

June 4, 1940.

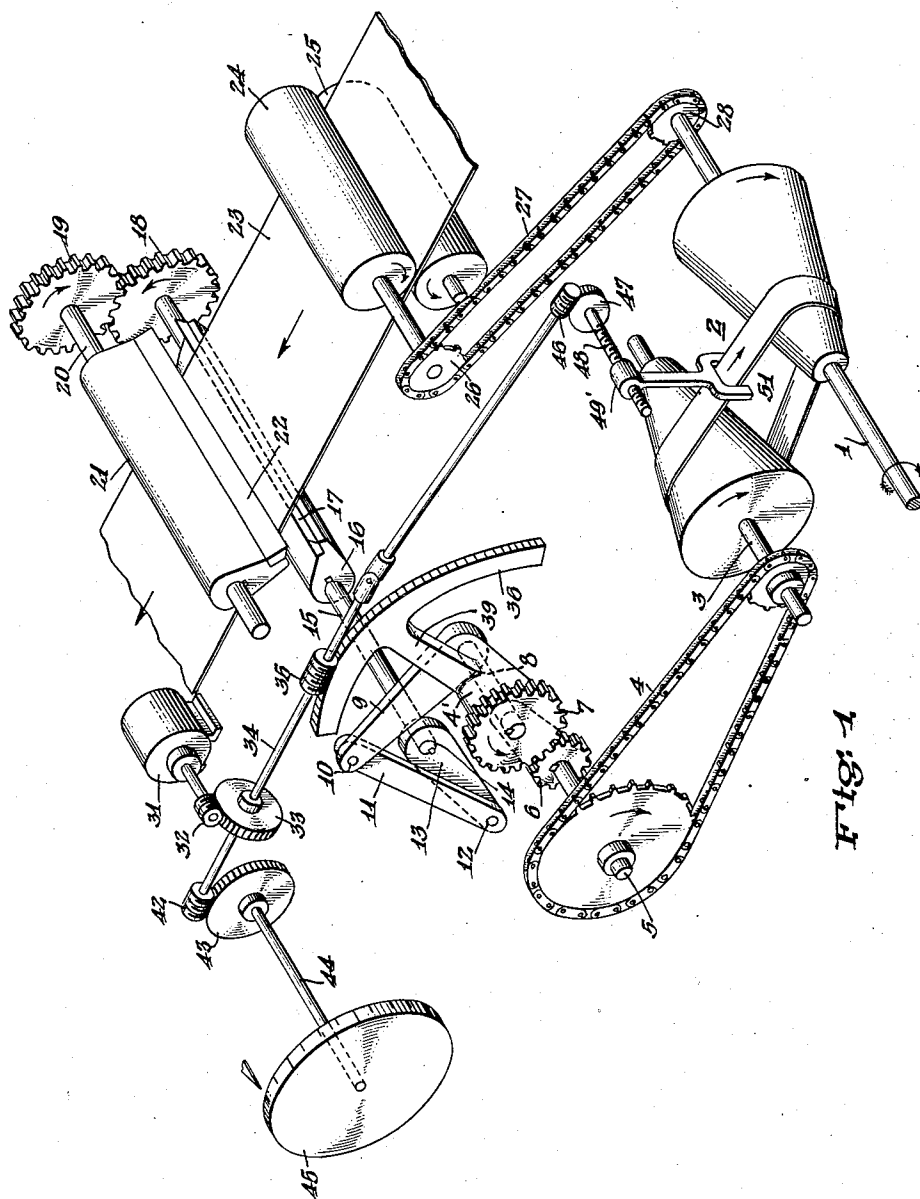
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2,202,872

CUTTING MECHANISM

Filed Feb. 17, 1938

5 Sheets-Sheet 1



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CUTTING MECHANISM

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5 Sheets-Sheet 2

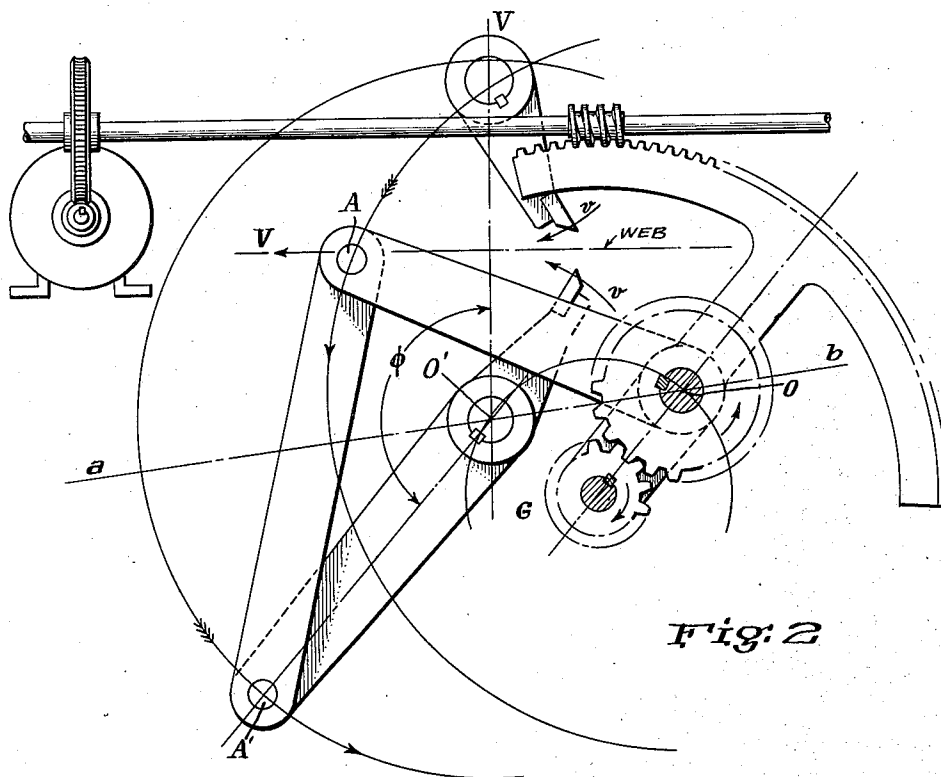


Fig. 2

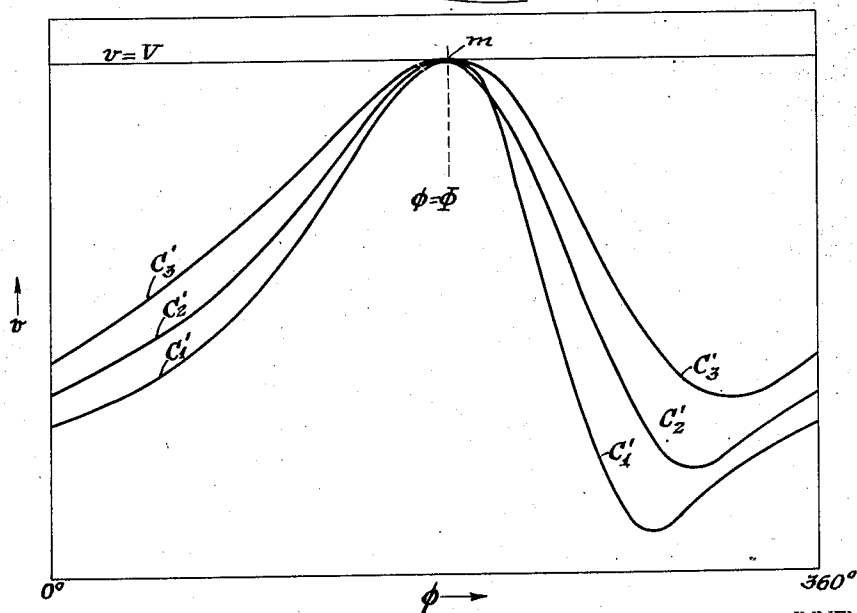


Fig. 3

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5 Sheets-Sheet 3

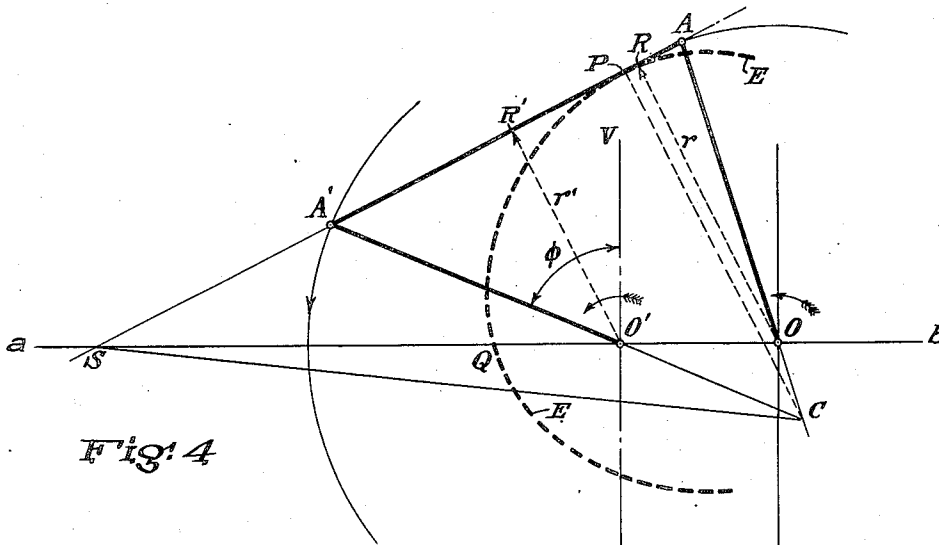


Fig: 4

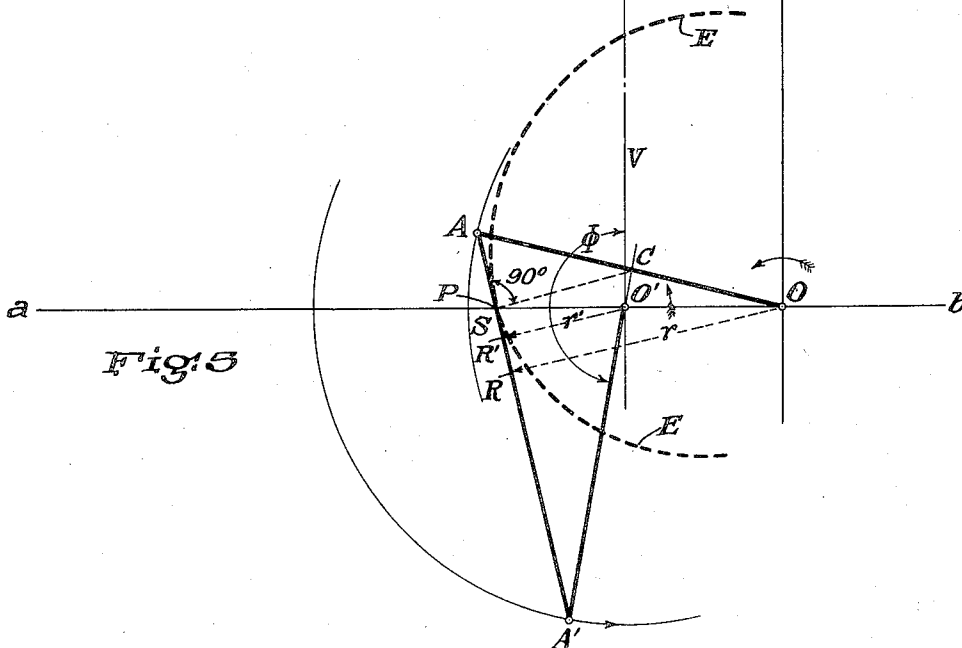


Fig: 5

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5 Sheets-Sheet 4

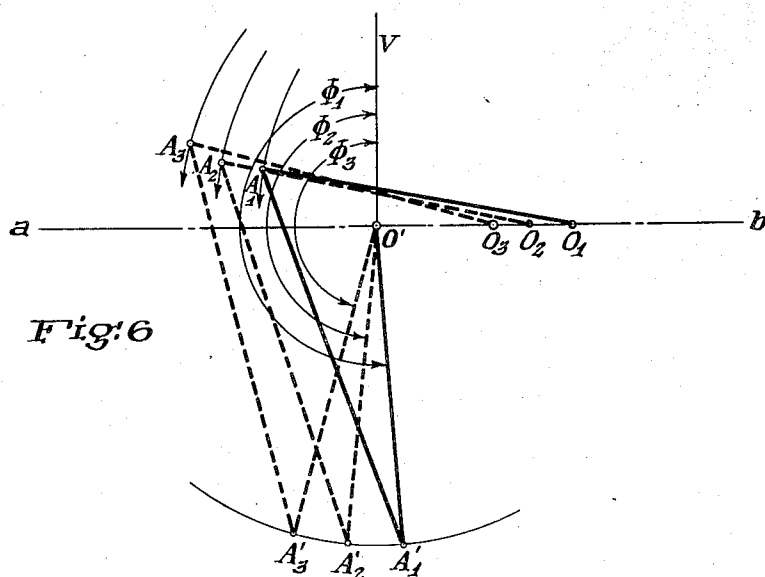


Fig: 6

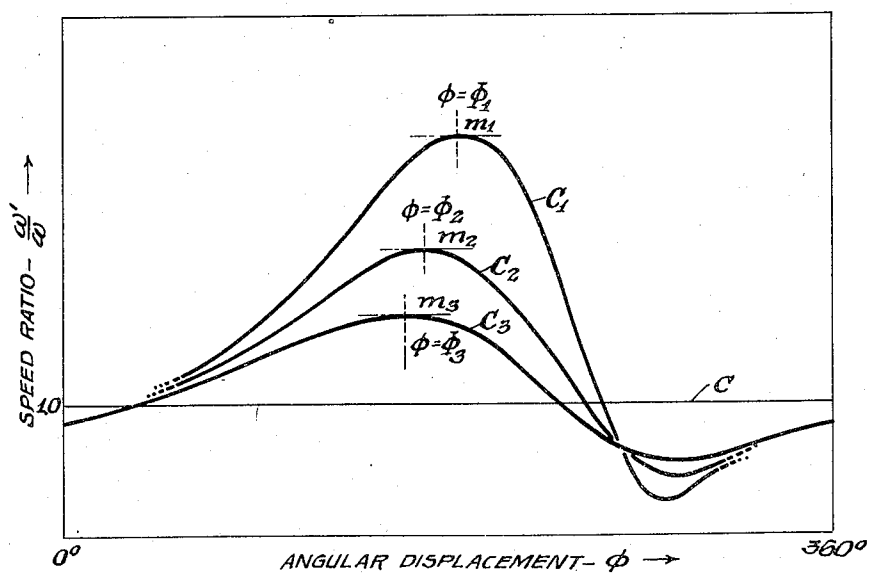


Fig: 7

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CUTTING MECHANISM

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5 Sheets-Sheet 5

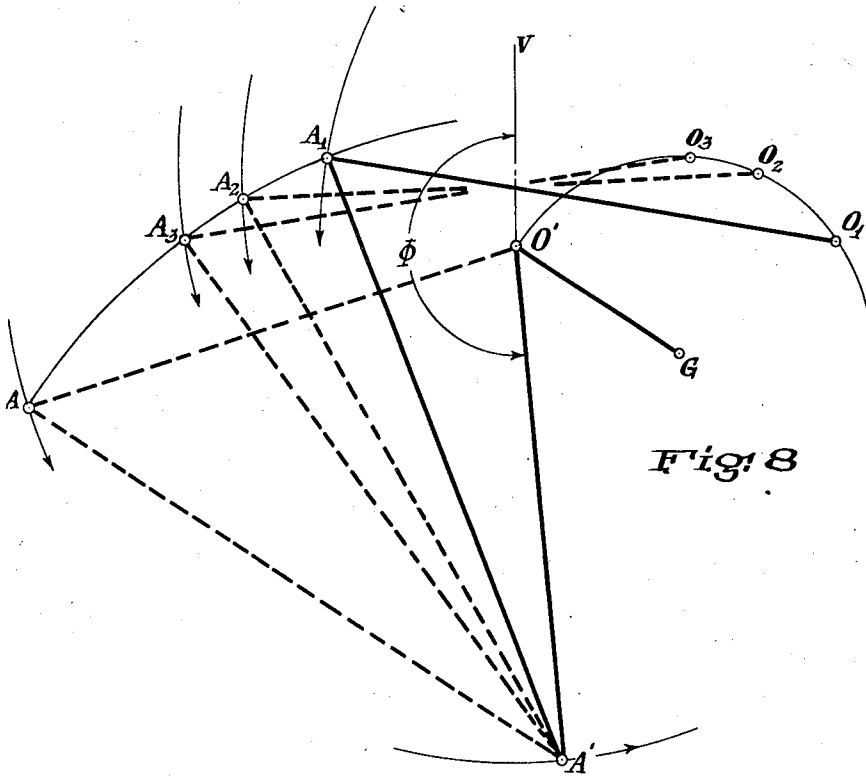


Fig. 8

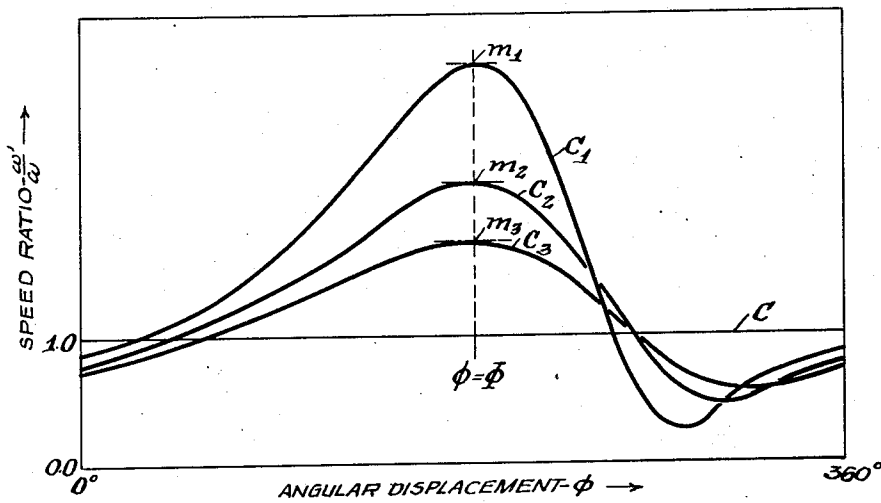


Fig. 9

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UNITED STATES PATENT OFFICE

2,202,872

CUTTING MECHANISM

Albert F. Shields, Jamaica, N. Y., assignor to S. & S. Corrugated Paper Machinery Co., Inc.,
Brooklyn, N. Y., a corporation of New York

Application February 17, 1938, Serial No. 191,060

13 Claims. (Cl. 164—68)

My invention relates to novel apparatus for and methods of cutting a continuous moving web and, more particularly, relates to novel methods of and apparatus for cutting continuous moving corrugated sheet material.

In the manufacture of corrugated sheets, the material, after it has passed through the corrugating machines, is fed at a continuous predetermined speed through a cutting mechanism which cuts the material at different predetermined lengths. The cutting mechanism usually comprises a pair of knives mounted on individual rotating drums, one drum located above and one drum located below the sheet to be cut so that the knives cyclically engage and cut the sheet material.

The length of sheet cut by the knives depends, of course, upon the time taken for the knives to complete each revolution or cycle. Accordingly, in order to change the lengths of the sheets, the R. P. M. of the knife drums is changed.

However, during the cutting interval, it is essential that the speed of the knives shall be equal to or substantially in synchronism with the linear movement of the sheet material in order to prevent either bulging of the sheet which would occur if the knives move too slowly or ripping of the sheet which would occur if the knives move too fast.

Numerous mechanisms have been proposed for securing synchronous movement with the knives in respect to the sheet material for all sizes of sheet material to be cut, but these have either involved complicated and expensive gear mechanism such as specially constructed elliptical gears or expensive hydraulic transmission systems which must be carefully controlled both as to temperature and pressure and must be constantly watched for leakage tendencies resulting in slipping.

Eccentric operations employing sliding members which produce eccentric movements have also been proposed but have the further disadvantage that they have a tendency to wear in the sliding parts and requiring exact oiling.

In accordance with my present invention I have materially simplified and rendered inexpensive the structure necessary for securing such synchronism by employing the principle of a kinematic or quadric chain having four turning pairs, which not only is less expensive and simpler than either the complex elliptical mechanism or the eccentric sliding principle but is more accurate and more easily adjustable and requires less maintenance.

Accordingly, an object of my invention is to provide a novel apparatus for and method of cutting corrugated board.

A further object of my invention is to provide novel transmitting mechanism for securing synchronism during the cutting interval.

Still a further object of my invention is to provide simplicity of adjustment of the connecting mechanism for securing different sized cuts of material while maintaining synchronism during the cutting interval.

Still a further object of my invention is to provide a kinematic or quadric chain for securing synchronism during cutting for any size material.

Still a further object of my invention is to provide a kinematic or quadric chain for securing synchronism of the knives with different size sheet material.

There are other objects of my invention which together with the foregoing will appear in the detailed description with the drawings, in which:

Figure 1 is a perspective view of the novel features of my invention.

Figure 2 is an enlarged detail of the kinematic chain mechanism employed in my invention.

Figure 3 is a series of curves showing the cutting position of the knives for different adjustments of the mechanism.

Figure 4 is a method of obtaining the angular velocity of the knife in any position.

Figure 5 illustrates a method of determining the angular velocity of the knife at the position of cutting.

Figure 6 shows the change in the angularity of the knife when the adjustment of a fixed length is made in a straight line.

Figure 7 is the velocity diagram illustrating this condition.

Figure 8 shows the cutting position of the knife remaining constant when adjustment of the fixed length O_o' is made in the arc of a circle.

Figure 9 shows the velocity of the diagram of this condition.

Referring to Figure 1, the driving shaft 1 driven from any suitable source of power drives the Reeves 2 through which adjustable speeds are obtaining on the output shaft 3 which is connected by a chain belt 4 to the shaft 5 determining the fixed center of my mechanism. Secured by any suitable means to the shaft 5 is a pinion 6 meshing with a gear 7 to which is secured by a keyway a shaft 8 carrying on one end of it the shaft turning link 9. At the opposite end the turning link 9 rotates on pin 10 and which carries connecting link 11 arranged to rotate with

respect to the turning link 9 on the pin 10. The connecting link 11 is also rotatably mounted at its opposite end in the pin 12, through which it carries a second rotatable link 13 which in turn is fastened at its opposite end as by a keyway 14 to a knife carrying shaft 15 which carries the roller drum 16 on which is mounted the knife 17.

The drum 16 carries at one end thereof a gear 18 meshing with gear 19 which is secured to and drives the knife drum carrying shaft 20 on which is mounted the drum 21 carrying the knife 22. As the drums 16 and 21 rotate in a counter-clockwise and clockwise direction respectively and the corrugated paper 23 coming from the corrugated rolls (not shown) is fed between the drums by the feed rolls 24 and 25, the cutting knives 17 and 22 cyclically engage and cut the strip material which is being fed forward by the feed rollers 24 and 25 driven through the sprocket and chain mechanism 26, 27 and 28 by the shaft 1 from the source of power.

Depending upon the period of time for cutting, these knife drums 16 and 21 are placed at a slight angle with respect to the direction of the movement of the paper. That is to say, if the cutting is to occur instantaneously, the knives would be substantially at right angles in the direction they travel. If, on the other hand, as is more commonly the practice, a shearing action occurs in which the knives start cutting first at one side and progress gradually across the sheet of material, the drums are mounted at some angle with respect to the direction of the travel of the paper depending upon the helical angle of the knife. This angle compensates for the forward movement of the sheet during the cutting period so that the resulting cut is straight across the sheet.

Referring now again to the kinematic chain including the rotating link 9, connecting link 11 and rotating link 13 shown in greater detail in Figure 2, it will be seen that as the power from the Reeves unit 2 drives the shaft 5 and through it pinion 6 and gear 7, the rotation of the shaft 8 causes a rotation of the rotating link 9. As the link 9 rotates it acts as a crank to drive the connecting link 11. Inasmuch as the distance between the pins 10 and 12 is fixed, as the crank mechanism 9 rotates, a corresponding movement of link 11 at pin 12 must occur.

This movement of link 11 at pin 12, in turn, drives the second rotating link 13, rotating the shaft 15. In the movement of link 11 at pin 12 and therewith link 13 produced by the rotation of crank 9 at pin 10 is a rotation about the shaft 15 as a center. Thus the result of this quadric or double crank movement is to produce a rotation of the pin 10 about the shaft 8 as a center and the rotation of the pin 12 about the shaft 15 as a center.

Inasmuch as the shaft 8 is rotating at a constant speed from power supplied by the Reeves drive, the pin 10 will also rotate at a constant speed. The actual rotation of pin 10 may of course be resolved into two components: (1) the component in the direction of the connecting link 11 and (2) at right angles to this latter direction. It is this cutter component which will produce the actual momentary velocity of pin 12.

By this arrangement a constant velocity of link 11 produces a variable velocity of link 13 during each cycle as will be explained more fully hereafter. During each revolution of link 13, there is a time when the link at a predetermined displacement has a linear velocity synchronous with the movement of the sheet material. This

synchronous movement of the driven link and sheet at a predetermined angular displacement obtains irrespective of the speed of rotation of the constant speed driven link. The speed of the latter is changed by the Reeves drive as already explained in order to change the period of each cycle of both the driving and driven link so as to change the size of sheet cut. Notwithstanding this change in speed of the driven link however, this latter link will move at synchronous speed with the sheet at a predetermined angular displacement thereof which in turn is fixed as the cutting position at which the knives engage the sheet material for cutting.

I have discovered that in order to insure that the synchronous speed occurs at a predetermined angular displacement of the driven link, the adjustments of the constant speed link must be made through a predetermined arcuate path as will be explained in more detail hereinafter. The mechanism for accomplishing this is disclosed in the electrical controlled motor 31 which through the worm 32 and worm gear 33 drives the shaft 34 carrying for rotation therewith the worm 35. The worm 35 meshes the gear sector 36 which is mounted through the arm 39 on the shaft housing 41. As the worm gear sector 36 is turned through an angle, it in turn carries the gear 7 and the shaft 8 which is rotated about the center of shaft 5.

The gear sector 36 which is attached to the housings for both shafts 8 and 5, thereby rotates shaft 8 about shaft 5 as a center while maintaining a fixed distance therebetween. This results in a change in the distance between the centers of shafts 8 and 15 and thereby changes the length effect therebetween so that the rate of acceleration and deceleration for each cycle is changed as will be explained in more detail hereinafter.

Carried also on the shaft 34 is a worm 42 meshing with worm gear 43 which rotates shaft 44 on the other end of which is carried an indicator 45. By means of indicator 45 the angular rotation that the motor 31 should transfer to the shaft 34 for any predetermined adjustment of the Reeves drive may be predetermined so as to stop the motor when the necessary adjustment had been obtained. I may also secure automatic adjustment of the connecting links for each change in the Reeves drive produced for different lengths of a sheet material. This is accomplished by extending the shaft 34 to a worm 46 which meshes with a worm gear 47 driving the shaft 48 which in turn, through screw 49 and fork 51, adjusts the belt of the Reeves drive corresponding to the adjustment made by the motor of the adjusting mechanism. It will be understood that the construction of the Reeves drive and of the length is such that a corresponding adjustment will be obtained.

In order to clearly describe the operation of the quadric chain, a geometric analysis has been made as illustrated in Figures 3, 4, 5, 6, 7, 8 and 9.

Figure 4 shows the quadric chain of Figures 1 and 2 reduced to a plane for convenience. The constant speed crank 9 of Figure 1 is represented by OA, with the center of rotation at O. The variable speed crank 13 is represented by O'A' with the center of rotation at O'. The connecting link 11 is represented by AA'. The chain is here shown in an arbitrarily assumed position and is assumed to be rotating in the direction shown by the arrows.

If the chain is so proportioned that both cranks OA and O'A' may indefinitely turn in the same

direction of rotation, the link will in its resultant motion determine an envelope E. By definition AA' remains always tangent to the envelope E. The point of tangency P is the foot of the perpendicular to AA' dropped from the instantaneous center C, the point of intersection of the cranks (produced if necessary). The envelope E crosses the line of centers of rotation O, O' (the line ab) at Q.

With these values it is now possible to determine the speed ratio of the driving and driven cranks OA and O'A' in the following manner: If ω is the angular speed of the crank OA and ω' is the angular speed of the crank O'A', then the speed ratio of the two cranks at any instant is

$$\frac{\omega'}{\omega} = \frac{r}{r'}$$

where r is OR and r' is O'R'.

These lines, called the virtual radii, are respectively the perpendicular distances of AA' to the centers of rotation O, O'. The line AA', produced if necessary, intersects the line of centers of rotation, i. e., ab, at S. The triangles SOR and SO'R' are similar. Therefore,

$$\frac{OR}{O'R'} = \frac{SO}{SO'}$$

that is,

$$\frac{\omega'}{\omega} = \frac{SO}{SO'}$$

$SO = OO' + SO'$. Accordingly,

$$\frac{\omega'}{\omega} = \frac{OO' + SO'}{SO'} = \frac{OO'}{SO'} + 1$$

Accordingly, if the centers of rotation O, O' remain fixed,

$$\frac{\omega'}{\omega}$$

will increase as SO' decreases and it will reach a maximum value when SO' becomes a minimum. As will be shown in the following this minimum of SO' is obtained when S becomes coincident with Q.

As the chain continues to rotate, the link will finally reach the position shown in Figure 5 where it is still tangent to the envelope E but now at the point of intersection Q of the envelope with the line of centers of rotation. At this position the points S, P and Q coincide with each other. Inasmuch as AA' remains always tangent to E, the point S will never lie within the envelope, having Q as a limit beyond which it cannot go. Accordingly, the minimum value that SO' can assume is QO' . Therefore, the maximum speed ratio

$$\frac{\omega'}{\omega}$$

will be attained at this position when AA' is tangent to E at Q.

It will now be clear that by this method it is possible to determine the maximum speed which the driven crank O'A' may attain for a predetermined speed of the crank OA with predetermined dimensions of links and with relative centers of rotation O, O' fixed. In order to determine this value, however, it is not necessary to draw the envelope E. Inasmuch as CP must always be perpendicular to AA', it is sufficient to bring the link into such a position that its point of intersection S with the line of centers ab is also the foot of the perpendicular, dropped from C to the link AA'. This is clearly shown in Figure 5, where the line CP is really the line CS since S and P coincide.

As will appear more fully hereinafter, the cutting period occurs at the time when the driven crank is rotating at its maximum speed and this maximum speed is therefore to be maintained fixed irrespective of the change in velocity of the driven member by its Reeves drive, the latter occurring, of course, in order to produce different lengths of sheets. Moreover, it is also essential that the angular position of the driven link at which this fixed maximum speed occurs shall also be fixed, inasmuch as the knives secured to the driven link are not adjustable with respect to the link and must engage the cutting sheet at the maximum speed. In order to secure the latter condition it is necessary, as will be shown in the following, to produce an angular rotation of the driving link about a predetermined center for each change in velocity produced by the Reeves drive.

It will be apparent at the outset that when the speed of the driving link is changed, its center must be shifted with respect to the center O' in order that the maximum speed of the driven link determined by the maximum ratio of the driving and driven speeds be such that the driven link will still have a maximum speed which is equal to the speed of the paper at the cutting period.

Assuming the center of rotation O' of the variable speed crank is fixed, then as the distance O, O' is varied in order to obtain different maximum speed ratios, the corresponding location of the center of rotation O of the constant speed or driving crank will in general if chosen arbitrarily be such that the position of the crank O'A' at the time of maximum speed ratio will not be the same with respect to a fixed line as, for example, the line O'V (Figure 6). As shown in Figure 6, there are three positions O₁, O₂ and O₃ of O, all lying in a straight line with O' having been assumed. Here the positions for maximum speed ratios of the crank O'A' are the distinct positions O'A'₁, O'A'₂, O'A'₃, making correspondingly distinct angles ϕ_1 , ϕ_2 , ϕ_3 with O'V. It will be understood, of course, that these positions were determined in accordance with the rule set down above in connection with Figures 4 and 5 and that for each of these positions a curve corresponding to E could be determined although for purposes of clarity it is not shown in Figure 6.

The set of curves C₁, C₂ and C₃ in Figure 7 further illustrate this. They represent graphically the speed ratios

$$\frac{\omega'}{\omega}$$

as a function of the angular displacement ϕ of O'A' of the driven crank with reference to the arbitrarily selected reference line O'V for the three positions O₁, O₂, O₃ of O in Figure 6. Thus it will be seen that the peaks or maximum points m_1 , m_2 , m_3 , Figure 7, of the curves, corresponding to the maximum speed ratios, have individual abscissa positions so that the driven crank reaches the synchronous speed of the paper at an independent angular position for each position of center O₁, O₂, O₃. The fourth curve C corresponds to the case in which the centers of rotation O, O' coincide, being one in which the speed ratio is throughout unity.

It will be noted, however, that this is exactly the condition which must be avoided. As pointed out above, it is essential not only that the driven crank reach a fixed maximum speed for cutting which is the same for all speeds of the driven

crank as produced by the Reeves drive but it is also essential that this maximum speed occur at the same angular displacement of the driven crank so that the knives will reach their maximum speeds at the instant when they start cutting.

I have discovered the locus of the different positions of the movable center O such that the position of the driven crank O'A' at the time of maximum speed ratio will remain fixed and predetermined as the distance O, O' is varied. This locus is a circle with O' on its circumference and having a center at G (Figure 8). This circle can be determined by locating two widely separated points, such as O₁ and O₂ in addition to O', using the principle already outlined for establishing the maximum speed ratios.

In order to determine such positions, as for example, O₁, the link AA' is selected arbitrarily. Then by trial and error a point such as O₁ is found which when joined with O' produces a line whose extension intersects AA' at a point which is the foot of the perpendicular drawn from the instantaneous center of the two cranks.

Figure 9 shows the speed ratio curves obtained with the arrangement of Figure 8. As will be noted, the curves here show the maximum points having a common abscissa ϕ ; that is to say, the driven cranks reach their maximum speed ratios and therefore their predetermined fixed maximum speed at the same angular displacement and therefore the knives start cutting the sheet invariably at the angular position at which they are at maximum speed or in synchronism with the paper.

Figure 3 shows a set of three curves giving the circumferential speed of the knives as obtained with the mechanism shown in Figure 2 where the circular principle of adjustment of Figure 8 is employed. The maximum circumferential speeds are brought to the same value and made equal to the speed of the corrugated board by giving the constant speed crank suitable angular velocities through the Reeves drive while at the same time rotating the constant speed or driving link through an arc whose center is G. This is accomplished as shown in Figures 1 and 2 by pinion and gears 6 and 7 which mesh with each other and are arranged so that the shaft 8 which is the center of the driving and constant speed link 9 rotates about the center of shaft 5 which is the center G for each adjustment of the Reeves.

It will be observed by comparison of Figure 5 and Figure 1 that the relative positions of the links are about the same so that the links in Figure 1 are at a position at which the driven link is about to reach its maximum speed and, as will be observed, the knives are in a position at which they are about to start cutting.

I claim:

1. In a mechanism for cutting continuously moving strip material, a cutting mechanism; a source of driving power therefor; and a first arm having an individual center about which said arm rotates, said arm being driven from said source of power; a second arm connected to and driving said cutting mechanism; and a link connecting said first and second arms, said first and second arms and said link connecting said cutting mechanism and said source of driving power for driving said cutting mechanism at variable speed throughout a cycle and at a predetermined speed during a predetermined portion of the cycle.

2. In a mechanism for cutting continuously moving strip material, a cutting mechanism; a

source of driving power therefor; a first arm having an individual center about which said arm rotates, said arm being driven from said source of power; a second arm connected to and driving said cutting mechanism; and a link connecting said first and second arms, said first and second arms and said link connecting said cutting mechanism and said source of driving power for driving said cutting mechanism at variable speed throughout a cycle and at a predetermined speed during a predetermined portion of the cycle; and means for changing the period of the cycle of said cutting mechanism to change the size of strip material while maintaining said cutting mechanism at said predetermined speed during said predetermined portion of the cycle.

3. In a mechanism for cutting continuously moving strip material, a cutting mechanism; a source of driving power therefor; and a first arm connected to said source of power, a second arm turning about its individual center and connected to said cutting mechanism, and a connecting link between said first and second arms, said arms and link connecting said cutting mechanism and said source of driving power for driving said cutting mechanism at variable speed throughout a cycle and at a predetermined speed during a predetermined portion of the cycle.

4. In a mechanism for cutting continuously moving strip material, a cutting mechanism; a source of driving power therefor; a first arm turning about its individual center and connected to said source of power, a second arm connected to said cutting mechanism, and a connecting link between said first and second arms, said arms and link connecting said cutting mechanism and said source of driving power for driving said cutting mechanism at variable speed throughout a cycle and at a predetermined speed during a predetermined portion of the cycle; and means for changing the period of the cycle of said cutting mechanism to change the size of strip material while maintaining said cutting mechanism at said predetermined speed during said predetermined portion of the cycle.

5. In a mechanism for cutting continuously moving strip material, a cutting mechanism; a source of driving power therefor; a first arm turning about its individual center and connected to said source of power, a second arm connected to said cutting mechanism, and a connecting link between said first and second arms, said arms and link connecting said cutting mechanism and said source of driving power for driving said cutting mechanism at variable speed throughout a cycle and at a predetermined speed during a predetermined portion of the cycle; and means for changing the period of the cycle of said cutting mechanism to change the size of strip material while maintaining said cutting mechanism at said predetermined speed during said predetermined portion of the cycle, said last means comprising means for shifting the center of rotation of said first arm about a predetermined center.

6. In a mechanism for cutting strip material, a first shaft; a source of power for driving said shaft; a second shaft; knife cutting mechanism driven by said second shaft; a positive drive connection between said first and second shafts; and means for shifting said first shaft in an arcuate path about a predetermined center for varying the ratio of speed transfer therebetween.

7. In a mechanism for cutting strip material, a first shaft; a source of power for driving said shaft; a second shaft; knife cutting mechanism

driven by said second shaft; a positive drive connection between said first and second shafts, said positive drive connection comprising arms connected to each of said shafts and a link connecting said arms; and means for shifting said shafts with respect to each other for varying the ratio of speed transfer therebetween.

8. In a mechanism for cutting strip material, a first shaft; a source of power for driving said shaft; a second shaft; knife cutting mechanism driven by said second shaft; a positive drive connection between said first and second shafts, said positive drive connection comprising arms connected to each of said shafts and a link connecting said arms; and means for shifting said first shaft in an arcuate path about a predetermined center for varying the ratio of speed transfer therebetween.

9. In a power transmission system, a source of driving power; a shaft driven by said source; a first arm mounted on and rotatable with said shaft; a driven shaft; a second arm rigidly mounted thereon for driving said shaft; and a link connecting said first and second arms; and means for changing the speed ratio between said driving and driven shafts.

10. In a power transmission system, a source of driving power; a shaft driven by said source; a first arm mounted on and rotatable with said shaft; a driven shaft; a second arm rigidly mounted thereon for driving said shaft; a link connecting said first and second arms; and means for changing the speed ratio between said driving and driven shafts, said means comprising mechanism for changing the relative position of said driving and driven shafts.

11. In a power transmission system, a source of

driving power; a shaft driven by said source; a first arm mounted on and rotatable with said shaft; a driven shaft; a second arm rigidly mounted thereon for driving said shaft; a link connecting said first and second arms; and means for changing the speed ratio between said driving and driven shafts, said means comprising mechanism for moving said driving shaft through an arc about a predetermined center.

12. In a power transmission system, a source of driving power; a shaft driven by said source; a first arm mounted on and rotatable with said shaft; a driven shaft; a second arm rigidly mounted thereon for driving said shaft; a link connecting said first and second arms; means for changing the speed ratio between said driving and driven shafts, said means comprising mechanism for changing the relative position of said driving and driven shafts; and means for changing the speed of rotation of said source of power and for simultaneously moving said first shaft about said arc through a predetermined angle.

13. In a power transmission system, a source of driving power; a shaft driven by said source; a first arm mounted on and rotatable with said shaft; a driven shaft; a second arm rigidly mounted thereon for driving said shaft; a link connecting said first and second arms; means for changing the speed ratio between said driving and driven shafts, said means comprising mechanism for moving said driving shaft through an arc about a predetermined center; and means for changing the speed of rotation of said source of power and for simultaneously moving said first shaft about said arc through a predetermined angle.

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