Dec. 8, 1942. W. W. BROUGHTON 2,304,238

CUTTING APPARATUS

Filed Dec. 3, 1940 2 Sheets-Sheet 1

FIG. 2

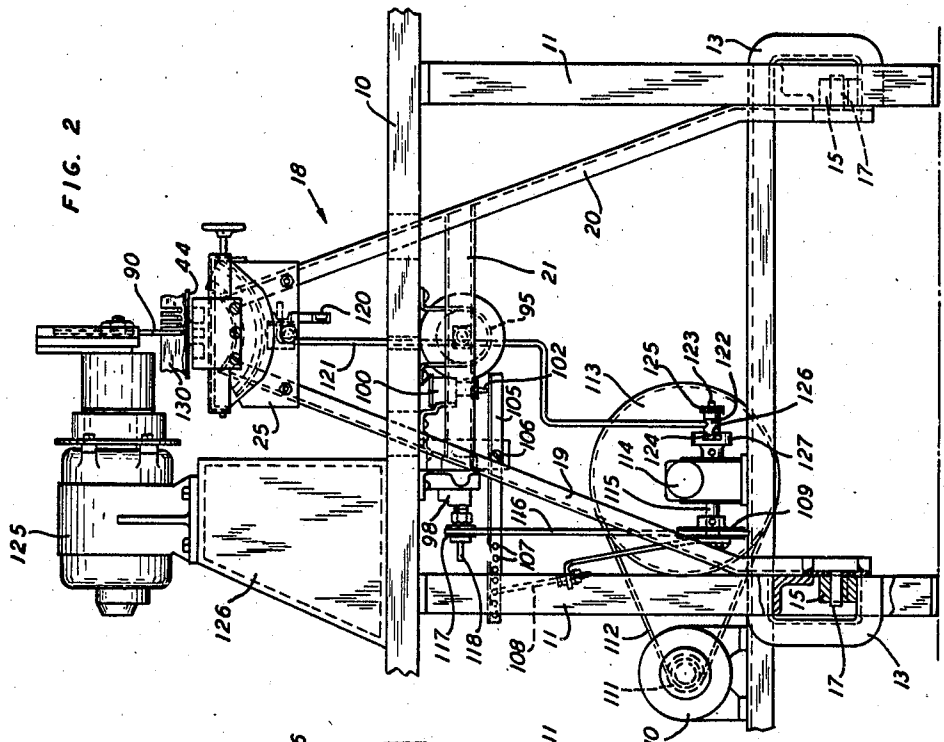

FIG. 1

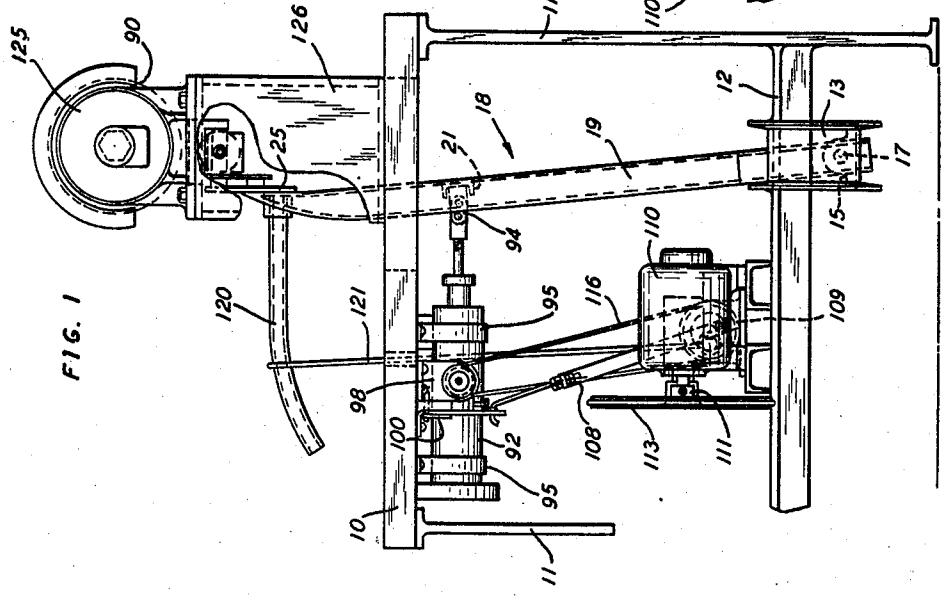

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FIG. 3

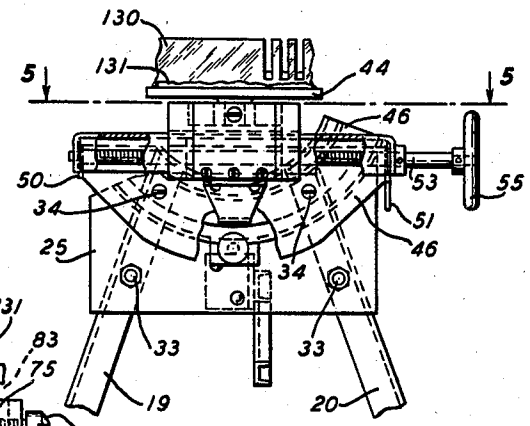


FIG. 4

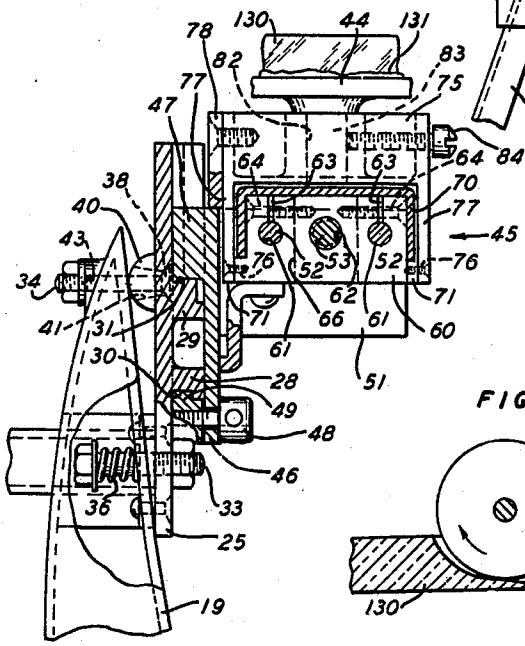


FIG. 9

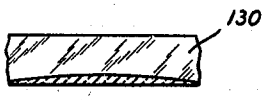


FIG. 7

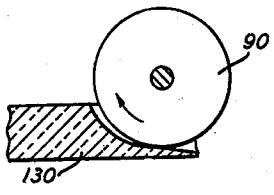


FIG. 8

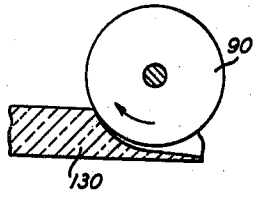


FIG. 5

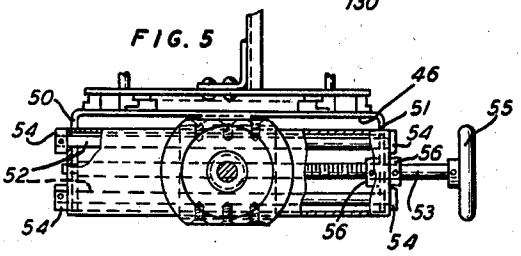
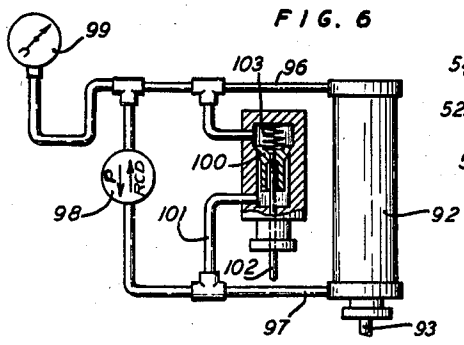


FIG. 6



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Patented Dec. 8, 1942

2,304,238

UNITED STATES PATENT OFFICE

2,304,238

CUTTING APPARATUS

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Application December 3, 1940, Serial No. 368,349

5 Claims. (Cl. 125—13)

This invention relates to cutting apparatus, and more particularly to apparatus for sawing quartz crystals.

Quartz crystal plates are used, for example, in filters in the communications art and these plates are produced from quartz crystal blanks. Due to the brittle nature, the granular structure and the natural hardness of quartz crystals, the production of plates of definite and uniform thickness therefrom is quite difficult and painstaking. The crystal plates cut from the crystal blanks must be cut with the grain of the blank and when the plates are rather thin difficulties arise in avoiding breaking of the plates before the cut is completed.

An object of the invention is to provide a cutting apparatus which is particularly adapted for efficiently and accurately cutting plates from quartz crystal blanks.

With this and other objects in view, the invention comprises a cutting apparatus including a work or quartz crystal support which, in addition to being mounted for movement into selected variable angles relative to a driven cutting element, is mounted for arcuate movement to feed the work to the element and for simultaneous oscillatory movement during the cutting operation to cause substantially tangential contact between the element and the work.

Other objects and advantages will be apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein

Fig. 1 is a side elevational view of the cutting apparatus, portions thereof being broken away;

Fig. 2 is a front elevational view of the cutting apparatus, a portion thereof being shown in section;

Fig. 3 is an enlarged fragmentary detailed view of the work support and the immediate structure associated therewith;

Fig. 4 is a fragmentary side elevational view of the structure shown in Fig. 3, portions thereof being shown in section;

Fig. 5 is a fragmentary sectional view taken along the line 5—5 of Fig. 3;

Fig. 6 is a diagrammatic illustration of the fluid means to impart one of the movements to the work support;

Fig. 7 illustrates the relative positions of the work and the cutting element at one end of one of the movements of the work support;

Fig. 8 illustrates the relative positions of the work and cutting element at the other end of the said movement of the work support, and

Fig. 9 illustrates the work at the completion of a cutting operation.

Referring now to the drawings, attention is first directed to Figs. 1 and 2, wherein a table 10 is supported by vertical leg members 11 having reenforcing cross pieces 12. Substantially U-shaped bearing supports 13 are positioned with the upper leg portions thereof resting upon the cross pieces 12 in general alignment with each other, while the lower leg portions support bearings 15. The U-shaped members are of sturdy structure, they being formed of suitable material such as channel iron and secured in place upon the cross pieces by suitable means such as welding. The bearings 15 receive stub shafts 17 which cooperate with the bearings in providing a pivotal support for a work supporting frame indicated generally at 18. The frame 18 has two main members 19 and 20 joined by an intermediate member 21 to complete a rigid structure. The members 19 and 20 are of channel structure, supporting the stub shafts 17 at the lower ends thereof, their upper ends being spaced apart as illustrated in Fig. 2 and formed as illustrated in Figs. 1 and 4.

Adjacent the upper ends of the members 19 and 20 of the frame 18 a movable support 25 (Figs. 1 to 5 inclusive) is disposed. This movable support is in the form of a flat plate having two arcuate tracks 28 and 29 secured to or formed integral therewith, the arcuate contours of the tracks having radii from a common center and each track having a groove therein. The groove for the track 28 bears reference numeral 30 and is on the under side of the track, while the groove for the track 29 bears reference numeral 31 and is on the upper or inner side of the track.

The movable support 25 is supported by the frame 18 at four spaced points represented by a pair of bolts 33 in the lower portion thereof and a pair of bolts 34 in the upper portion thereof. The bolts 33, as illustrated in Fig. 4, extend through the support 25 and through an aperture in a wall of each of the members 19 and 20 of the frame 18. The apertures through which the bolts pass are of sufficient size to permit movement of the support 25 arcuately about the ends of the bolts 34, but the support is normally held in the position shown in Fig. 4 by springs 36 positioned between the walls of their respective frame members 19 and 20 and the adjacent heads of the bolts 33. The bolts 34 are slightly different in structure from the bolts 33, in that the heads 38 thereof are of the

flat tapered type and are disposed in apertures of similar contour in the movable support 25. Semi-cylindrical members 40 are positioned between the movable support 25 and the adjacent flat surfaces of their respective frame members 19 and 20, the flat surfaces of the members 40 lying flush with the adjacent wall of the movable support while the arcuate surfaces engage and are positioned to ride upon their respective frame members. Tapered openings 41 are provided in the semi-cylindrical members which hereinafter may be termed "pivot members," these openings allowing movement of the members relative to their bolts 34. The bolts 34 extend through apertures 43 in embossed portions of the frame members 19 and 20 as illustrated in Fig. 4.

A work supporting table 44 has table supporting means, indicated generally at 45, for adjustably securing the table to the movable support 25. The table supporting means includes an element 46 formed, for example, of sheet metal with a flat upper edge and a substantially arcuate lower edge. The element 46 has an arcuate tongue portion 47 of a cross-sectional contour, as illustrated in Fig. 4, to interengage the track 29 for movement in an arcuate path on the track. Locking means in the form of a bolt 48 disposed in an aperture in the lower central portion of the arcuate element 46, has a nut 49 formed to interengage the groove 30 of the track 28, to lock the element in any desired position relative to the movable support 25. The outer ends of the element 46 are bent outwardly, as at 50 and 51 (Figs. 3 and 5), to support a pair of spaced rods 52 and an adjusting screw 53. As illustrated in Fig. 5, the rods 52 are held against displacement by collars 54 disposed on the ends thereof, while the adjusting screw is provided with a hand wheel 55 and is held against longitudinal movement relative to the rods by suitable means such as collars 56.

A cubical member 60 is apertured at 61 to receive the rods 52, and at 62 to receive the adjusting screw 53. Slots 63 are formed in the member 60 at the apertures 61 to form resilient portions so that the member 60 may be held against accidental displacement. A vertical aperture is formed in the central portion of the member 60 to receive a nut 66 which is threaded to receive the adjusting screw 53 and to cause movement of the member 60 on the rods 52 upon rotation of the adjusting screw. A cover 70, which in the present instance is formed of sheet metal, has side and end portions bent downwardly, the side portions being positioned upon each side of the member 60 and resting upon integral projections or shoulders 71 of the member while the end portions extend upon the outside surfaces of the ends 50 and 51 of the element 46 (Fig. 5) where apertures are provided for the rods 52 and the adjusting screw 53.

The member 60 supports a bracket 75 through the aid of screws 76, the latter extending through legs 77 of the bracket and into the projections 71 of the member. The legs 77 of the bracket straddle the member 60 and the cover 70 positioned thereon, so that the bracket may move freely with the member 60 through the adjusting of the screw 53. A plate 78 fixed to the bracket 75 rides on the flat upper surface of the element 46 during movement of the table 44 and the parts linking the table with the adjusting screw 53. A central aperture 82 in the bracket 75 receives a column 83 of the work supporting table 44, the column being secured in place by a set screw 84.

The work supporting table 44 may be adjusted arcuately through the adjustment of the element 46 relative to the movable support 45, to position work thereon at any desired angular position with respect to a cutting element 90 shown in Figs. 1 and 2, and the work may be moved while in the selected angular position through the adjustment of the screw 53. Two other movements, which have not as yet been described, may be imparted to the work support, one being the movement of the work support in another acuate path to feed work to the cutting element and the other being means to oscillate the table during the cutting operation to cause point contact between the cutting element and the work. The first of these moving means includes a cylinder 92 including a piston (not shown) fixed to a piston rod 93. The outer end of the piston rod 93 is adjustably connected through a link 94 to the cross member 21 of the frame 18. The cylinder 92 is supported by brackets 95 at the under side of the table 10, each end of the cylinder communicating with the fluid lines 96 and 97 of a fluid supply circuit shown in Fig. 6. The fluid lines 96 and 97 are supplied with fluid under pressure by a reversible constant delivery pump 98, a pressure gage being indicated at 99, to determine the pressure supplied to the piston in the cylinder. A relief valve 100 is disposed in a by-pass 101 between the fluid lines 96 and 97 and has a valve stem 102 extending downwardly therefrom urged in this direction by a spring 103 which normally seats the valve. Pressure against the piston in the cylinder 92 will force the frame 18 clockwise (Fig. 1) about it spivots 17. This movement is controlled, however, through a lever 105 having one end engaging the valve stem 102 and pivoted at 106 to a bracket supported by the table 10. A plurality of apertures 107 is provided in the other end of the lever 105 and to any one of these an adjustable link 108 is connected, the link 108 being oscillated through an eccentric 109 to which it is connected. The eccentric 109 is driven by a motor 110 through a pulley 111, a belt 112, a pulley 113 and reduction gears indicated generally at 114, the latter driving a shaft 115 upon which eccentric 109 is mounted. The eccentric 109 is also grooved to receive a belt 116 which, through a pulley 117, drives a shaft 118 of the pump 98 shown schematically in Fig. 6.

The means for oscillating the work support includes an arm 120 having one end fixed to the movable support 25 and operatively connected, intermediate its ends, to one end of a link 121. A bearing 122 is fixed to the other end of the link 121 and is disposed on a pin 123, the latter carried by a slide 124 and having a nut 125 on the outer threaded end thereof. The slide is slidably adjustable in a groove 126 of an eccentric 127 and held in adjusted position by the nut 125. The eccentric is mounted on the end of the shaft 115 opposite the end supporting the eccentric 109.

The cutting element 90 is circular and of the type employed in cutting stones and the like. A motor 125 mounted upon a bracket 126 on the table 10, rotates the cutting element when energized.

Upon conditioning the apparatus for operation the work is disposed upon the work support or table 44. In the present instance a quartz crystal blank 130 is disposed upon the work support and secured thereto by cement 131 (Figs. 3 and 4) or other suitable means.

Before the quartz crystal blank is mounted upon the work support, the direction of the grain in the blank is determined and the work support is then adjusted into a desired angular position so that the direction of the grain of the crystal blank will be parallel with the cutting element 90. This adjustment is made by loosening the bolt 48 and moving the element 46 arcuately in the desired direction, the tongue portion 47 riding in groove 31 of the track 29 until the support of the crystal blank has been located in the desired position. Bolt 48 is then tightened to lock the element 46 in the adjusted position.

The work support 44 may then be moved laterally relative to the cutting element to position the crystal blank for the first cutting. This movement of the work support is brought about by rotation of the adjusting screw 53 to move the cubical member 69 with its associated parts, including the bracket 75 and the work support 44, longitudinally on the spaced rods 52. When these two adjustments have been made, the adjustment of the work support to locate the crystal blank with the grain thereof parallel with the cutting element and the adjustment of the work support to position the crystal blank for the first cut, the apparatus is in condition for operation. The motor 125 is then energized and at the same time the motor 119 is energized, the first motor driving the cutting element while the second motor drives the mechanism for imparting the two movements to the work support, one to feed the crystal blank to the cutting element and the other to cause simultaneous oscillatory movement with the feeding movement to cause tangential contact between the cutting element and the work.

The two movements of the work support during the cutting operation are controlled through the eccentrics 109 and 127 which are mounted upon the common shaft 115. These eccentrics are synchronized so that, during one half of a cycle of the eccentric 127 to cause the work support 44 to be moved clockwise, the valve 100 in the by-pass 101 of the fluid control means (Fig. 6) is closed, allowing pressure from the pump 98 to move the piston in the cylinder 92 and thus move the frame 18 with the work support clockwise (Fig. 2). During the other half of the cycle of the eccentrics 109 and 127 the work support is rocked counterclockwise and during this movement the valve 100 is opened through the link 108 connecting the lever 105 with the eccentric 109. The opening of the valve 100 opens the by-pass 101 for the circulation of the fluid from the pump therethrough and equalizes the pressure on both sides of the piston in the cylinder, removing or rendering ineffective the force for moving the frame 18 and the work support relative to the cutting element 90. In cutting quartz crystals the maximum pressure which may be employed in feeding the work to the cutting element is approximately 8 pounds. Therefore, during the rocking or oscillatory movements of the work relative to the cutting element, causing a cut in the work of an arc with a radius greater than that of the cutting element, the pressure may be applied to the work during the rocking or oscillatory movement in one direction, but this pressure must be removed during the rocking or oscillatory movement of the work in the opposite direction. This may be more clearly understood by viewing Figs. 7 and 8. Considering Fig. 7, it will be noticed that the cutting element is rotating clockwise and that the work has reached the extreme point in its oscillatory movement counterclockwise, leaving a gap between the cut and the edge of the cutting element from the bottom of the cut where the work and the cutting element engage, to the top of the cut. Let it be assumed now that during the continued rotation of the cutting element clockwise, the work is moved arcuately clockwise to feed the cut surface point by point to the cutting element. During this half cycle of the arcuate movement of the work clockwise it may be said that the cutting element is cutting up-hill and into or against the direction of movement of the work. Therefore, the movement of the work is opposite that of the cutting element and during such opposed movements a certain pressure will build up between the cutting element and the work which will be sufficient for this half cycle of the cutting operation without any added force through the feeding means associated with the frame 18. If the feeding means for the frame should be rendered operative during this half cycle, that is, should the valve 100 be closed to render the pump 98 effective to apply a moving force to the frame, this force when coupled with the force created by the cutting element cutting up-hill or opposite the force or direction of movement of the work, would cause the cutting element to become heated and to break the work, thus rendering the device ineffective. The force for moving the frame with the work support and the work during this half cycle is, therefore, not needed. The back pressure built up during the clockwise opposing movements of the work relative to the cutting element is sufficient during this half cycle.

During the next half cycle of movement of the work support through the moving means coupled with the eccentric 127 to rock the work clockwise, the work would be moved away from the cutting element should the hydraulic frame moving means not be effective to apply the required pressure to keep the work in engagement with the cutting element. During this half cycle the eccentric 109 is moved to move the lever 105 through the link 108, to allow the spring 103 of the valve 100 to close the valve, rendering the pump 98 effective to force the piston in the cylinder to the right (Fig. 1) and move the frame with the work support and the work toward the cutting element. Therefore, during the last mentioned cycle of the oscillating means, the work is moved toward the cutting element through the movement of the frame 18 while the work is rocked or oscillated in a direction with the cutting element from the position shown in Fig. 8 to the position shown in Fig. 7.

Due to the brittle nature of the crystal blank the cut does not extend all the way through the blank, as illustrated in Fig. 9. This leaves an uncut portion beginning at a thin edge, increasing in thickness to the center portion of the cut and terminating in a thin edge so that the piece may be readily broken from the blank. This result is brought about through the arcuate movement of the work support with the frame 18 about its aligned pivots 17. This apparatus, therefore, provides a cutting element mounted at a position to rotate at a constant speed in one direction. Positioned near the cutting element is a work support movable arcuately to locate work mounted thereon in any desired angular position with respect to the cutting element. Through the adjusting screw 53 the work support may be moved to move the work from one cutting position to another after each cutting operation has been

completed. Another means is associated with the work support to oscillate it arcuately, moving the work arcuately with respect to the cutting element in definite cycles synchronized with means to move the frame so that during one half of each cycle wherein the work support is oscillated, the moving means for the frame is operative to apply a definite pressure of the work on the cutting element, this means being rendered inoperative during the other half of the oscillating cycle wherein the work is moved in a direction opposing that of the cutting element, rendering the cutting element effective to push the work in a direction away therefrom and build up a sufficient pressure for the cutting operation.

The embodiment of the invention herein disclosed is illustrative and may be modified and departed from in many ways without departing from the spirit and scope of the invention as pointed out in and limited solely by the appended claims.

What is claimed is:

1. In a cutting apparatus, a cutting element, means operable to oscillate work to be cut toward and away from the cutting element, and feeding means synchronized with the said oscillating means to create a force to move work toward the cutting element during one oscillatory movement of the work.

2. In a cutting apparatus, a cutting element, means operable to oscillate work to be cut toward and away from the cutting element, and feeding means synchronized with the said oscillating means to create a force to move work toward the cutting element during oscillatory movement of the work away from the cutting element.

3. In a cutting apparatus, a cutting element, means operable to oscillate work to be cut toward and away from the cutting element, feeding means synchronized with the said oscillating means to create a force to move work toward the cutting element during oscillatory movement of the work away from the cutting element, and means to render the feeding means ineffective during oscillatory movement of the work toward the cutting element.

4. In a cutting apparatus, a rotatable cutting element, a support for work to be cut, power means to move the support with the work in a path relative to the cutting element to render the element effective to cut a groove in the work, means to simultaneously therewith impart repeated transverse movements to the support and work, and means controlled by the transverse moving means to render the said power means ineffective during certain of the transverse movements of the support and work.

5. In a cutting apparatus, a rotatable cutting element, a support for work to be cut, power means to move the support with the work in a path relative to the cutting element to render the element effective to cut a groove in the work, means to simultaneously therewith impart repeated transverse movements to the support and work, and means controlled by the transverse moving means to render the said power means ineffective to move the support and work during alternate transverse movements thereof.

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