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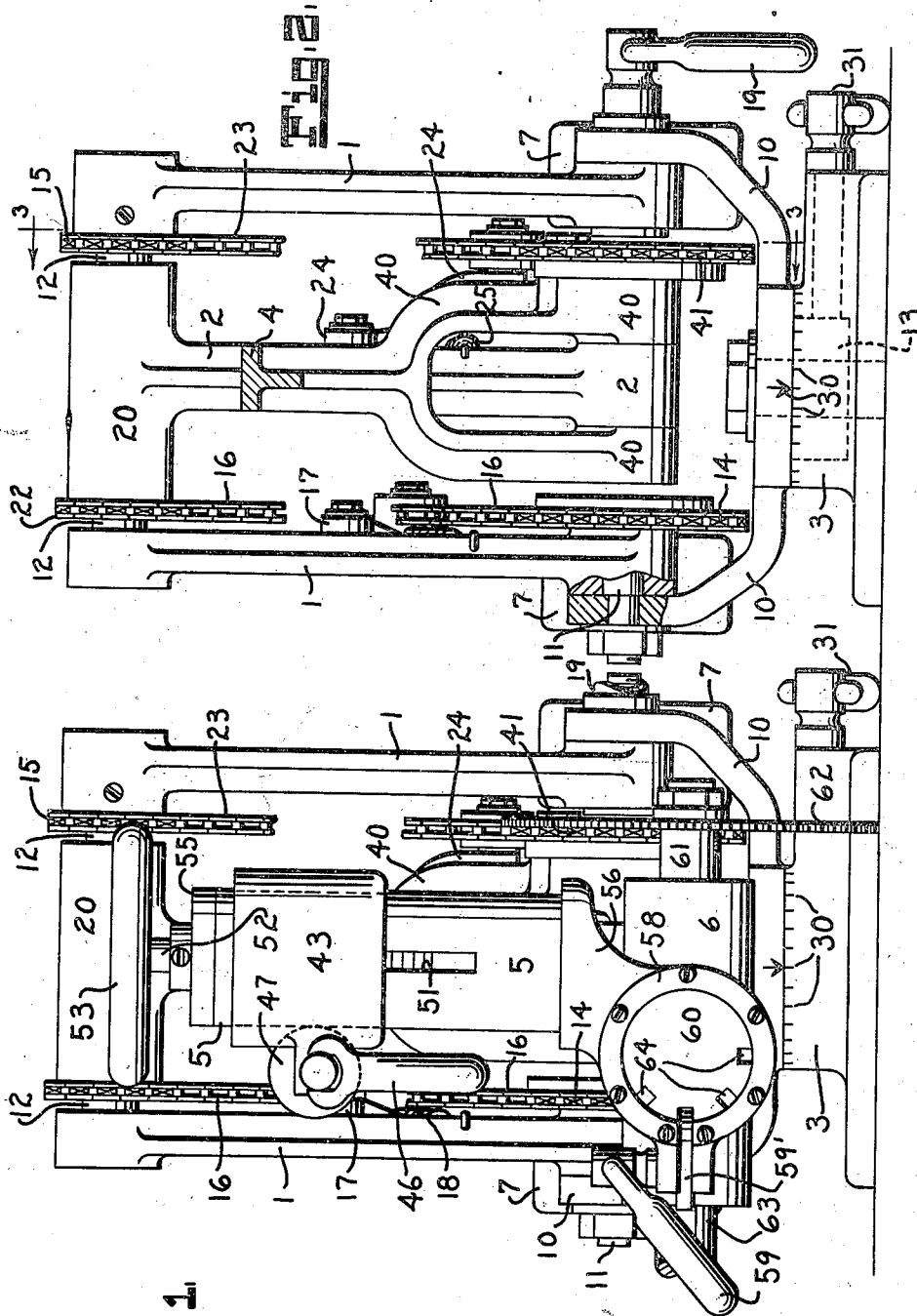
E. E. CRANE

2,389,296

TOOL SUPPORT

Filed July 7, 1941

3 Sheets-Sheet 1



Inventor

Everett E. Crane

by *Reynolds + Beach*

Attorney

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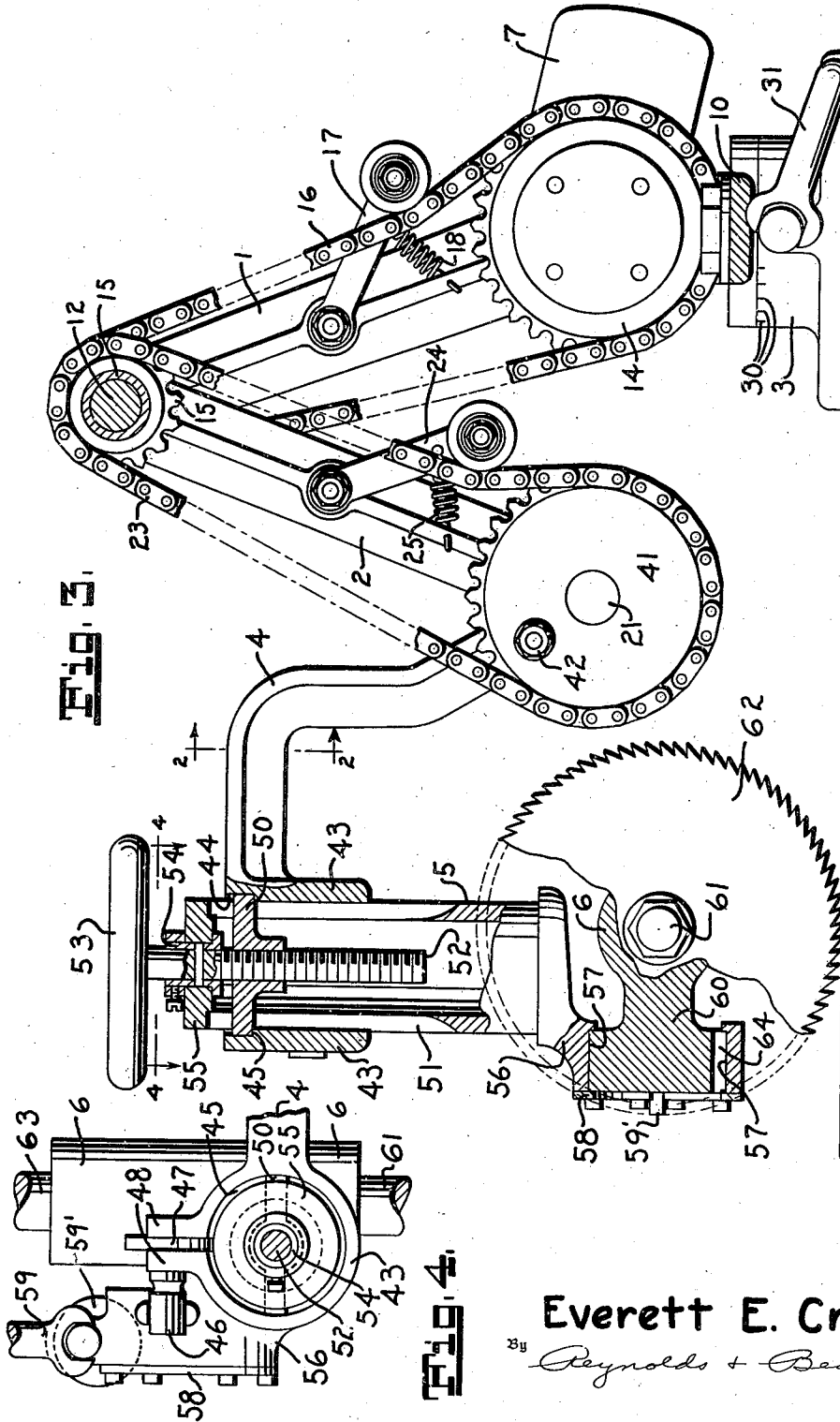
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Fig. 6.

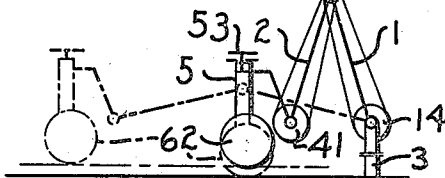


Fig. 5.

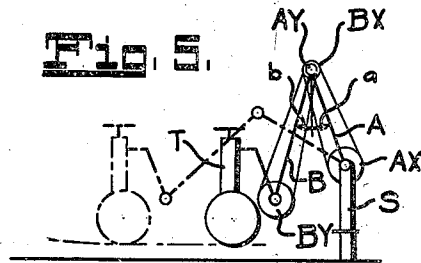


Fig. 11.

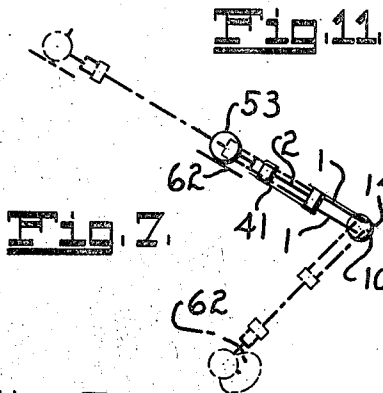


Fig. 7.

Fig. 8.

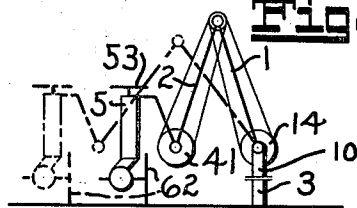
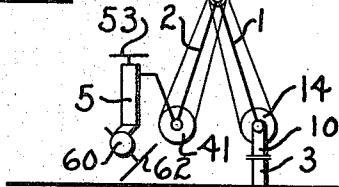
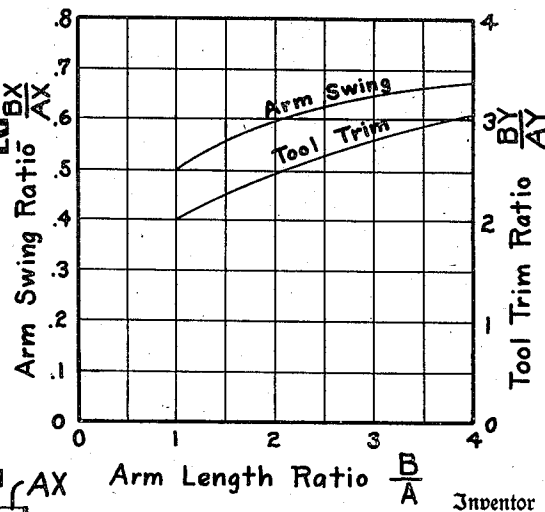
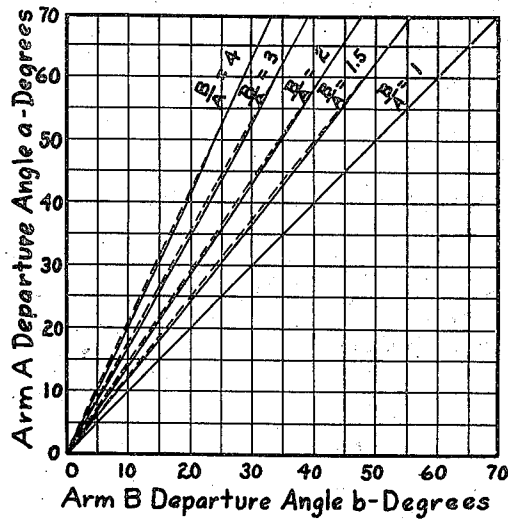
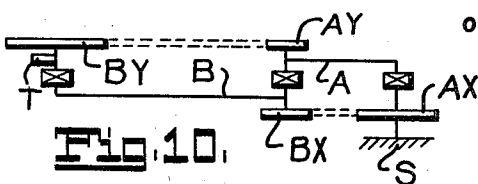


Fig. 9.



Everett E. Crane

Reynolds + Beach

Attorney

UNITED STATES PATENT OFFICE

2,389,296

TOOL SUPPORT

Everett E. Crane, Seattle, Wash.

Application July 7, 1941, Serial No. 401,350

20 Claims. (Cl. 143—46)

The mechanism of my invention will support a tool or the like for straight line motion toward and away from a reference point. The tool or other reciprocating element is carried by the free end of a dog-leg linkage supported in cantilever fashion by the other end, and the relative movement of the links is positively controlled to compel the tool to trace a linear locus.

Supports for lineally reciprocating tools and similar elements heretofore have generally employed guideways extending parallel to and over the length of path travelled. The space occupied by the work being operated upon is usually obscured to a greater or less degree by such guideways in every position of extension or retraction of the tool. With my mechanism the space over the work may be cleared entirely by retraction of the tool.

My tool support consists primarily of a dog-leg type linkage, that is, one composed of two links which are pivotally connected end to end. The other end of the inner or supporting link is pivoted to a mounting bracket, while the opposite end of the supported link carries the tool, which may be a trim saw, or any other desired element. The pivoted end of the outer or supported arm is controlled from such mounting bracket so that its angular departure from a given reference direction, such as vertical, will bear a predetermined relationship to the departure of the supporting arm from the same reference direction. To express this relationship in another way, movement of the arms is controlled and coordinated so that the angular velocity of the supporting arm bears a predetermined and substantially constant relationship to the angular velocity of the supported arm. I have found that linear movement of the free end of the supported arm may be maintained within very close limits for any given relative arm lengths, if the proper constant angular velocity ratio of the arms for such arm lengths is maintained. For a reasonable angular departure from the reference direction, provided that the difference in arm lengths of the dog-leg linkage is not too great, linear motion of the free end of the supported arm may be maintained within the limitations of the mechanism employed, such as the rigidity of the arms under load, the accuracy of pivot pin fit, and the play and strain of the arm control mechanism.

Not only can the free end of the supported link be restricted to linear motion, but the tool pivoted on such arm end may be controlled from the supporting arm so that it will always remain

in a predetermined attitude, such as vertical, with respect to the reference direction. This result is produced by regulating the angular velocities or relative angular departures from the reference direction of the supported arm and tool head, so that a constant ratio again is present. Similarly, while maintenance of an exact attitude may not quite be achieved theoretically, for all practical purposes the change of attitude is inconsequential.

The controlling mechanism for the linkage which insures maintenance of the desired ratio of angular movement may take various forms, but I have found that chain and sprocket connections are simple and effective. Correct relative arm movement for linear traverse of the linkage end may be obtained by interconnecting a sprocket fixed to the linkage support with a sprocket rigid with the pivoted end of the supported arm. The attitude of the tool may be maintained constant by interconnection of a sprocket integral with it and a second sprocket rigid with the outer end of the inner or supporting arm. In each case, of course, the sprocket ratio selected will be determined by the relative lengths of the arms constituting the linkage.

It will be evident that my linkage mechanism may be made in a wide variety of sizes and forms according to the particular use for which it is intended. Thus it may support the pen of a recording machine, in which case the structure will be very small and light, or the same principle may be utilized in a lifeboat davit, for example, requiring heavy construction. In fact, my mechanism is applicable to any use in which pivotal or rotary motion is to be transformed into linear motion. A particularly useful application is for a bench trim saw support, which has been illustrated in detail in the drawings, and is specifically described hereafter.

A primary purpose of my invention, therefore, is to support an element in cantilever fashion and guide it for linear reciprocation without work-obscuring guide mechanism, such as ways and the like. This operation I accomplish by the use of simple mechanical parts, various types of machine elements being available for accomplishing the desired controlled movement of the linkage, those selected being dictated by the purpose for which the mechanism is to be used and the preference of the individual designer.

Furthermore the accuracy of operation of my controlled linkage may be checked readily, and if not proper it may be adjusted quickly and with little difficulty.

Especially when applied to a bench trim saw or the like, it is an object to afford universal movement for the saw, so that it may be swung bodily for reciprocation along any line of cut, with the saw blade either parallel to the plane of the supporting linkage, or making an angle relative thereto such as for chamfering or bevel cutting edges. For ripping purposes, whether the saw is vertical or inclined, the tool head may be swingable with respect to the free end of the supported arm which carries the saw. Moreover the saw may be vertically adjustable with respect to the free end of the supported arm, or the entire linkage may be movable vertically, to enable the depth of cut made by the saw or other tool to be varied as desired.

The bench trim saw shown in the drawings represents a typical example of a practical embodiment of my invention, but the principles employed, by which linear movement of a tool support while maintained in a constant attitude is obtained, may be utilized in devices of widely divergent nature.

Figure 1 is a front elevation view of my invention embodied in a bench trim saw, while Figure 2 is a section through such trim saw along line 2-2 of Figure 3, showing the supporting linkage, and Figure 3 is a section through Figure 2 along line 3-3, showing portions of the linkage in side elevation. Figure 4 is a section on line 4-4 of Figure 3, of a portion of the tool unit itself.

Figure 5 is a diagrammatic view of mechanism utilizing links of different lengths, and indicating in exaggerated fashion the deviation from linear movement occasioned by a large angle of departure of the arms from vertical. Figure 6 is a diagrammatic view similar to Figure 5, in which the arms of the linkage are equal in length.

Figure 7 is a diagrammatic plan view of bench saw mechanism showing how both square and inclined angle cuts may be made. Figure 8 is a diagrammatic side elevation view of the table trim saw mechanism, set for a lengthwise or rip inclined cut. Figure 9 is a view similar to Figure 8 with the saw positioned for a vertical rip cut.

Figure 10 is a diagrammatic plan view of my dog-leg linkage in general illustrating a preferred type of interconnection of the arms and control mechanism, and showing the linkage in fully expanded condition, so that the arms appear full length.

Figure 11 is a graph indicating the relative angular departures of the linkage arms which must be maintained to produce substantially straight-line motion of the free end of the supported arm when different arm lengths are employed. Figure 12 is another graph showing the inter-relationship between the arm length ratio and the relative diameters of the arm control sprockets, one curve designating the relationship which must be maintained to secure substantially straight-line movement of the free end of the supported link, and the other curve that necessary to preserve in all extended positions of the linkage a constant attitude of the tool mounting or equivalent element.

My tool support consists principally of a dog-leg linkage, that is, one composed of a supporting link 1, having one end pivoted to a bracket 10 by pins 11, and its other end pivoted by a pin 12 to one end of a supported link 2. Without the provision of control mechanism the free end of the supported link 2 could be moved universally within a circle having a radius equal to the combined length of arms 1 and 2 when extended

in alignment, except as such movement might be prevented near the center of the circle by the relative lengths of arms 1 and 2, or by interference of the supporting base. The links 1 and 2 need not be of equal length, but if supported link 2 is longer than supporting link 1 the free end of the former could not be moved closer to the pivot 11 than the difference in length of the two arms.

Universal movement of a tool or other element has been permitted by using such a dog-leg or two-arm linkage as a support. The problem which I have solved by the present invention was to restrict movement of the free end of the linkage to substantially linear or straight-line movement. Moreover, such solution enables arms of different lengths to be employed, the supported arm 2 usually being longer than the supporting arm 1 in such installations. No control mechanism has been proposed for such linkages heretofore which would restrict movement of the free end of the supported link to linear or substantially linear motion.

While I have illustrated my invention as incorporated in a support for a bench trim saw, it is to be understood that the same operating principles are applicable to similar mechanism used as a support for any tool or element which is to have straight-line motion.

I have found that movement of such dog-leg linkage may be governed to afford substantially linear reciprocation of its free end even though the arms are of different lengths, as shown in Figure 5. The method of obtaining such motion is to control relative angular departure of the two arms from a given reference direction in the manner determined by the relative arm lengths. If the linkage is mounted for extension and collapse in a vertical plane, and horizontal traverse of its free end is desired, the reference direction will be vertical. In any case the reference direction, from which the relative angular departure of the arms is measured, will be perpendicular to the linear locus or path to be traveled by the free end of the linkage.

In Figure 5 a representative diagram of linkage having arms of unequal length is shown, while in Figure 6 the special case in which the arms are of equal length is illustrated. For purposes of general discussion the supporting arm is designated A and the arm supported thereby is indicated at B. In order to obtain straight-line motion a predetermined, constant relationship between the angular movement of arms A and B must be maintained. As indicated in Figure 5, the angular departure of arm A from vertical is the angle a , whereas the corresponding angular departure from vertical of arm B is the angle b . If the relationship of angle a to angle b is maintained a constant, properly selected according to the relative lengths of arms A and B, substantially straight-line movement of the free end of arm B will be maintained within reasonable limits of angles a and b .

In order to determine the conditions for linear movement of the free end of arm B the following equation must always be satisfied.

$$B \cos b - A \cos a = \text{a constant}$$

The limiting position of the arms will, of course, be when they are in alignment, overlapping each other, such as both vertical, in which case the angles a and b become zero. Since the above equation must be true in this special situation, as in others, the difference in arm length, or B

minus A, must be the equation constant for straight-line movement, both angles a and b in such case being zero, and their cosines equal to 1. We may thus write the equation as follows:

$$B \cos b - A \cos a = B - A$$

Transposing

$$B \cos b = A \cos a - A + B$$

or

$$\cos b = \frac{A(\cos a - 1) + B}{B}$$

$$\frac{A(\cos a - 1)}{B} + 1 = \frac{\cos a - 1}{\frac{B}{A}} + 1$$

We now have an expression in which a function of the angular departure of arm A, a , is modified by the relative lengths of the arms,

$$\frac{B}{A}$$

which arm length ratio for any given linkage is necessarily constant.

From this equation, selecting arms of equal length, we can plot the line shown in Figure 11 designated

$$\frac{B}{A} = 1$$

which is a straight line, indicating that when the arms A and B are equal in length the arms' angular departures, angles a and b , must also be equal. Plotting the lines represented by the above equation when the several arm ratios of 1.5, 2, 3, and 4 are used, we obtain the lines

$$\frac{B}{A} = 1.5, \frac{B}{A} = 2, \frac{B}{A} = 3, \text{ and } \frac{B}{A} = 4$$

respectively, of Figure 11. The broken lines drawn from 0 degrees to 60 degrees departure of arm A, namely, angle a , alongside each of the curves

$$\frac{B}{A} = 1.5, 2 \text{ and } 3$$

and from 0 degrees to 50 degrees for the curve

$$\frac{B}{A} = 4$$

are straight lines, and the distances of these lines from the solid lines plotted from the above equation for the several arm length ratios is a measure of the deviation from linear motion of the free end of the linkage throughout an angular departure of 60 degrees for arm A when the angular velocities or relative angular displacements of arms A and B are in direct proportion, that is, when a/b is of constant value.

Even for this large departure angle of 60 degrees it will be seen that the deviation from a/b being constant is extremely small, and considering possible deflection of the arms under load, looseness of the pin joints, and play and strain in the arm interconnecting mechanism, for practical purposes the motion of the free end of the linkage is linear. The deviation will, of course, be substantially decreased for smaller angles of departure of arm A, and cannot be noticed at all by a graphic comparison for values of a up to 20 degrees. Beyond this point the amount of deviation gradually increases, but it would seldom be necessary in most installations to use an angular deflection of arm A greater than 60 degrees, represented by broken lines in Figure 5, although with arms of equal length precisely

straight-line movement is preserved for any angle of deflection, as shown by the broken line position which the equal arm linkage of Figure 6 may assume.

Having now proven that substantially linear movement may be obtained with such a dog-leg linkage whether the arms are of equal length or not, and throughout reasonable angles of arm departure from mutual registry, merely by effecting proportionate relative angular movement of the arms, it merely remains to devise mechanism to produce relative movement of this type, and to determine what angular ratio of arm swing is necessary to obtain such linear motion with linkages of various arm length ratios. Such control of the two arms may be attained by reaction on arm B from the linkage support to which arm A is pivoted. Suitable mechanism is diagrammatically represented in Figure 10, in which a sprocket, for example, designated AX, is held rigid with the support S, so that its effective rotation relative to arm A will be angle a . To this sprocket is connected, by a chain or the like, a second sprocket BX, which is fixed to arm B in registry with its pivot and in alignment with sprocket AX.

Because arm B is supported from arm A, when arm A swings about its pivot through angle a arm B must swing about its pivot, and relative to arm A, through angle $a+b$ to attain a departure from the reference direction, such as vertical, of angle b . To effect such relative arm movements the working or root diameters of sprockets AX and BX must be inversely proportional to the actual pivotal motions of arms A and B through angles a and $a+b$, respectively. The diameter ratio of sprockets AX and BX would therefore be

$$\frac{BX}{AX} = \frac{a}{a+b}$$

A curve of arm swing sprocket diameter ratio may now be plotted, as shown in Figure 12, designated arm swing, coordinating sprocket diameter ratio with arm length ratio, the values for a and b being selected at $a=60$ degrees for each arm length ratio curve of Figure 11.

The arm swing curve of Figure 12 thus furnishes a definite relationship between the pivotal movements or control sprocket ratios of arms A and B and their relative lengths. From this curve we see that for an arm length ratio of

$$\frac{B}{A} = 1$$

the arm pivot or sprocket ratio,

$$\frac{BX}{AX}$$

is .50; for

$$\frac{B}{A} = 1.5$$

for

$$\frac{BX}{AX} = .55$$

for

$$\frac{B}{A} = 2, \frac{BX}{AX} = .59$$

for

$$\frac{B}{A} = 3, \frac{BX}{AX} = .64$$

for

$$\frac{B}{A} = 4, \frac{BX}{AX} = .67$$

From these values we may determine that the equation for this arm swing curve of the catenary type is

$$\log\left(\frac{B}{A} - .3\right) = 4.2\left(\frac{BX}{AX}\right) - 2.26$$

Therefore

$$\frac{B}{A} - .3 = \frac{10^{4.2\left(\frac{BX}{AX}\right)}}{182}$$

Transposing

$$\frac{B}{A} = \frac{10^{4.2\left(\frac{BX}{AX}\right)}}{182} + .3$$

The proper arm length ratio

$$\frac{B}{A}$$

to obtain linear movement of the free end of the linkage for any selected sprocket diameter ratio

$$\frac{BX}{AX}$$

may thus be determined either by solution of this equation or from the arm swing curve of Figure 12. Conversely, any desired arm length ratio

$$\frac{B}{A}$$

may be selected, and the above equation solved to find the required sprocket diameter ratio

$$\frac{BX}{AX}$$

for such reciprocation, or such ratio may be determined graphically from the arm swing curve of Figure 12.

Extending the problem somewhat farther, the tool or equivalent element may not only be reciprocated lineally, but may be retained in a constant attitude during such reciprocation. It will be evident that such element, if fixed to arm B, would be deflected with it through the angle b from the reference direction. Constant attitude control may be exercised, however, if the tool holder is swung through the angle b with respect to arm B for a departure of the latter through angle b from the reference direction, such as vertical, or for a deflection of such arm through angle $a+b$ with respect to arm A. Controlled swinging of the tool, designated T in Figure 10, may be accomplished from arm A by means of a sprocket BY rigid with the tool carrier, and a second sprocket AY aligned therewith and fixed upon the end of arm A to which arm B is pivoted, coinciding with such pivot axis. As before, the relative diameters of these sprockets would be inversely proportional to the actual pivot movement of the tool and arm A with respect to arm B. Thus for a pivotal tool movement of b the sprocket diameter ratio

$$\frac{BY}{AY}$$

would be

$$\frac{a+b}{b}$$

Again for various arm length ratios of

$$\frac{B}{A}$$

the value of

$$\frac{a+b}{b}$$

may be determined from the several curves of Figure 11 at 60 degrees departure of arm A. These values plotted against arm length ratio give the tool trim curve of Figure 12, by which the arm length ratios,

$$\frac{B}{A}$$

and the tool trim sprocket ratios,

$$\frac{BY}{AY}$$

are coordinated. Selecting values from this curve we find that for an arm length ratio of

$$\frac{B}{A} = 1$$

the arms being of equal length, the sprocket ratio,

$$\frac{BY}{AY}$$

is 2; for

$$\frac{B}{A} = 1.5, \frac{BY}{AY} = 2.25$$

$$\frac{B}{A} = 2, \frac{BY}{AY} = 2.45$$

for

$$\frac{B}{A} = 3, \frac{BY}{AY} = 2.78$$

and for

$$\frac{B}{A} = 4, \frac{BY}{AY} = 3.05$$

The equation which may be derived for this curve, also of the catenary type, is

$$\log\left(\frac{B}{A}\right) + 1 = 3.3 \log\left(\frac{BY}{AY}\right)$$

Therefore

$$10\left(\frac{B}{A}\right) = \left(\frac{BY}{AY}\right)^{3.3}$$

Transposing

$$\left(\frac{B}{A}\right) = \frac{\left(\frac{BY}{AY}\right)^{3.3}}{10}$$

From either this equation or the tool trim curve of Fig. 12 either the proper arm length ratio, or tool trim sprocket ratio, may be determined when the other has been established.

For further convenience the two final equations given above may be combined in the form

$$\frac{B}{A} = \frac{10^{4.2\left(\frac{BX}{AX}\right)}}{182} + .3 = \frac{\left(\frac{BY}{AY}\right)^{3.3}}{10}$$

from which we may determine any two of the factors arm length ratio, arm swing sprocket ratio, and tool trim sprocket ratio, by selecting a desired or controlling value for the third. Similarly the curves of Figure 12 may be used jointly for the same purpose, since if a point is selected on either the arm swing curve or the tool trim curve for any one of the ratios

$$\frac{BX}{AX}, \frac{BY}{AY}$$

and

$$\frac{B}{A}$$

the other two values required to obtain straight-

line motion and constant tool attitude are thereby established.

While, as suggested, a chain and sprocket type mechanism is quite suitable for controlling the relative movements of the two arms A and B, the linkage base or support S and the tool T, it will be understood that any mechanism which will positively interconnect these various elements to control their movement in the manner described may be employed. For instance, a bevel gear may be substituted for each of the sprockets AX, BX, AY, and BY, such gears of each pair having the same effective relative diameters as the sprockets, determined as described above. Movement of the gears BX and AX may be coordinated by a shaft carried by arm A, having on each end a bevel pinion, one meshing with bevel gear AX and the other with bevel gear BX, which pinions are of equal size. Such interconnected bevel gears, BX and AX, must be on opposite sides of the shaft so that they will turn in the same direction. Similarly a shaft would be carried by arm B and provided with a pinion on each end, of the same size, and meshing, respectively, with bevel gears AY and BY, also located on opposite sides of the pinion shaft.

Spur gears, on the other hand, might replace the several sprockets, such spur gears being of proportional size as in the case of the sprockets. Such gears AX and BX might be interconnected by a train of intermeshing idler gears carried by arm A, provided that an odd number of idler gears is used to establish relative rotation of the control gears in the same sense. Similarly gears AY and BY could be interconnected by a row of intermeshing idler gears, again an odd number of such gears being required. Instead of interconnecting such spur gears by idler gears reciprocating racks might be mounted one on each arm A and B, which would mesh with the gears AX, BX, and AY, BY, respectively, to transmit motion from one gear to the other in each case. Such gears might alternatively be interconnected by a silent chain instead of using idler gear or rack connections.

A combination of such interconnecting mechanisms might be employed. Two pairs of gears, one to control arm swing and the other to control tool trim, the gears of each pair being of the proper relative diameters and meshing directly, may be mounted with one gear of each pair aligned with a pivot axis. The motion of the other gear of each pair, not in registry with a pivot, may be transmitted to the pivot axis at the more remote end of the arm by unit movement ratio mechanism, such as a chain and sprocket arrangement employing sprockets of equal size, a bevel gear and pinion train employing pinions of equal size and gears of equal size, or a rack and pinion connection having pinions of equal size. Still other types of connection may be preferable for certain installations.

For purposes of illustrating further the capabilities of my linear motion mechanism, in Figures 1 to 4, inclusive, I have shown it used as a bench trim saw support. Other devices in which linkage of this type is useful, however, have been mentioned above.

The supporting link of the trim saw linkage is composed of two arms in spaced, parallel relationship, one being pivoted to each bifurcation of a yoke 10 by a pin 11. In operation these two arms act in unison. This yoke, in turn, is mounted to swivel on a fixed base 3. Index marks 30, cooperating between the yoke 10 and

base 3, indicate the angular disposition of the yoke, and consequently of the vertical plane in which the linkage swings. The yoke may be clamped in any desired angular position by means of the clamping screw and lever arrangement 31, including a set screw which may be screwed inwardly to engage an extension 13 of yoke 10 projecting into base 3. Any other clamping mechanism of suitable type may be used instead of such a set screw device.

The supported end of link 2 is received between the arms 1, and, as previously described, these supported and supporting links, respectively, are interconnected by a pivot pin 12 extending through a long bearing 20 integral with the supported end of link 2. The immediate saw-supporting bracket 4 preferably is bifurcated to form fingers 40 straddling the free end of arm 2 and connected to it by a pivot pin 21. All of the arms 1, 2, and 4 should be ribbed, such as of T-beam or cruciform section, so that they will have great stiffness for their weight, to reduce, as far as possible, bending which would induce departure of the pivot pin 21 from linear motion during extension movement of the linkage.

Control of the relative angular departures of the arms is obtained in the manner previously described. The specific saw mechanism linkage illustrated has arms 1 and 2 of equal length, and hence sprocket 14 has an effective diameter twice as great as sprocket 22. Sprocket 14 corresponds to member AX shown in the diagram of Figure 10, and is integral with pivot pin 11, which in turn is secured in yoke 10 against rotation. Each arm 1, therefore, moves upon its pivot pin 11 and relative to both sprocket 14 and yoke 10. Sprocket 22 corresponds to element BX in the diagram of Figure 10, and is secured rigidly to the bearing sleeve 20 of arm 2. Sprocket 15 is secured rigidly to arm 1, and corresponds to element AY shown diagrammatically in Figure 10. Its effective diameter is one-half that of sprocket 41, which is rigid with a bifurcation of bracket 4, and corresponds to element BY of Figure 10.

A chain 16 interconnects sprockets 14 and 22, and a second chain 23 interconnects sprockets 15 and 41, so that the cooperating sprockets will be positively interconnected to control accurately the relative angular velocities of the arms 1 and 2, and of the saw head. In order to maintain maximum accuracy, while enabling the control mechanism to be assembled easily, a tightener 17 is pivoted on arm 1 for holding chain 16 tight, and a similar tightener 24, pivoted on arm 2, keeps chain 23 tight. These tighteners are urged toward arms 1 and 2 by springs 18 and 25, respectively, which extend between each tightener and its arm. In order to enable the parts to be adjusted for establishing the proper initial relationship of the arms, the angular position of sprocket 14 with respect to yoke 10 may be varied by slackening off the clamping nut of pivot pin 11 to which it is screwed, and then retightening it, to secure it again against movement with respect to yoke 10, when the proper position of the sprocket has been established. Similarly a set screw 42 enables sprocket 41 to be set in its proper angular position with respect to yoke 40 of bracket 4, and then secured in such position.

The saw mechanism and arms will have considerable weight, and hence counterbalances 7 may be secured to the lower ends of arms 1, which will tend to equalize the turning moments of the various parts of the arrangement about pivot 11.

The saw mechanism itself is supported upon a vertical spindle 5, which is snugly received in a collar 43 formed by the outer end of bracket 4. An annular recess 44 is cut in the top of this collar to form a depressed shoulder 45 on which seats a cross bar 50, serving as a support for spindle 5 and extending through slots 51 in opposite sides of the spindle. The center of cross bar 50 is bored and threaded to receive a screw 52, rotatable for vertical adjustment of the spindle 5 by hand wheel 53, integral with the screw. Pinned to screw 52, or secured in any suitable fashion, is a supporting bushing 54 which is engaged beneath an end plate 55 integral with spindle 5. A set collar may be clamped to the upper end of bushing 54 to prevent lifting of the spindle under upward thrust created in making a cut.

By this supporting arrangement the spindle 5 may be rotated about a vertical axis to dispose the saw in position, for making a vertical cut along any line, and the hand wheel 53 may be turned to raise or lower the saw for any desired depth of cut. After the saw's angular position has been established by a proper setting of cross bar 50 on shoulder 45, it will not be turned further as hand wheel 53 is revolved to raise or lower the saw, because bushing 54 has a rotative but snug fit in plate 55. When both angular and vertical adjustments have been completed, clamp 46 is set, which forces an eccentric disc 47, carried by the clamp rod between ears 48 of collar 43, into firm holding engagement with spindle 5.

A bracket 56, integral with the lower end of spindle 5, has a transverse aperture 57 therein to receive the circular head 60, integral with the saw bearing sleeve 6, which receives arbor 61 of saw 62. Aperture 57 is flanged at one end to prevent endwise movement of head 60 out of such aperture, and a thrust ring 58, projecting inward beyond its periphery, restricts the opposite end of the aperture to engage the other end of head 60. The saw may be rotated by a motor, or other suitable drive, connected to end 63 of spindle 61 by a flexible connection.

Aperture 57 may be formed as a split ring and a clamp 59 provided to constrict the ring for clamping head 60 in any rotative position with respect to the ring. A lug 59' may be carried by the rod of this clamp, adapted to seat in any one of the notches 64 extending radially inward from the periphery of head 60. These notches are preferably spaced 45 degrees apart, so that the head may be located readily in any such position, and correspond severally to vertical disposition of the saw 60, 45 degrees upswing, 45 degrees downswing, and 90 degrees downswing. The bar or lug 59' may be swung out of the aperture 57 and aligned notch 64 in order to allow the head 60 to be rotated from one such position to another. Furthermore, this bar may be left in such outwardly swung position, in which case head 60 may be set in any angular position intermediate those corresponding to such notches, and clamp 59 tightened to secure the head in such intermediate angular position. Ring 58 and head 60 may be indexed to facilitate such settings. A cut with any degree of chamfer or inclination may therefore be made.

Figures 7, 8, and 9, as well as Figure 6, indicate diagrammatically various types of cut which may be made by properly adjusting the mechanism described. In Figure 6 the saw is parallel to the plane in which the dog-leg linkage moves, and such plane is perpendicular to the work table. The saw is thus set for a shallow, straight cross-

cut, as indicated by one dotted line position, and, as indicated by the other dotted line position, the saw head may be raised or lowered by means of hand wheel 53 to cut completely through the work, or to make a cut of any desired depth. If yoke 10 is swung and reclamped in a new position by clamp 31 an angle cut may be made, as shown in Figure 7, in one instance a vertical cut at an oblique angle of 60 degrees being indicated. In the other instance of Figure 7, the head 60 is also rotated to swing the saw down through 45 degrees, and the yoke 10 is swung in the opposite direction through an angle of 45 degrees from center, to make a chamfer or bevel cut along an opposite oblique line.

Either a bevel, or a vertical, rip cut may also be made, the saw being positioned as shown in Figures 8 and 9, respectively. The saw is set at the desired spacing from the base 3 and the lumber moved past it in a direction perpendicular to the plane of the linkage. The distance from the cut to the base may be varied, and when the proper distance has been established, handle 19 may be rotated to secure arm 1 against pivotal movement relative to yoke 10, by lateral contact, and hence further relative movement of all linkage parts, both extension and retraction, is prevented until after the cut has been completed.

While I have described in detail only one particular embodiment, applications of the principles involved in my controlled linkage for use in other mechanisms requiring linear movement, such as suggested above, may readily be devised.

What I claim as my invention is

1. Supporting mechanism for a tool or the like, comprising a base, dog-leg linkage, including a supporting link pivotally connected to said base, and a supported link pivotally connected to said supporting link at a location remote from the base pivotal connection, linkage control means for coordinating the angular movement of said supported link and said base relative to said supporting link, a tool carrier pivotally supported upon the free end of said supported link, and tool trim control means extending closely alongside said supported link in all angular positions thereof reacting solely from said supporting link, and governed by relative movement of said links to coordinate the angular movement of said tool carrier and said supporting link relative to said supported link, for maintaining said tool carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage within its normal working range.

2. Supporting mechanism for a tool or the like, comprising a base, dog-leg linkage, including a supporting link having one end pivotally connected to said base, and a supported link pivotally connected to the other end of said supporting link, linkage control means for coordinating the angular movement of said supported link and said base relative to said supporting link, a tool carrier pivotally supported upon the free end of said supported link, and tool trim control means connected between said other end of said supporting link and said tool carrier, reacting solely from said supporting link, and governed by relative movement of said links to coordinate the angular movement of said tool carrier and said supporting link relative to said supported link, for maintaining said tool carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage within its normal working range.

3. Supporting mechanism for a lineally reciprocable tool, comprising a base, dog-leg linkage, including a supporting link pivotally connected to said base, and a supported link pivotally connected to said supporting link at a location remote from the base pivotal connection, linkage control means interengaged between said base and said linkage, and operable to guide movement of said supported link for substantially linear reciprocation of its free end, a tool carrier pivotally supported upon the free end of said supported link, and tool trim control means interengaged between said linkage and said tool carrier, reacting solely from said supporting link, and governed by relative movement of said links to control angular movement of said tool carrier relative to said supported link, for maintaining said tool carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage within its normal working range.

4. Supporting mechanism for a lineally reciprocable tool, comprising a base, dog-leg linkage, including a supporting link pivotally connected to said base, and a supported link pivotally to said supporting link at a location remote from the base pivotal connection, linkage control means for restricting movement of said linkage relative to said base and of said links relative to each other, to guide said supported link for substantially linear reciprocation of its free end, a tool carrier pivotally supported upon the free end of said supported link, and tool trim control means to control movement of said tool carrier relative to said supported link, for maintaining said tool carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage within its normal working range, including a circular control element supported nonrotatively with respect to said tool carrier, a second circular control element supported upon and nonrotatively with respect to said supporting link, and means interconnecting said control elements and operable to coordinate the respective rotations thereof relative to said supported link.

5. Supporting mechanism for a lineally reciprocable tool, comprising a base, dog-leg linkage, including a supporting link pivotally connected to said base, and a supported link pivoted to said supporting link at a location remote from the base pivotal connection, linkage control means for restricting movement of said linkage relative to said base and of said links relative to each other, to guide said supported link for substantially linear reciprocation of its free end, a tool carrier pivotally supported upon the free end of said supported link, and tool trim control means, including a circular control element supported nonrotatively with respect to said tool carrier, a second circular control element supported upon and nonrotatively with respect to said supporting link and means interconnecting said control elements and operable to coordinate the respective rotations thereof relative to said supported link for maintaining said tool carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage within its normal working range, said tool trim control means conforming substantially to the equation

$$\frac{B}{A} = \frac{\left(\frac{BY}{AY}\right)^{3.3}}{10}$$

in which

$$\frac{B}{A}$$

5 is the ratio of the effective length of the supported arm to that of the supporting arm, and

$$\frac{BY}{AY}$$

10 is the ratio of the effective radius of said first control element to that of said second control element.

6. Supporting mechanism for a lineally reciprocable tool, comprising a base, dog-leg linkage, including a supporting link pivotally connected to said base, and a supported link of equal length pivotally connected to said supporting link at a location remote from the base pivotal connection, linkage control means for restricting movement of said linkage relative to said base and of said links relative to each other, to guide said supported link for substantially linear reciprocation of its free end, a tool carrier pivotally supported on the free end of said supported link, and tool trim control means to restrict movement of said tool carrier relative to said supported link, for maintaining said tool carrier in constant angular attitude relative to said base for all extended positions of said dog-leg linkage, including a circular control element supported nonrotatively with respect to said tool carrier, a second circular control element of one-half the effective radius of said first control element, supported upon and nonrotatively with respect to said supporting link, and means interconnecting said control elements and operable to coordinate the respective rotations thereof relative to said supported link.

7. Supporting mechanism for a tool or the like, comprising a base, dog-leg linkage, including a supporting link pivotally connected to said base, and a supported link pivotally connected to said supporting link at a location remote from the base pivotal connection, linkage control means for coordinating the angular movement of said supported link and said base relative to said supporting link for effecting substantially linear movement of the free end of said supported link, including a circular control element supported nonrotatively with respect to said base, and a second circular control element supported nonrotatively with respect to said supported link, and connected to said first control element to effect rotation of said second circular control element relative to said supporting link in the rotative sense opposite that in which said supporting link swings relative to said base, a tool carrier pivotally supported upon the free end of said supported link, and tool trim control means for coordinating the angular movement of said tool carrier and said supporting link relative to said supported link, for maintaining said tool carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage within its normal working range, including a circular control element supported nonrotatively with respect to said tool carrier, a second circular control element supported upon and nonrotatively with respect to said supporting link, and means interconnecting said last two circular control elements and operable to effect rotation of said tool carrier circular control element relative to said supported link 75 in the opposite sense and proportional in degree

to the swinging of said supported link relative to said supporting link.

8. Supporting mechanism for a tool or the like, comprising a base, dog-leg linkage, including a supporting link pivotally connected to said base, and a supported link pivotally connected to said supporting link at a location remote from the base pivotal connection, linkage control means for coordinating the angular movement of said supported link and said base relative to said supporting link, including a circular control element supported nonrotatively with respect to said base, and a second circular control element supported nonrotatively with respect to said supported link, and connected to said first control element, a tool carrier pivotally supported upon the free end of said supported link, and tool trim control means for coordinating the angular movement of said tool carrier and said supporting link relative to said supported link, for maintaining said tool carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage within its normal working range, including a circular control element supported nonrotatively with respect to said tool carrier, and a second circular control element supported nonrotatively with respect to said supporting link and connected to said tool carrier control element, said linkage control means and said tool trim control means conforming substantially to the equation

$$\frac{B}{A} = \frac{10}{182} \left(\frac{BX}{AX} \right)^{4.2} + .3 = \frac{(BY)^{3.3}}{10}$$

in which

$$\frac{B}{A}$$

is the ratio of the effective length of the supported link to that of the supporting link,

$$\frac{BX}{AX}$$

is the ratio of the effective radius of said supported link control element to that of said base control element, and

$$\frac{BY}{AY}$$

is the ratio of the effective radius of said tool carrier control element to that of said supporting link control element.

9. Supporting mechanism for a tool or the like lineally reciprocable in a constant attitude, comprising a base, dog-leg linkage including a supporting link pivotally connected to said base, and a supported link pivotally connected to said supporting link at a location remote from the base pivotal connection, linkage control means for restricting movement of said linkage relative to said base, and of said links relative to each other, to guide said supported link for substantially linear reciprocation of its free end, including a circular control element supported nonrotatively with respect to said base, and a second circular control element supported nonrotatively with respect to said supported link and connected to said first control element, a tool carrier pivotally supported on the free end of said supported link, and tool trim control means for restricting movement of said tool carrier with respect to said linkage, to maintain said tool carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage within its normal working range, in-

cluding a circular control element supported nonrotatively with respect to said tool carrier, a second circular control element supported upon and nonrotatively with respect to said supporting link, and means interconnecting said control elements and operable to coordinate the respective rotations thereof relative to said supported link.

10. Supporting mechanism for a tool or the like lineally reciprocable in a constant attitude, comprising a base, dog-leg linkage, including a supporting link pivotally connected to said base, and a supported link of equal length pivoted to said supporting link at a location remote from the base pivotal connection, linkage control means for coordinating the angular movement of said supported link and of said base relative to said supporting link, to guide said supported link for linear reciprocation of its free end, including a circular control element supported nonrotatively with respect to said base, and a second circular control element, of one-half the effective radius of said first control element, nonrotatively supported with respect to said supported link, and connected to said first control element, a tool carrier pivotally supported upon the free end of said supported link, and tool trim control means for coordinating the angular movement of said tool carrier and of said supporting link relative to said supported link, for maintaining said tool carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage, including a circular control element supported nonrotatively with respect to said tool carrier, a second circular control element of one-half the effective radius of said tool carrier control element, supported upon and nonrotatively with respect to said supporting link, and means interconnecting said control elements and operable to coordinate the respective rotations thereof relative to said supported link.

11. Supporting mechanism for a bench saw or the like lineally reciprocable in a constant attitude, comprising a base, dog-like linkage, including a supporting link pivotally connected to said base, and a supported link pivotally connected to said supporting link at a location remote from the base pivotal connection, linkage control means interengaged between said base and said linkage, and operable to guide movement of said supported link for substantially linear reciprocation of its free end, a saw carrier pivotally supported upon the free end of said supported link, saw carrier trim control means interengaged between said linkage and said saw carrier, reacting solely from said supporting link, and governed by relative movement of said links to control angular movement of said saw carrier relative to said supported link, for maintaining said saw carrier in substantially constant angular attitude relative to said base for all extended positions of said dog-leg linkage within its normal working range, a saw, an arbor carrying said saw, and means supporting said saw arbor from said saw carrier for adjustment of said saw relative to said carrier about a horizontal axis.

12. Mechanism of the character described comprising a base, a supporting arm pivoted at one end to said base and swingable to either side of its pivotal connection therewith, a supported arm pivoted at one end to the other end of said supporting arm and having its other end free, said supported arm being swingable across said supporting arm to either side of the latter and

also to either side of the pivotal connection between said supporting arm and said base, and gearing positively connecting said base with said supported arm and constraining said arms to swing simultaneously and the free end of said supported arm to traverse a straight line, said connecting gearing being disposed substantially parallel to and being confined substantially within the length of said supporting arm.

13. Mechanism of the character described comprising a base, a supporting arm pivoted at one end to said base, a supported arm pivoted at one end to the other end of said supporting arm and having its other end free, a sprocket wheel fixed to said base in axial alinement with the pivot between the latter and said supporting arm, a sprocket wheel fixed to said supported arm in axial alinement with the pivotal connection between said arms, and a sprocket chain connecting and cooperating with said sprocket wheels to constrain said arms to swing simultaneously and to cause the free end of said supported arm to traverse a straight line.

14. Mechanism of the character described comprising a base, a supporting arm pivoted at one end to said base, a supported arm pivoted at one end to the other end of said supporting arm and having its other end free, a gear wheel fixed to said base in axial alinement with the pivot between the latter and said supporting arm, a gear wheel fixed to said supported arm in axial alinement with the pivotal connection between said arms, means connecting and cooperating with said gear wheels to constrain said arms to swing simultaneously and to cause the free end of said supported arm to traverse a straight line, a tool support pivoted to the free end of said supported arm, a gear wheel fixed to said supporting arm in axial alinement with the pivotal connection between said arms, a gear wheel fixed to said tool support in axial alinement with the pivotal connection between the latter and the free end of said supported arm, and means connecting and cooperating with said two gear wheels last mentioned to cause said tool support to maintain a constant angular attitude relative to said base during its straight line movement with the free end of said supporting arm.

15. Mechanism of the character described comprising a base, a supporting arm pivoted at one end to said base, a supported arm pivoted at one end to the other end of said supporting arm and having its other end free, a sprocket wheel fixed to said base in axial alinement with the pivot between the latter and said supporting arm, a sprocket wheel fixed to said supported arm in axial alinement with the pivotal connection between said arms, a sprocket chain connecting and cooperating with said sprocket wheels to constrain said arms to swing simultaneously and to cause the free end of said supported arm to traverse a straight line, a tool support pivoted to the free end of said supported arm, a wheel fixed to said supporting arm in axial alinement with the pivotal connection between said arms, a wheel fixed to said tool support in axial alinement with the pivotal connection between the latter and the free end of said supported arm, and means positively connecting said two wheels last mentioned and acting precisely tangentially of both thereof in all swung positions of said arms to cause said tool support to maintain a constant angular attitude relative to said base

during its straight line movement with the free end of said supported arm.

16. Mechanism of the character described comprising a base, a supporting arm pivoted at one end to said base, a supported arm pivoted at one end to the other end of said supporting arm and having its other end free, a gear wheel fixed to said base in axial alinement with the pivot between the latter and said supporting arm, a gear fixed to said supported arm in axial alinement with the pivotal connection between said arms, means connecting and cooperating with said gear wheels to constrain said arms to swing simultaneously and to cause the free end of said supported arm to traverse a straight line, a tool support pivoted to the free end of said supported arm, a sprocket wheel fixed to said supporting arm in axial alinement with the pivotal connection between said arms, a sprocket wheel fixed to said tool support in axial alinement with the pivotal connection between the latter and the free end of said supported arm, and a sprocket chain connecting and cooperating with said two sprocket wheels last mentioned to cause said tool support to maintain a constant angular attitude relative to said base during its straight line movement with the free end of said supported arm.

17. Mechanism of the character described comprising a base, a supporting arm pivoted at one end to said base, a supported arm pivoted at one end to the other end of said supporting arm and having its other end free, a sprocket wheel fixed to said base in axial alinement with the pivot between the latter and said supporting arm, a sprocket wheel fixed to said supported arm in axial alinement with the pivotal connection between said arms, a sprocket chain connecting and cooperating with said sprocket wheels to constrain said arms to swing simultaneously and to cause the free end of said supported arm to traverse a straight line, a tool support pivoted to the free end of said supported arm, a sprocket wheel fixed to said supporting arm in axial alinement with the pivotal connection between said arms, a sprocket wheel fixed to said tool support in axial alinement with the pivotal connection between the latter and the free end of said supported arm, and a sprocket chain connecting and cooperating with said two sprocket wheels last mentioned to cause said tool support to maintain a constant angular attitude relative to said base during its straight line movement with the free end of said supported arm.

18. Mechanism of the character described comprising a base, a supporting arm pivoted at one end to said base and swingable to either side of its pivotal connection therewith, a supported arm pivoted at one end to the other end of said supporting arm and having its other end free, said supported arm being swingable across said supporting arm to either side of the latter and also to either side of the pivotal connection between said supporting arm and said base, gearing positively connecting said base with said supported arm and constraining said arms to swing simultaneously and the free end of said supported arm to traverse a straight line, said connecting gearing being disposed substantially parallel to and being confined substantially within the length of said supporting arm, a tool support pivoted to the free end of said supported arm, and gearing positively connecting said supporting arm with said tool support and con-

straining the latter to maintain a constant angular attitude relative to said base during its straight line movement with the free end of said supported arm, said last mentioned gearing being disposed substantially parallel to and being confined substantially within the length of said supported arm.

19. Mechanism of the character described comprising a base, a supporting arm pivoted at one end to said base, a supported arm pivoted at one end to the other end of said supporting arm and having its other end free, a circular member fixed to said base concentrically with the pivot between the latter and said supporting arm, a second circular member fixed to said supported arm concentrically with the pivotal connection between said arms, and means positively connecting corresponding sides of said two circular members and acting on parallel lines precisely tangentially of both thereof in all swung positions of said arms to constrain said arms to swing simultaneously through corresponding angles, thus to cause the free end of said supported arm to traverse a straight line.

20. Mechanism of the character described 25

comprising a base, a supporting arm pivoted at one end to said base, a supported arm pivoted at one end to the other end of said supporting arm and having its other end free, a circular member fixed to said base concentrically with the pivot between the latter and said supporting arm, a second circular member fixed to said supported arm concentrically with the pivotal connection between said arms, and means positively connecting said two circular members, operable to effect rotation of said second circular member relative to said supporting arm in the rotative sense opposite to that in which said supporting arm swings relative to said base, and acting precisely tangentially of both of said circular members in all swung positions of said arms to preserve a constant ratio between the rotation of said second circular member relative to said supporting arm on the one hand, and the rotation of said supporting arm relative to said base on the other hand, thus to cause the free end of such supported arm to traverse a straight line within its normal working range.

EVERETT E. CRANE.