensional reproducing machine disclosed, the pantograph swingable horizontally in a normally-fixed horizontal plane from a normally-fixed vertical axis supported by the frame, carries at its outer or free end a removable vertical member relatively slidable longitudinally and normally providing the tracer located over the normal pattern table. This pantograph is also provided with a cutter head that forms a part of the pantograph, and this head carries a vertical cutter spindle located between said member and the pantograph axis in accord with the reproducing ratio at which the pantograph is set. This vertical cutter spindle is also relatively movable vertically and normally provides the cutter located over the normal work table.

The vertically and laterally swingable lever 8 is operatively coupled to said member and to said cutter spindle to control the vertical movements of the cutter by the vertical movements of the tracer according to said reproducing ratio at which the pantograph is set; and to this end said lever is directly connected to the frame by a novel swivel coupling that determines the axes on which said lever is swingable laterally and vertically. This novel coupling is fully explained hereinafter.

The machine disclosed also presents certain advantageous features in the mountings for the pantograph and for said coupling, fully explained hereinafter.

Novel advantageous provisions are also hereinafter explained, whereby the machine can be adapted for three dimensional enlarging reproduction work with the work on the pattern table and the pattern on the work table, without disturbing or removing the normally-permanent cutter head and its cutter spindle and barrel, other than by substituting a tracer bit or tool for the cutter normally in the cutter spindle collet or chuck; by removing said normal tracer-providing vertical member, and substituting in the pantograph, a novel unit including an auxiliary driven rotary cutter spindle and its mounting, and coupling said unit to the lever 8, and shifting and extending the machine belt drive to actuate said rotary cutter shaft of the unit.

In the machine illustrated, a normal pattern table 1, and a normal work table 2, are diagrammatically indicated, and these tables are usually provided with any suitable adjustments and feed means, as may be required by the particular machine embodiment. Each table 1, 2, is suitably formed at its horizontal top to receive and have either the work or the pattern securely clamped or otherwise secured thereon below the horizontal pantograph, and in operative relation to either the cutter spindle or the tracer movable laterally with and vertically with respect to the pantograph.

The pantograph in the example illustrated, is of the jointed bar or link parallelogram type, horizontally disposed over and above the tables 1, 2, and confined to lateral swing and contraction and expansion in a normally-fixed horizontal plane. The pantograph, in this instance, is supported or hung from its inner end, on or from a normally-fixed vertical axis defined by vertical axial line 4—4, Fig. 1, on which the pantograph is swingable laterally. This axis is carried by the machine frame through rigid upright supporting column 7, rising from or constituting a part of said frame. The pantograph, in this example, includes the links 3, 4, 5, and 6, united at their intersections by four, in this instance, pivotal connections, whereby the links are swingable on four vertical axes, all parallel with the main axis from which the pantograph is bodily swingable laterally. The pantograph, is preferably adjustable by any suitable provision and settable after adjustment, as is common in the art, or otherwise, to any reproducing ratio within the capacity of the machine or particular pantograph.

In the example shown, without desiring to so limit the invention, the pantograph supporting axis 4—4, is located at the inner end of the pantograph; namely, at the inner end of the main supporting link 3, while at the outer end of the pantograph; namely, at the free end of what is normally the tracer or operating link 6, is located a vertical member parallel with axis 4—4, and laterally movable with the pantograph, and also vertically movable in and relatively thereto. The outer or free end of pantograph link 6, is provided with a vertical bore in which such member is held against objectionable relative lateral movement, while slidable vertically therein, and capable of being released and removed therefrom. For instance, in this example, the free end of pantograph link 6, provides a pair of laterally projecting eyes or lugs 6a, rigid therewith, and widely spaced vertically, and each formed with a vertical bore alined vertically with the bore of the other lug. Where the machine is to be normally employed on what is usually reduced reproduction work, a vertically elongated stylus or tracer spindle 20, is removably arranged and vertically slidable in said eyes while held thereby against relative lateral movement, with the longitudinal axis of the spindle parallel with the pantograph supporting axis. The depending end of spindle 20, is usually provided with handle 20b, and with a chuck or collet 20c, to replace-

ably hold a depending alined stylus or tracer tool or bit **20***d*, Fig. 3.

Where the machine, is to be otherwise employed, as for instance, where enlarging reproducing work is to be performed, the member **20**, is removed, and another member or unit is substituted therefor, that carries an auxiliary rotary cutter spindle for operation on work clamped on the pattern table. This auxiliary unit is relatively vertically movable in the eyes **6***a*, and is held thereby in the pantograph against relative lateral movement. This cutter-spindle-carrying auxiliary unit or member, is more fully described hereinafter.

Whether the tracer member **20**, or the substitute auxiliary cutter spindle member, is operatively located in the pantograph eyes **6***a*, such member moves laterally with the pantograph during lateral dimensional operations, and is relatively movable vertically during depth dimensional operations.

The machine is provided with a cutter head **15**, the lateral dimensional movements of which are controlled by the pantograph, and in the example illustrated, this cutter head is located between the pantograph axis **4—4**, and the vertically movable member in the pantograph eyes **6***a*, and is carried by and included in the pantograph, as a permanent part thereof, although I do not wish to so limit all features of my invention. This cutter head is provided with a vertical quill or barrel **15***a*, longitudinally slidable in the head, and carrying the vertical cutter spindle **15***b*, rotatable in said barrel and carried thereby against relative endwise and lateral movements. The depending end of the cutter spindle is provided with a chuck or collet to removably hold the normal rotary cutter, or a stylus or tracer bit **15***d*, as a substitute therefor, while the cutter spindle driving pulley **15***e*, is shown in the upper portion of the cutter head, for actuation by the machine belt drive.

During depth dimensional operations, the cutter spindle and its barrel as a unit, is vertically floatable in the cutter head and such unit is constantly spring pressed upwardly, as disclosed and described in my said pending patent applications. The cutter head is usually provided with feed and adjustable stop mechanisms for the cutter spindle-barrel unit, as is common in the art.

If so desired, this permanent cutter head **15**, can form a portion of the vertical axis pivotal connection between the front ends of pantograph links **4**, **5**, with said vertical axis alined with the longitudinal axis of the cutter spindle **15***b*.

The longitudinally slidable vertical member in the pantograph eyes **6***a*, is operatively coupled to the longitudinally movable rotary cutter spindle **15***b*, of the cutter head, for depth dimensional operation, by the depth scaling lever **8**, at its fulcrumed portion, directly connected to a support, such as the machine frame, by a hereinafter described swivel connection providing a vertical axis substantially in alinement with the pantograph supporting axis, on which the lever is swingable laterally with the pantograph, and also providing a transverse axis, substantially perpendicular to and intersecting said vertical axis, on which said lever is relatively swingable vertically.

In this example, this lever **8**, is a stiff strong unit or bar having straight parallel longitudinal edges throughout the major portion of its length. One end of this lever **8**, is removably and pivotally joined to the upper end of the longitudinally slidable vertical member in the pantograph eyes **6***a*, by a transverse pivot **8***a*, against lost motion so that longitudinal movement of said member will accurately and correspondingly move said lever up or down, and so that up or down movement of the lever will correspondingly impel the member longitudinally.

The normal cutter spindle **15***b*, and the lever **8**, are also accurately coupled together, at a point intersected by the longitudinal axial line of the cutter spindle, against relative vertical movements, and to accurately move vertically together, whichever one impels the other. For instance, in the example illustrated, an upwardly extending rigid bracket **17**, movable vertically with the cutter spindle barrel **15***a*, is provided with upper and lower parallel rollers **18**, journalled thereto on vertically-spaced transverse axes **18***a*, and fitting the upper and lower longitudinal parallel straight edges, respectively, of lever **8**, against objectionable relative vertical movements between the lever and said rollers. The axes of these rollers are preferably located in the vertical plane that includes the longitudinal axis of the cutter spindle **15***b*. The lever **8**, is free to travel endwise on said rollers **18**, or said rollers are free to travel longitudinally of and along said lever, depending on the lever mounting and the operative connection between the lever and the tracer or its substitute member.

In the example shown, where the longitudinally movable member slidable in the pantograph eyes **6***a*, is directly pivoted to the otherwise free end of lever **8**, against relative movements longitudinally of said lever, said lever **8**, is endwise or longitudinally movable with respect to the transverse axis on which said lever is swingable vertically, and through the bracket carrying rollers **18**, under movements of the pantograph that carry said vertical members slidable in eyes **6***a*, in lateral directions toward or from the vertical pantograph supporting axis. Thus, the scaled relationship or reproduction ratio between the vertical axis of the said member slidable in eyes **6***a*, the vertical axis of cutter spindle **15***b*, the vertical supporting axis of the pantograph, and the transverse axis on which lever **8**, is vertically swingable, is maintained substantially the same, for both lateral and depth dimensional operations. This same relationship can be maintained, within certain features of my invention, where the lever **8**, is so mounted as not to be endwise or longitudinally movable with respect to the transverse axis on which it is swingable vertically, by providing an operative connection between a straight free end portion of lever **8**, and the upper end of the vertical member slidable in pantograph eyes **6***a*, on the order of the operative slide connection **17**, **18**, between cutter spindle **15***b*, and lever **8**, to permit lateral movements of said member and said cutter spindle toward and from the pantograph vertical axis, longitudinally and relatively of the lever **8**. In this last mentioned arrangement the upper end of said member vertically slidable in the pantograph eyes **6***a*, will be pivotally joined to the slider on lever **8**, against lost motion, by the transverse pivot **8***a*, as said member is confined to straight line vertical movement by the pantograph eyes **6***a*, while the lever **8**, in this suggested arrangement is held against endwise movement when swinging vertically, although such suggested arrangement does not possess the advantages and accuracy of the gen-

eral arrangement disclosed providing for endwise movement of lever 8.

In the particular example shown, when the non-rotary elongated vertically sliding member in the pantograph eyes 6a, consists of the tracer spindle 20, Fig. 2, having a tracer tool or bit in the chuck or collet with which the handled depending end of said spindle is equipped, and when the chuck or collet of the driven rotary cutter spindle 15b, carries an appropriate cutter, the machine is adapted for reduced reproduction, in the work on the normal work table, of the pattern on the normal pattern table. In this arrangement, Fig. 3, the tracer spindle 20, is freely slidable longitudinally through pantograph eyes 6a, and is longitudinally removable downwardly therefrom when released from lever 8. The two spring abutment clamps 20i, 22, and intermediate coiled spring 23, are loose on spindle 20, when said clamps are expanded and the spindle can then slide freely therefrom. The clamp 24, fixed to lower eye 6a, is normally expanded during depth dimensional operation and the spindle is freely slidable therethrough. The clamps 20i, 22, and 24, and spring 23, are disclosed and the functions thereof are described by my hereinbefore identified patent applications.

Any suitable coupling is provided for establishing an operative transverse pivot connection between tracer spindle 20, and the lever 8, or between said spindle and a slider operatively arranged on and slidable longitudinally of the lever 8. For instance, in the example disclosed, a forked clip or coupling 21, embraces the rounded free end of lever 8, and is confined thereto against relative lost motion by a transverse pivot 8a, on which the coupling is rotatable vertically around the end of the lever, the end edge of which is preferably concentric with said transverse pivot. This coupling, as a rigid part thereof, forms a radially projecting socket 21a, open at its outer end. This socket is longitudinally split and forms a normally expanded spring clamp, provided with a clamping screw or bolt 21b, by which the clamp can be contracted for removably locking thereto, a complementary member longitudinally inserted in the socket. This socket clamp 21a, is adapted to removably receive and rigidly clamp a complementary rigid part of tracer spindle 20. For instance, I show said spindle provided with such complementary part, in the form of central longitudinal rigid stud or tenon 20a, forming the upper end of said spindle, adapted to be longitudinally inserted in and removed from socket 21a, and to be fixedly clamped thereby to said swingable coupling 21.

The spindle 20, is preferably of uniform exterior cross sectional dimensions through its length from its lower portion to the upwardly facing annular shoulder surrounding the base of tenon 20a, to permit downward longitudinal removal of the spindle from socket 21a, (when expanded), and eyes 6a, and the annular clamps and coiled spring, or application through said parts for securing by socket clamp 21.

Where the machine is to be employed for enlarging reproduction work, or otherwise, I utilize the normal or permanent cutter spindle as the tracer or tracer spindle without otherwise disturbing the same, and substitute for the normal tracer spindle 20, a novel unit that includes an auxiliary driven work cutter, as generally disclosed by Figs. 1 and 2.

This unit includes a rotary cutter spindle and its mountings carrying said spindle. This elongated rotary cutter spindle 30, at its upper end is provided with a concentric driving member, such as belt pulley 30a, and at its lower end is provided with a suitable chuck or collet 30b, for replaceably clamping a suitable rotary work cutter 30c. The mountings for this spindle include the straight elongated tubular quill or barrel 31, rigid with its upper end head or box 31a, housing the upper end and radial thrust bearings 31b, for the rotary spindle 30, and the lower removable end head or box 31c, normally rigid with said barrel, and housing the lower radial and end thrust bearings 31d, for spindle 30. This lower head 31c, of the barrel 31, is also preferably provided with the exterior accessible handle or handles 31e, by which said unit can be manipulated and controlled when operatively applied to the pantograph.

The removable lower end head 31c, of the barrel, preferably forms a vertical open-end split spring clamp socket 31f, adapted to removably receive the lower end of barrel 31, and be rigidly contracted thereon by the clamping bolt or screw of said socket. When the unit is to be applied to or removed from the pantograph, the clamping bolt of said socket 31f, is operated to permit expansion of the socket and removal of said head from the barrel. To permit this removal of the head without disturbing the lower spindle bearings, the spindle 30, includes a short alined end section 30e, mounted in said end head 31c, and operatively united to the main length of spindle 30, by a longitudinally separable coupling 30d. Thus, when head 31c, is removed from the barrel, spindle section 30e, slips down out of operative engagement with spindle 30, and remains in its bearings in the head. When the head 31c, is again applied to the barrel 31, the lower end of spindle 30, slips into operative rotary driving connection with shaft section 30e.

The fixed upper end head 31a, of barrel 31, provides a rigid laterally-offset and upwardly extending arm 31g, provided at its upper end with a rigid laterally projecting stud or tenon 31h, arranged horizontally above the spindle driving pulley 30a. This rigid stud 31h, is complementary to and adapted to operatively enter and be rigidly clamped by the socket 21a, of the coupling 21, mounted on lever 8, to relatively swing on transverse axis 8a. This projecting stud 31h, corresponds to the rigid stud 20a, of the tracer spindle 20. However, with this auxiliary cutter spindle, the stud 31h, is arranged horizontally longitudinally of and toward lever 8, requiring the socket 21, to project outwardly longitudinally of the lever to bring the transverse axis 8a, substantially into the vertical plane in which the axis of cutter spindle 30, is located, when said unit is operatively connected to lever 8, and arranged in the pantograph.

The barrel 31, of this auxiliary cutter unit is freely slidable longitudinally in the pantograph eyes 6a, and is held thereby to straight line vertical movement, the same as tracer spindle 20. The barrel 31, is longitudinally removable upwardly from said eyes 6a, and applicable downwardly thereto, when the lower head 31c, has been removed, the clamps and coiled spring hereinbefore described, being then loose on the barrel. The upper end of the unit including stud 31h, can be easily assembled with and separated from the coupling 21, of the lever 8, because the lever, in this example, is freely endwise movable.

When the auxiliary cutter spindle unit is operatively but removably assembled in the machine, Fig. 1, the belt drive is temporarily detached from the regular or normal cutter spindle driving pulley, and operatively and removably applied to auxiliary driving pulley 30*a*, and the well known tension rod of the regular belt drive, can be temporarily detached from the cutter head, and elongated and removably applied to the upper head 31*a*, of said unit as indicated at 31*i*.

The normally-fixed vertical supporting axis for the pantograph 3, 4, 5, and 6, is established by an advantageous arrangement, that includes locating the inner end of the main supporting link 3, of the pantograph, between upper and lower strong lugs 9, 10, rigid with and projecting laterally from the machine frame column 7, and providing said end of link 3, with strong rigid alined vertical trunnions 11, rigid therewith, one projecting upwardly and the other projecting downwardly, from said link end. The depending trunnion 11, is suitably rotatably mounted in or to the lower lug 10, against objectionable lateral play and sagging, and the upper trunnion 11, is rotatably mounted in or to the upper lug 9, against such objectionable play. An end and lateral thrust ball or roller bearing 12, is preferably provided for the lower trunnion, and seated down in lug 10. An end and lateral thrust ball or roller bearing 13, is also preferably provided for the upper trunnion 11.

The pivotal mounting between upper trunnion 11, and lug 9, is established through the medium of a vertically adjustable and longitudinally removable block 14, extending longitudinally through the vertical bore of an annular split clamp 9*a*, formed by the lug 9, with bearing 13, seated in the lower end of said block. This block is normally held rigidly by this clamp, but on loosening the clamping bolt of the clamp, the block can be relatively adjusted vertically, or longitudinally removed from the clamp, during assembly or disassembly, or for adjustment after assembly to take up lost motion or otherwise.

The specific swivel coupling shown, by which the lever 8, is directly connected to the main frame to swing laterally and rock vertically on the hereinbefore defined and located axes, includes a vertical post or shaft 23, horizontally rotatable on a vertical axis alined with the vertical supporting axis of the pantograph. This post or shaft is formed with a diametrical slot or opening extending transversely therethrough for the free endwise passage and vertical swing of the depth scaling lever 8, and for the reception of means confining said lever to a vertical plane substantially including the vertical axial line of the axes of the pantograph and post. This post is usually of yoke or forked form in that it provides laterally spaced longitudinal side walls or arms. This post or yoke will function if strongly journaled and supported from one end only for rotary movements on said vertical axial line. However, for purposes of strength and maintained accuracy, I prefer to journal and support such yoke at both ends.

Hence, this yoke 23, is provided with longitudinally-projecting central upper and lower strong rigid alined trunnions 23*a*, substantially alined with the axial line of said pantograph supporting axis. The lower or depending trunnion 23*a*, is mounted in and upheld and centered by radial and end thrust bearings 23*b*, seated down in the upper end of the hereinbefore described block 14, that is normally rigidly held in the split clamp of frame lug 9. The upwardly projecting top trunnion 23*a*, is mounted in and held centered by the radial and end thrust bearings 23*c*, seated up in the lower end of the longitudinally adjustable and removable vertical top block 14*a*, longitudinally alined with lower block 14, and extending through and normally clamped rigidly in a top lug 9*c*, rigid with and projecting laterally from the frame column 7. This lug 9*c*, is preferably cut to form a split spring clamp having a screw or bolt for holding the same contracted to clamp said block, or to permit the clamp to expand for permitting longitudinal adjustment or removal or application of the block.

A transverse axis-defining and confining mounting for lever 8, is arranged within and carried by the post or yoke 23. This mounting includes a lever holding sleeve-like member or bracket 24, mounted to said yoke by and rotatable or oscillatory vertically with the lever 8, on a transverse axis 25, substantially intersecting and perpendicular to the vertical common axial line of the pantograph axis and the axis of the yoke or post 23. In the particular example disclosed, this bracket embodies vertical rigidly connected side walls with a slot or opening extending completely through the bracket between said side walls and intermediate the top and bottom of the bracket, for the passage of the lever 8.

This bracket provides upwardly and downwardly extending vertical guide surfaces or flanges 24*a*, lapping opposite side faces of the lever 8, to hold the lever against lateral deflection from its desired central position. This bracket also provides upper and lower cross guiding and confining members or elements bearing, respectively, on top and bottom longitudinal edges of the lever 8, to hold said lever against relative vertical displacement from its intended position, and to require the bracket to rock vertically with the lever on the transverse axis 25. For instance, in this particular example, these cross guiding members are provided by a cross roller 26, mounted in said bracket 24, concentric with and to rotate around the transverse axis 25, with its circumferential tread bearing against a longitudinal edge of lever 8; and a pair of parallel cross rotary rollers 26*a*, 26*a*, spaced apart longitudinally of lever 8, with their circumferential treads both bearing on the longitudinal edge of lever 8, opposite to that engaged by the roller 26. The roller 26, is in this instance located in a vertical plane midway between the two rollers 26*a*, 26*a*, which two rollers hold the lever to the roller 26, and against relative vertical movements in the bracket. The two rollers are mounted in the bracket by transverse axes 26*b*, as shown, one of which is preferably provided with an axial spindle having an eccentric portion by which the roller mounted thereon can be slightly raised or lowered to take up undesirable lost motion of the lever between the opposing edge rollers. This eccentric spindle is normally locked against rotation by a set screw which can be released to permit rotative adjustment of the spindle. This adjustment for rollers, is a common expedient.

In the specific example illustrated, the roller supports 26, 26*a*, mounted in oscillatory or rotatable bracket 24, permit free endwise movements of the lever 8, through said bracket, while holding the lever against relative vertical movement in the bracket. If necessary for any required situation, the lever if wedged in or fixed to the bracket 24, will still be swingable vertically on the transverse axis 25.

In this particular example, the cross spindle **25**, fixed in the opposite side walls of bracket **24**, with which roller **26** is concentric and around which it rotates, is formed at its opposite end faces with centered alined conical sockets **25***a*, receiving and centering the alined pointed conical extremities of opposite alined trunnion forming screws or pins **23***e*, normally fixed in and extending through the opposite side walls of yoke or post **23**.

To attain at least theoretically mathematical accuracy in depth dimensional reproduction work where comparatively large work is required with comparatively heavy depth cutting, the bracket **24**, is preferably arranged with the roller **26**, contacting the lower edge of the lever **8**, with the axis **25**, thus constituting the transverse axis on which lever **8**, swings vertically, with this transverse axis **25**, in a straight line or common plane with the transverse axis **18***a*, of lower roller **18**, of the operative connection between lever **8**, and the upwardly spring pressed vertically movable spindle **15***b*, and with the transverse axis **8***a*, constituting the operative connection between lever **8**, and the vertically movable tracer member **20**, or the vertically movable cutter unit **30**.

On the other hand for small depth reproduction work requiring but slight vertical swing of lever **8**, reproduction work within allowable commerical tolerance can be produced where the roller **26**, and the transverse axis **25**, on which the lever **8**, is vertically swingable, are arranged above lever **8**. This is possible of attainment by reversing the position of the yoke or post **23**, in its mounting in blocks **14**, **14***a*, i. e., by assembling the yoke **23**, upside down from the position shown in the drawings, with the present upper trunnion **23***a*, in the bearings **23***b*, in block **14**, and the present lower trunnion in the bearings in upper block **14***a*.

The supporting mountings for the pantograph and the swivel coupling for lever **8**, hereinbefore explained, attain and maintain accuracy, sturdiness, ease and accuracy in assembly and disassembly, and ease and accuracy of adjustment. The end of pantograph arm **3**, carrying trunnions **11**, can be easily inserted laterally between lugs **9**, **10**, and then dropped to its seat in lug **10**. The bearing block **14**, can then be inserted in lug **9**, to properly center upper trunnion **11** and the ball bearings therefor in the lower end of said block. The block **14**, can then be clamped rigidly in lug **9**, when lost motion is taken up. The swivel mounting for the lever **8**, can then be inserted between lugs **9**, **9***c*, and the lower trunnion **23***a*, of vertical yoke **23**, properly seated and centered with its bearings **23***b*, in the socket in the upper end of block **14**. The upper block **14***a*, can then be inserted through upper lug **9***c*, and the upper trunnion **23***c*, and its bearings properly centered by and in the socket in the lower end of said block **14***a*, which can then be clamped rigidly in lug **9***c*, after longitudinal adjustment to take up lost motion. The parts can be as easily disassembled. By loosening either block **14**, or **14***a*, or both, adjustments and tightening can be easily made.

For lateral length and width dimensional enlarging reproduction work, when the normal cutter spindle carries a tracer, and the longitudinally removable and applicable auxiliary cutter unit is operatively arranged in the pantograph eyes **6***a*, the lever **8**, can be withdrawn endwise from the machine, after releasing its coupling clamp from the upper end of said unit, thus leaving said unit operatively arranged in and carried by the pantograph, as in Fig. 1, for lateral dimensional operation on the work secured to the normal pattern table under the lateral dimensional ratio control of the tracer carried by the normal cutter spindle.

This case discloses certain structures common to and disclosed by one or the other or both of my hereinbefore identified U. S. patent applications Serial Nos. 693,175 and 33,611, and here this application is in part a continuation of said pending applications and takes the dates thereof, respectively, as to such disclosures appearing therein, respectively, and common to this case.

What I claim is:

1. In a machine for producing work in enlarged scaled reproduction of a pattern, in combination, a frame; a pantograph swingable in a normally fixed horizontal plane on a vertical axis carried by said frame, the normal tracer arm of said pantograph provided with a vertical confining guideway the longitudinal axis of which is parallel with said pantograph axis; a normally permanent cutter head included in the pantograph and provided with a vertical cutter spindle adapted to be operatively provided with either a cutter or a tracer; and an auxiliary cutter unit longitudinally removable from and applicable to said guideway and normally held thereby against relative lateral movement, and including a vertical rotary cutter spindle provided with a concentric driving member, and a mounting for said spindle that includes a longitudinal barrel slidable in said guideway and provided with end heads, and a handle, one of said end heads being removable.

2. A three dimensional machine for producing work in enlarged scaled reproduction of a pattern, including a frame; a pantograph swingable laterally on a normally fixed vertical main axis; a pair of vertical members arranged in said pantograph in enlarging reproduction ratio relationship to each other and said axis and relatively longitudinally movable for depth dimensional operations, one of said members providing the normal cutter sprindle adapted to removably and operatively receive a pattern tracer pin, and the other of said members providing the rotary driven cutter, the normal tracer link of said pantograph providing fixed alined vertically spaced eyes, one of said members being longitudinally removable from and applicable to said eyes and held thereby to free straight-line longitudinal movements therein; a lever swingable laterally with said pantograph and relatively swingable vertically and operatively associated with both of said members to control the longitudinal movements of one of said members by the longitudinal movements of the other of said members; and a coupling between said lever and said member in said eyes, holding said lever and said last named member against relative vertical movements, said coupling including a transverse pivotal connection, and a detachable connection for release of said last mentioned member, to permit longitudinal withdrawal thereof from said eyes.

3. In a three dimensional machine for producing work in enlarged scaled reproduction of a pattern, having a vertically movable tracer and a vertically movable cutter controlled in its vertical movements by the vertical movements of said tracer for enlarged scaled reproduction work; in combination; a frame; a pantograph hung to swing laterally in a normally fixed horizontal plane, said pantograph provided with a cutter

head, a vertical rotary cutter spindle and its barrel freely longitudinally movable in said head and held thereby to straight line vertical movements in depth dimensional operations and adapted to operatively and removably receive a tracer pin, the normal tracer link of said pantograph provided with a vertical bore; a removable longitudinally elongated vertical member in and depending from said bore and held thereby to free relative straight-line longitudinal movements in depth dimensional operations and providing a rotary driven spindle for a rotary cutter for operating on the work, said member provided with a projecting stud or tenon; a lever coupled to said frame to swing laterally with the pantograph and to relatively swing vertically, said lever being operatively associated with said cutter spindle against relative vertical movements and to move vertically therewith; and means joining said lever and said member against relative vertical movements and to move vertically together, said means including a transverse pivotal axis for relative angular movements of the lever, and a clamp for normally locking said member to said lever through the medium of said tenon, and for releasing said tenon to permit longitudinal removal of said member from said pantograph.

4. In a three dimensional reproducing machine for scaled enlarged reproduction work; a pantograph swingable laterally, and provided with and carrying a vertical rotary spindle adapted to operatively receive either a cutter or a tracer, and held by said pantograph to straight-line relative longitudinal movements during depth dimensional operations; the normal tracer arm of said pantograph provided with a vertical bore; an elongated vertical longitudinally-removable member located in said bore for relative straight-line longitudinal sliding movements therein during depth dimensional operations under the control of the vertical movements of said spindle, and provided with a cutter for operation on the work, said member provided with a rigid tenon; a lever swingable laterally with said pantograph and relatively swingable vertically and operatively associated with said spindle under the control thereof and to move vertically therewith; and a coupling joining said lever and said member to move vertically together, said coupling including a transverse pivotal axis joining the same to said lever and a clamp socket normally rigidly holding said tenon, and adapted to release the same for endwise removal of said member from said pantograph and lever.

5. A three dimensional reproducing machine having a horizontally swingable pantograph provided with a vertical normal cutter spindle relatively movable longitudinally in a straight-line, and having a collet to replaceably receive a cutter or a tracer; the normal tracer link of said pantograph provided with a vertical slideway; a longitudinally elongated unit removaby confined to said slideway for relative straight line longitudinal sliding movements, said unit embodying a longitudinal rotary auxiliary cutter spindle and its barrel, and mountings, said barrel provided with a projecting part; a lever operatively associated with the pantograph and said spindle and unit to control the vertical movements of the unit by the vertical movements of said normal spindle; and a coupling confined to said lever for relative oscillatory lever movements on a transverse axis, and including releasable means for normally rigidly securing said barrel part and said coupling together.

6. An auxiliary rotary cutter unit for enlarging reproduction work, adapted to be substituted for the normal removable vertical tracer spindle of a three dimensional reproducing pantograph machine having the normal vertical rotary cutter spindle with a collet to receive either a cutter or a tracer, and the vertical removable normal tracer spindle relatively longitudinally movable in the laterally swingable pantograph and operatively associated with a lever swingable laterally with the pantograph and relatively swingable vertically to control the vertical movements of the cutter spindle by the vertical movements of the tracer spindle, the lever having a coupling secured thereto by a transverse pivot and means for removably securing said normal tracer spindle; said unit consisting of an auxiliary rotary cutter spindle and its driving member and an elongated barrel for said spindle with end boxes providing the bearings for the spindle, the lower box being removable and the upper box having a rigid tenon adapted to be removably secured to said coupling by said means.

7. In a three dimensional machine for the production of enlarged reproductions, having a laterally swingable pantograph, the normal tracer link of which is provided with a vertical slideway; a vertical normal rotary cutter spindle at its free end with a collet adapted to replaceably receive either a cutter or a tracer, said spindle carried by said pantograph and relatively longitudinally movable; a removable vertical auxiliary cutter unit confined by said slideway and relatively longitudinally movable therein; a vertically swingable lever operatively associated with said pantograph and said spindle and unit to control the vertical movements of said unit by the vertical movements of said spindle; and an operative connection removably securing said unit to said lever, including a coupling confined to the lever by a transverse pivotal axis and a clamp for normally holding the unit rigidly united to the coupling.

8. In a three dimensional pantograph machine for the enlarged reproduction of a pattern, having a laterally swingable pantograph, the normal tracer link of which is provided with a vertical slideway; a vertical normal rotary cutter spindle with a collet adapted to replaceably receive either a cutter or a tracer, said spindle carried by said pantograph and relatively longitudinally movable; a removable vertical auxiliary cutter unit confined by said slideway and relatively longitudinally movable therein during its enlarging reproduction operation on the work; a vertically swingable lever operatively associated with said pantograph and said spindle and unit to control the vertical movements of said unit by the vertical movements of said spindle as the tracer traces the pattern; said unit embodying a longitudinally elongated barrel longitudinally slidable in said slideway and having a rigid head above the slideway and an offset arm provided with an elevated laterally projected stud, and a bottom head below the slideway and removably secured to the barrel, and a rotary spindle longitudinally extending through said barrel and heads and mounted therein with a driving member above the upper head and a cutter holding collet below said bottom head; and a clamp socket swingably joined to said lever by a transverse axis, and removably securing said unit to said lever against relative vertical movements through the medium of said stud.

9. In a three dimensional reproducing panto-

graph machine, in combination, a laterally swingable pantograph provided with a vertical rotary cutter spindle relatively freely movable longitudinally and adapted to replaceably receive either a cutter or a tracer; a vertical auxiliary cutter unit carried by said pantograph and relatively freely longitudinally movable therein under the control of said spindle and its tracer for enlarging reproduction work, and removable therefrom; a lever swingable laterally with the pantograph substantially on a common vertical axial line, and also relatively swingable vertically on a transverse axis substantially intersecting said axial line, said lever operatively associated with the cutter spindle and the auxiliary unit to control the vertical movements of the unit by the vertical movements of the spindle for enlarging reproduction work; said unit embodying a vertical barrel provided with a rigid top arm having a laterally projecting rigid stud, and a rotary spindle longitudinally arranged in said barrel and mounted thereto and provided with a depending means to hold the cutter, and with a rotary driving member; and a coupling vertically swingable around the lever end on a transverse axis, provided with clamping means for removably securing the coupling to the unit through the medium of said stud, said transverse axis being intersected by the vertical axial line of said spindle mounted in the barrel.

10. In a three dimensional reproducing pantograph machine, in combination, a pantograph swingable laterally on a normally fixed vertical axis and provided with a relatively longitudinally movable cutter spindle, and with a relatively longitudinally movable tracer; a lever operatively associated with said spindle and said tracer to control the vertical movements of one by the vertical movements of the other; and a swivel coupling between said lever and the machine frame rendering said lever laterally swingable with the pantograph on substantially the axial line of the pantograph axis and relatively swingable vertically on a transverse axis substantially intersecting said axial line, said coupling including a vertical element mounted to the frame to oscillate substantially on said vertical axis; and an upright member mounted to said element to oscillate on said transverse axis, said lever being mounted in and confined to said member to rock vertically therewith, said upright member including means whereby said lever is freely endwise movable through said member and is held to said member against relative vertical movements therein.

11. In a three dimensional reproducing pantograph machine, in combination, a pantograph swingable laterally on a normally fixed vertical axis and provided with a relatively longitudinally movable cutter spindle, and with a relatively longitudinally movable tracer; a lever operatively associated with said spindle and said tracer to control the vertical movements of one by the vertical movements of the other; and a swivel coupling between said lever and the machine frame rendering said lever laterally swingable with the pantograph on substantially the axial line of the pantograph axis and relatively swingable vertically on a transverse axis substantially intersecting said axial line, said coupling including a vertical yoke, mounted to the frame to oscillate substantially on said vertical axis, and an upright member mounted to said yoke to oscillate on said transverse axis, said member having upper and lower transverse rollers engaging the upper and lower longitudinal edges of said lever, permitting free endwise movement of the lever through the member, said member and rollers being arranged to hold the lever against lateral deflection and to confine the lever to the member against relative rocking and vertical movements.

12. In a three dimensional reproducing pantograph machine, in combination, a pantograph swingable laterally on a normally fixed vertical axis and provided with a relatively longitudinally movable cutter spindle, and with a relatively longitudinally movable tracer; a lever operatively associated with said spindle and said tracer to control the vertical movements of one by the vertical movements of the other; and a swivel coupling between said lever and the machine frame rendering said lever laterally swingable with the pantograph on substantially the axial line of the pantograph axis and relatively swingable vertically on a transverse axis substantially intersecting said axial line, said coupling embodying a vertical yoke-like member mounted in the frame at its upper and lower ends to oscillate on said axial line, and a sleeve-like member mounted in the yoke for relative vertical oscillation on said transverse axis, with the lever endwise movable therethrough and confined thereby to said yoke and against relative vertical movements and held within said member against relative rocking movements between the lever and member.

13. In a pantograph reproducing machine of the type defined, in combination, a pantograph swingable laterally from a normally fixed vertical axis and provided with a relatively vertically movable cutter spindle, and a relatively vertically movable tracer, and a lever swingable laterally with the pantograph and relatively swingable vertically and operatively coupled on parallel transverse axes with the cutter spindle and the tracer, to control the vertical movements of the cutter by the vertical movements of the tracer; and a swivel coupling connecting said lever to the frame to swing laterally substantially on the axial line of said pantograph axis, and to swing vertically on a transverse axis substantially intersecting said axial line, said coupling embodying a vertical post oscillatory substantially on said axial line, and a relatively vertically oscillatory member mounted to said post to oscillate on a transverse axis substantially in a common plane with said transverse axes between the spindle and tracer and the lever, said member having transverse portions fitting the opposite longitudinal edges of the lever to confine the lever to vertical swing with the member.

14. In a pantograph reproducing machine of the type defined, in combination, a pantograph swingable laterally from a normally fixed vertical axis and provided with a relatively vertically movable cutter spindle, and a relatively vertically movable tracer, and a lever swingable laterally with the pantograph and relatively swingable vertically and operatively coupled on parallel transverse axes with the cutter spindle and the tracer, to control the vertical movements of the cutter by the vertical movements of the tracer; and a swivel coupling connecting said lever to the frame to swing laterally substantially on the axial line of said pantograph axis, and to swing vertically on a transverse axis substantially intersecting said axial line, said coupling embodying a vertical post oscillatory substantially on said axial line, and a vertically disposed member fixed to said post by said transverse axis on which said member is relatively vertically oscillatory, said

member provided with transverse spaced rollers fitting one longitudinal edge of said lever and a transverse roller fitting the opposite longitudinal edge of said lever and approximately centrally arranged with respect to the rollers fitting the opposite longitudinal edge of the lever.

15. In a three dimensional pantograph machine, in combination, a frame providing vertically spaced lateral supporting portions; a pantograph laterally swingable in a horizontal plane from a normally fixed vertical axis, the supporting link of said pantograph being arranged between adjacent frame supporting portions and provided with alined upper and lower vertical projecting trunnions, the depending trunnion being centered and mounted for rotation in a lower frame supporting portion and the upwardly projecting trunnion being mounted to an upper frame supporting portion, said upper portion provided with a vertical bore; a vertical bearing block normally rigidly clamped in said bore and provided at its lower end with bearings receiving and centering said upwardly projecting trunnion; said pantograph provided with a relatively longitudinally movable cutter spindle, and a relatively longitudinally movable vertical tracer, and a lever controlling the longitudinal movements of the spindle by the longitudinal movements of the tracer; a coupling directly connecting said lever to the frame to swing laterally with the pantograph substantially on the axial line of the pantograph axis and to relatively swing vertically on a transverse axis substantially intersecting said line, said coupling including a vertical post horizontally oscillatory substantially on said axial line and having upper and lower alined projecting trunnions, the lower trunnion provided with bearings mounting and centering the same to the upper end of said block, and another bearing block longitudinally alined with the first named block and removable from but normally secured in a frame bore, and bearings centering and mounting the upper trunnion of said post in the lower end of said last mentioned block, said lever being confined to said post to rock vertically on said transverse axis.

16. In a reproducing pantograph machine, in combination, a frame having a vertical series of spaced laterally disposed supporting portions, at least several of said portions having vertically alined bores extending therethrough, longitudinally alined bearing blocks, extending through said bores and longitudinally removable therefrom and applicable thereto, and adjustable longitudinally therein when released, respectively, each block being normally fixed in its bore; a pantograph swingable laterally on a normally fixed vertical supporting axis longitudinally alined with said bores and blocks, the supporting link of said pantograph being rotatably mounted to and between one of said supporting portions and the adjacent end of the block in the opposing supporting portion to establish said vertical axis, said pantograph provided with a vertical cutter spindle and a vertical tracer relatively movable longitudinally; a lever operatively associated with said spindle and tracer; and a swivel coupling between said lever and said frame, rotatably mounted to and between the adjacent ends of said blocks to oscillate horizontally on a vertical axis substantially alined with said pantograph axis, whereby the pantograph and lever are swingable laterally on a substantially common axial line, said coupling establishing a transverse axis on which said lever is relatively swingable vertically.

17. In a reproducing pantograph machine, in combination, a frame; a pantograph swingable in a normally-fixed horizontal plane from a normally-fixed vertical axis carried by said frame, said pantograph provided with a vertical cutter spindle and a vertical tracer both relatively movable longitudinally; a lever swingable laterally with said pantograph substantially on the line of said axis, and relatively swingable vertically on a transverse axis substantially intersecting said line to control the longitudinal movements of the cutter by the longitudinal movements of the tracer; said frame providing vertically spaced supporting portions at least one of which has a vertical bore extending therethrough, and a longitudinally adjustable and removable bearing block normally fixedly held in said bore; and a swivel coupling connecting said lever to said frame and establishing said transverse axis, said coupling being rotatably mounted in one of said supporting portions and the adjacent end of said block to establish said vertical axial line.

18. In a reproducing pantograph machine, in combination, a frame providing a lower laterally extending portion, and a laterally projecting lug spaced upwardly from said portion and having a bore extending vertically therethrough, said lug providing means whereby said bore can be contracted and allowed to expand; a bearing block extending longitudinally through said bore and adapted to be longitudinally applied thereto and removed therefrom and adjusted therein and normally rigidly clamped therein; and a parallelogram jointed link pantograph, the main supporting arm of which is provided with longitudinally alined upper and lower projecting pintle studs, the lower stud centered and mounted in said laterally extending portion, and the upper stud mounted and centered in the lower end of said block, to provide a vertical pantograph supporting axis on which the pantograph is swingable laterally in a normally fixed horizontal plane, said pantograph provided with and including a cutter head having a vertical cutter spindle, and a vertical tracer.

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