

Oct. 14, 1941.

A. F. SHIELDS

2,258,816

CYCLICAL KNIFE ADJUSTMENT

Filed Feb. 10, 1940

4 Sheets—Sheet 1

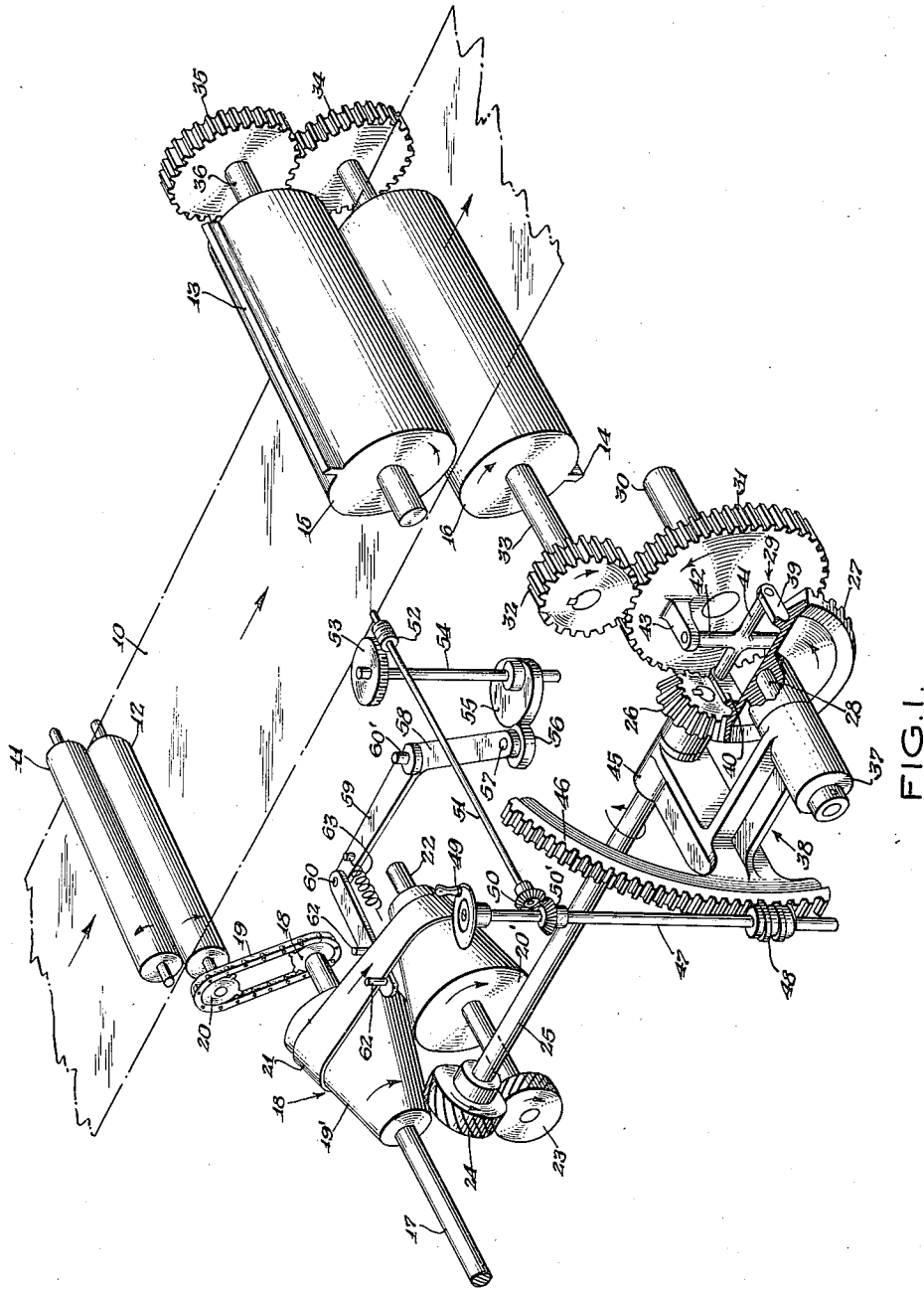


FIG. 1.

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4 Sheets-Sheet 2

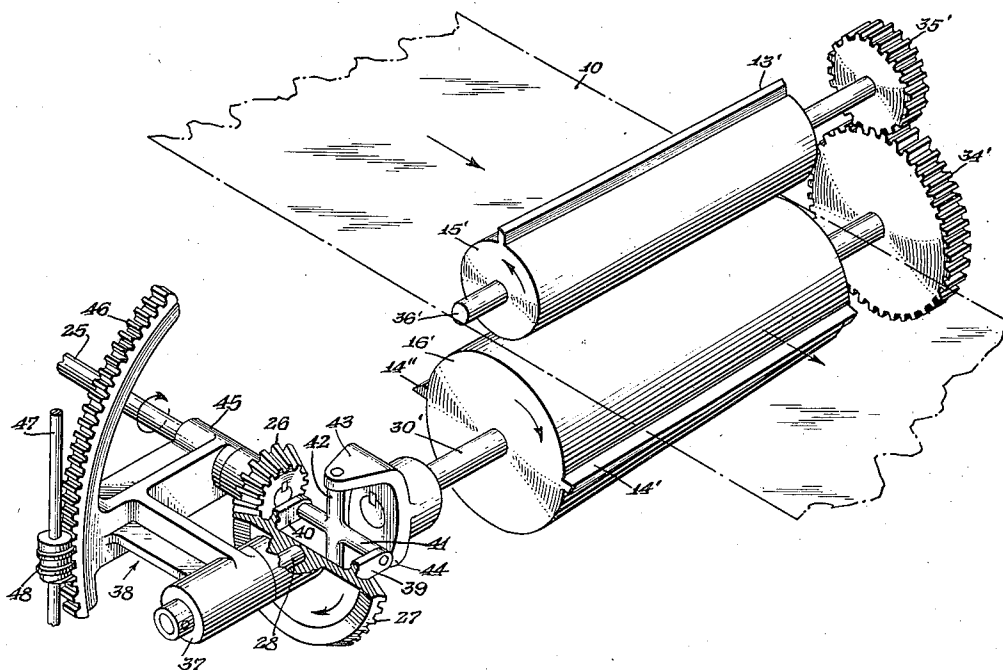


FIG. 2.

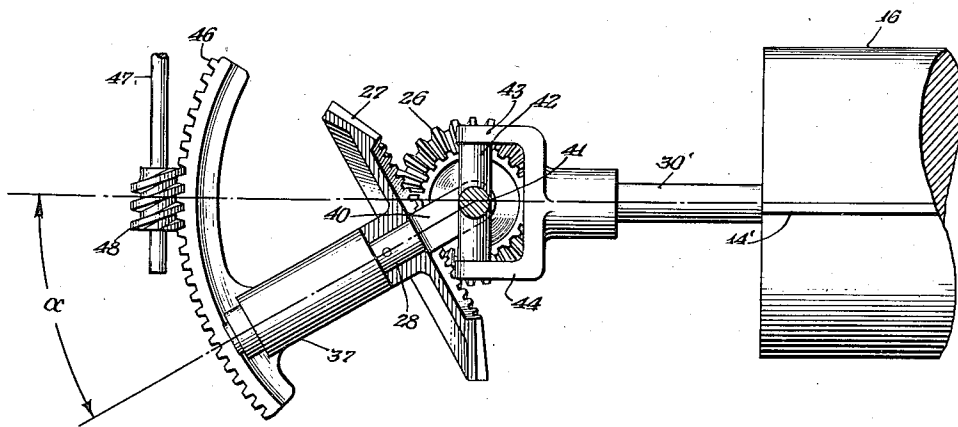


FIG. 3.

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4 Sheets-Sheet 3

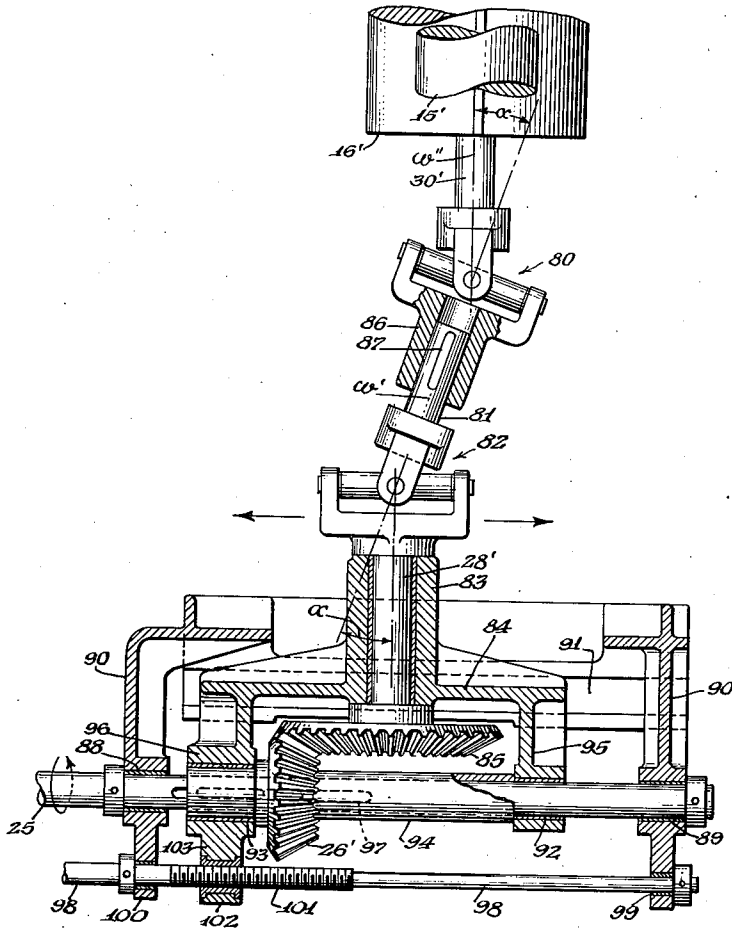


FIG. 4.

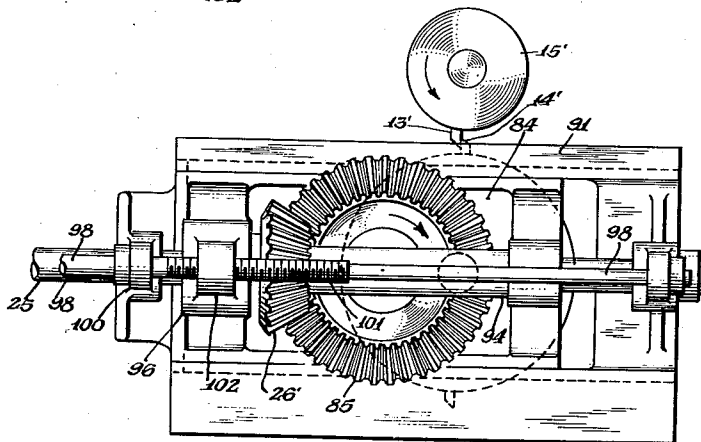


FIG. 5.

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4 Sheets-Sheet 4

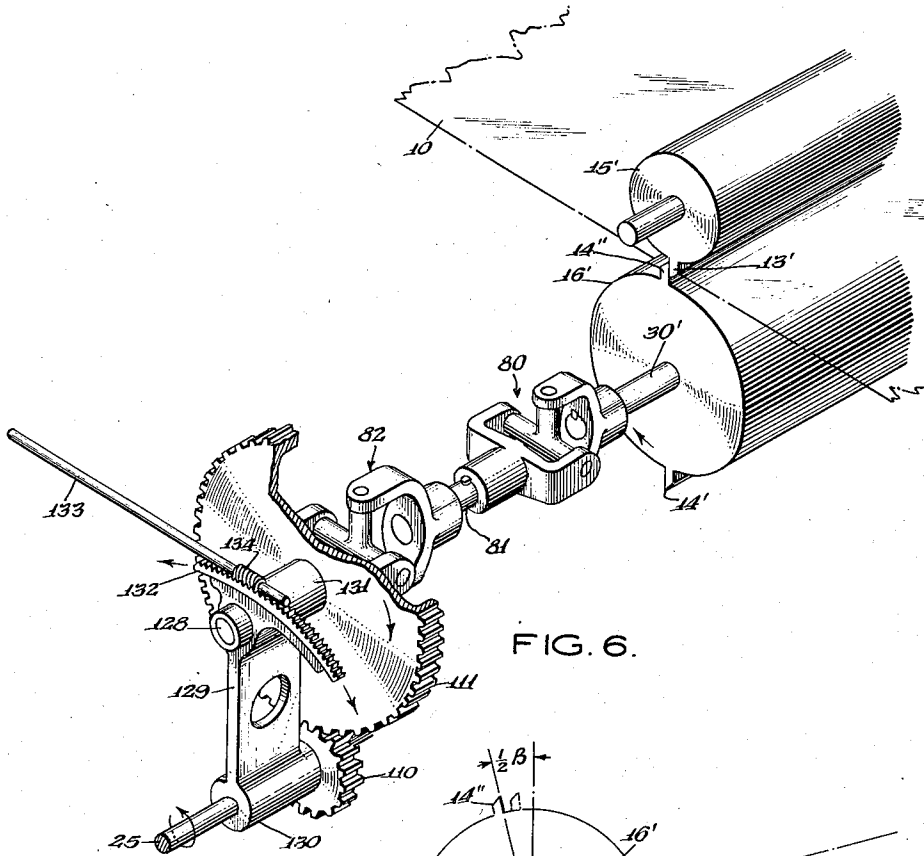


FIG. 6.

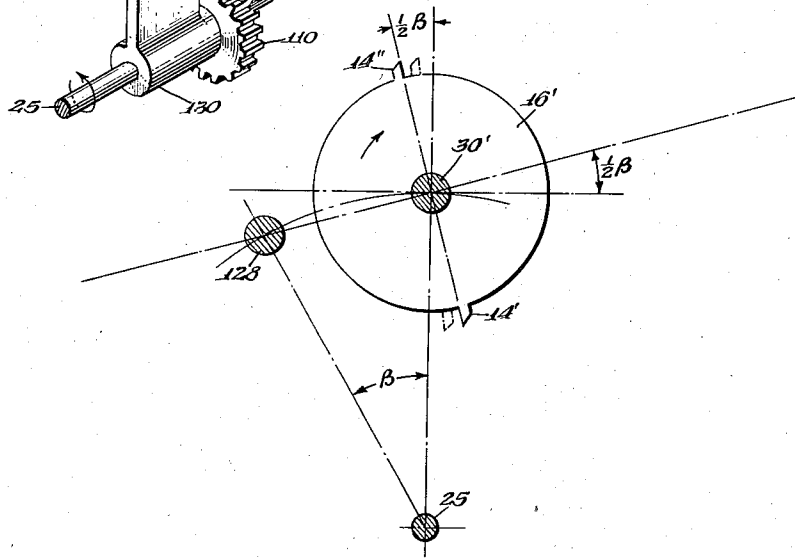


FIG. 7.

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UNITED STATES PATENT OFFICE

2,258,816

CYCLICAL KNIFE ADJUSTMENT

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Application February 10, 1940, Serial No. 318,294

19 Claims. (Cl. 164—68)

This invention relates to cutting knives and more particularly to synchronously operated knives adapted to cooperate with a continuous web moving at a constant speed and arranged to cut sheets of predetermined length without interfering with the continuous movement of the web and irrespective of the average circumferential speed of the knife.

For this latter purpose, this invention also relates to the means for varying the circumferential speed of rotating knives during a cycle thereof so that while the average circumferential speed may be different from the linear speed of a continuous web with which the knife cooperates, the circumferential speed during the period when the cutting operation takes place will be the same as the linear speed of the web.

Ordinarily where sheets of only one particular length are to be cut from a continuously moving web, the circumference and speed of rotation of the knife drum may be so arranged that the circumferential speed of the knife blade will always be equal to the linear speed of the continuous web. The knife blade meets the web once during each revolution, effecting the cutting operation as it passes along with the web at the speed of the web, and then meeting the web once more at a distance from the original cut equal to the length of sheet desired. Problems of adjustment arise when sheets of different length must, at different times, be cut by the same machine.

The problems of adjustment of circumferential speed of the knife during a single revolution thereof so that the knife will be moving at the speed of the paper during the actual cutting operation and so that the average speed of rotation of the knife drum may be such as to give the predetermined sheet length which will not necessarily be that produced by ordinary pure synchronous rotation of the knife drum have been solved in various different ways.

Thus, for instance, the shaft transmitting power to the knife drum has not been connected directly to the knife drum itself but a device producing an eccentric type of connection has been used in order that the effective radius of rotation of the power transmission shaft be varied once during a particular revolution of the knife drum. This has been accomplished, for instance, by the crank and bifurcated arrangement shown in Patent No. 2,070,386, or by the quadric chain arrangement shown in application Ser. No. 2,208,350, issued July 16, 1940, or by

other means such as that shown in application Ser. No. 320,571, filed Feb. 24, 1940.

Although a universal joint is commonly known and understood, nowhere in the prior art or in the industry has there been any demonstration or teaching of the use thereof in connection with rotating knives, the speed of rotation of which may be varied with respect to the continuously moving web in order to obtain cut-off sheets of different lengths (the speed of the knife drum being varied so that it will be exactly that of the continuously moving web during the cutting operation).

The novelty of the present invention resides therefore in the use of a universal joint forming part of the power path to the cutting knives for the purpose of cyclically adjusting the speed of the cutting knives so that whatever the average speed thereof, they will be traveling at the same speed as the continuously moving web with which they cooperate at the time that the actual cutting process is taking place, the predetermined average speed of the knives for selected sheet lengths being nevertheless maintained by a change of speed of the rotation of the cutting knives in an opposite sense (either a slowing-down or speeding-up) during the remainder of the revolution thereof.

Objects of this invention, therefore, are to provide in connection with cutting knife mechanisms which are to operate cyclically upon continuously moving webs for the purpose of cutting sheets of predetermined length therefrom, means for adjusting the cyclical speed of the knives to that of the continuously moving web during the interval during which cutting takes place.

Still a further and most important object of the present invention is to provide for such automatic adjustment by providing a universal joint in the power path to the cutting knives.

Still another object of this invention is to provide a means for varying the angle formed between the shaft connected by the universal joint for the purpose of changing the cyclical variation in the speed of rotation of the cutting knives in order to enable the cutting of different sheet lengths.

Other objects and uses of the present invention will in part be apparent and in part be pointed out in the following description and drawings in which:

Figure 1 is a schematic view in perspective showing the general organization of my invention with particular emphasis on the provision

of a universal joint in the power path to the rotating cutting knives for the purpose of impinging upon the average rotation thereof, a cyclical variation in such rotation.

Figure 2 illustrates a slightly modified form of the apparatus of Figure 1 showing an arrangement of the cutting knives which utilizes each of the variations induced by the universal joint as hereinafter explained.

Figure 3 is an end view of Figure 2 showing the universal joint adjusted for a position which induces cyclical variations in the speed of rotation of the cutting knives.

Figure 4 illustrates in top plan view partly in cross-section a modified form of the construction of either Figure 1 or 2 wherein the universal joint angle may be varied in a different plane for accomplishing the same purpose.

Figure 5 is an end view of Figure 4.

Figure 6 illustrates in diagrammatic perspective a slight modification of the form shown in Figure 4 wherein the angle of the universal joint may be varied in two planes.

Figure 7 is a diagram illustrating the variations in position of the members of Figure 6.

Referring now to Figure 1, it should be noted that the position of the universal joint here shown is such that no cyclical variation in the speed of rotation of the cutting knives will ensue while when the universal joint is moved so that the shafts which it connects are no longer coaxial, to for instance a position similar to that shown in Figure 3, cyclical variation in the speed of rotation of the cutting knives will be effected.

In Figure 1 I have shown a cutting machine wherein the continuously moving web 10 is fed by the feed rollers 11 and 12 in the direction indicated by the arrows between the cutting knives 13 and 14 which are respectively mounted on the drums 15 and 16. The speed of movement of the continuous web 10 is constant, the feed rollers 11 and 12 being caused to rotate at the constant speed by power transmitted thereto from the power shaft 17, sprocket 18, chain 19 and sprocket 20.

The knife drums, however, are not connected directly to the power shaft although they are driven from the shaft. Where, for instance, a continuous web is moving at a speed of 120" per minute and it is desired to obtain 30" sheets therefrom, it will be necessary for the drums of the knife shaft to rotate four times per minute. Where a variation is desired and 60" lengths are required, then the knife drums must be caused to rotate twice per minute while for 120" lengths the knife drums must rotate once per minute.

Owing to the fact that corrugated sheet material is fairly heavy, it is necessary to have a shearing action in cutting the sheet material so that the sheet material is cut not at a single moment but over a relatively short period. During this short period, whatever the average speed of rotation the knife drums require in order to obtain sheets of desired length, it is necessary that the knives themselves move at the exact speed of the paper, any speeding up of the knife drums necessary to accomplish this purpose being compensated for by a corresponding slowing down of the knife drums at a time when the knives are not in engagement with the sheet.

In order to provide for variations in the speed of rotation of the knife drums and in order to obtain sheets of varying length, a Reeves drive 18 is interposed in the power path between the

power shaft 17 and the knives. The Reeves drive comprises as will be noted, cones 19 and 20 and belt 21 interconnecting the two. Movement of the belt back and forth upon the cones will result in variations in speed imparted to the shaft 22 of the Reeves drive in a manner which is now well known in the art.

Shaft 22 of the Reeves drive is keyed to and drives gear 23 which meshes with gear 24 which in turn is keyed to shaft 25 and drives the same. Shaft 25 carries at the opposite end thereof bevel gear 26 which meshes with bevel gear 27 thus causing shaft 28 to rotate which through the universal joint 29 causes the shaft 30 and its associated gear 31 to rotate.

Rotation of gear 31 causes the rotation of gear 32 which in turn causes shaft 33 to rotate thereby rotating knife drum 16 which carries the knife 14. Rotation of shaft 33 likewise through gears 34 and 35 causes rotation of shaft 36 which in turn rotates the knife drum 15 carrying the knife 13.

Variation in average speed of rotation of the knife drums is accomplished therefore by movement of the belt 21 of the Reeves drive upon the cones thereof in order to obtain variations in the speed of the shaft 25 in a manner well known in the art.

With the universal joint in the position shown in Figure 1, no other variation in the speed of rotation of the knife drums 15 and 16 occurs. But when the shaft 28 is moved to a position similar to that shown for instance in Figure 3 where it is no longer coaxial with shaft 30 but rather it is at an angle thereto, cyclic variations in the speed of rotation of shaft 30 and consequently in the speed of rotation of drums 15 and 16 and their associated knives will occur.

In order to provide an adjustment which will readily move the shaft 28 to a position at an angle to and non-coaxial with the shaft 30 bearing gear 31 and therefore in order to provide a means for cyclically varying the speed of rotation of the drums 15 and 16, I have added the series of adjustments shown particularly in Figure 1. Thus the shaft 28 is rotatably mounted in the sleeve 37 which is part of a casting 38 hereinafter more particularly described. The shaft 28 also carries either keyed thereto or as a part thereof the bevel gear 27 and also carries the tangs 39 and 40 for rotatably supporting the rod 41 of the universal joint.

When bevel gear 26 therefore rotates bevel gear 27 and causes a rotation of the shaft 28 it likewise by means of the tangs 39 and 40 causes a rotation of the rod 41 of the universal joint 29. This rod 41 is integral with rod 42 of the universal joint 29 and is at right angles thereto.

Rod 42 of the universal joint is rotatably supported in the tangs 43 projecting from the face of the gear 31 which may be regarded as an extension of the shaft 30. The casting 38 pivots about the shaft 25 on its sleeve 45. The casting 38 also carries a segment of a worm gear wheel. Control shaft 47 carries at one end thereof the spiral gear 48 which meshes with the teeth of the gear segment 46. Rotation of the control shaft 47 by, for instance, the handle 49 will cause a corresponding rotation of the spiral gear 48. The control shaft is mounted in such manner that it cannot shift longitudinally along its axis. Therefore rotation of the spiral gear 48 will result in a corresponding movement in one direction or the other of the segment. Since the segment 46 is integral with or securely attached

to the casting 38, movement of 46 about the pivoting point 45 will cause the entire casting to rotate about the sleeve 45 and to thereby cause the sleeve 37 supporting the shaft 28 to also rotate thus placing the shaft 28 at an angle with respect to the shaft 30 in the manner shown in Figure 3.

Power, however, is continuously being transmitted to the shaft 28 from the bevel gear 26 through the bevel gear 27 which continuously remains enmeshed whatever the angular position of the shaft 28 with respect to the shaft 30 so that whatever the angle at which the universal joint is placed, the power transmitted to shaft 28 is always constant and unvarying.

I have found that when the shaft 28 is at an angle to the shaft 30 as for instance in the manner shown in Figure 3, then although the shaft 28 rotates at a constant speed, the rotation of shaft 30 will vary cyclically. Thus when the shaft 28 is at an angle such as that shown in Figure 3 with respect to the shaft 30 and when the rods 42 and 41 of the universal joint are in the position shown with respect to each other, and with respect to the angle formed between the shafts, then the shaft 30 will be rotating at a speed which is less than that of the speed of rotation of the shaft 28. When the shaft 28 has rotated through 90° so that the rods 41 and 42 of the universal joint also have removed to a position 90° from that shown in Figure 3, then the speed of the rotation of shaft 30 will be correspondingly greater than the speed of rotation of shaft 28.

In this case it will be noticed therefore that there are two maximum speeds and two minimum speeds of rotation of shaft 30 in a single cycle, while the average speed of rotation of shaft 30 is the same as that of shaft 28. The variations from maxima to minima in the speed of shaft 30 will vary in accordance with the angle which shaft 28 is caused to assume with respect to shaft 30.

Since there are two maximum speed positions and two minimum speed positions in a single rotation of shaft 30 then the variation from the lowest speed to the highest speed takes place within an arc of 180°. By a proper adjustment of the control shaft 47 and proper corresponding adjustment of the belt 21 of the Reeves drive 18, the cutting operation may be caused to take place at any desired point over any desired interval of said 180° at the moment when the circumferential speed of rotation of the knife shaft is the same as that of the linear movement of the continuous web. Preferably, however, the cutting operation should take place at either a maximum point or a minimum point and the knives are so arranged that they will register with the paper only at maximum or minimum points.

Since a complete cyclical variation in the speed of rotation of the shaft 30 can take place once in each 180°, that is, the shaft may reach its maximum speed and drop to its minimum speed within 180° and since it will reach two such maximum within a full rotation of 360° then such elements may be utilized and the knife shafts may be caused to rotate twice for every single revolution of the shaft 30 so that there will be only one maximum and one minimum cyclic speed within any single revolution of the knife shafts.

In order to accomplish this, gears 31 and 32 are in two to one ratio so that the shaft 33 rotates at twice the speed of shaft 30.

By proper calculation, calibration, testing and adjustment, the exact relationship between the angle at which the universal joint is placed and the position at which the belt 21 of the Reeves drive is placed may be obtained and since any movement of the belt 21 of the Reeves drive must necessarily require a corresponding movement of the shaft 28 to a different angle with respect to the shaft 30 then the two motions may be inter-related and the very control shaft 47 which controls the angle which shaft 28 reaches with respect to shaft 30 may also be used to control the position of the belt 21 in the Reeves drive.

Thus bevel gear 50' on the control shaft 47 may mesh with bevel gear 50 at one end of shaft 51, the opposite end of shaft 51 carrying the worm gear 52 which in turn meshes with the gear 53 carried by the shaft 54. Rotation therefore of the handle 49 of the shaft 47 results as has been noted in rotation of shaft 47 causing an adjustment of the universal joint such rotation also resulting in a corresponding rotation of shaft 51 resulting also in a rotation of shaft 54.

Rotation of shaft 54 results in rotation of the cam 55 which bears upon the rotatable wheel 56 which is pivoted at 57 to the lever 58. Movement of the cam 55 will cause a change in the position of the wheel 56 with respect thereto and consequently will cause a movement of the lever 58 about its fulcrum 59.

Such movement of the lever 58 about its fulcrum 59 will, through the pin 60 and the link 61 carrying the members 62 which engage the belt, cause a corresponding movement of the belt 21 upon the cones of the Reeves drive.

Spring 63 will tend to cause a movement of the lever in the opposite direction from that induced by the eccentric 55 and therefore will cause the wheel 56 to bear against the eccentric 55, the motion of the eccentric 55 counteracting the force exerted by the spring 63.

Consequently, a single adjustment or rotation of the handle 49 will result in a variation in speed of rotation of the knife shaft in order to produce a sheet of a different length while at the same time resulting in a variation of the angle which shaft 28 assumes with respect to shaft 30 in order to cause the appropriate cyclical variation in speed of rotation of the knife shafts in order that the knives will be traveling at the speed of the sheet during the interval when the cutting takes place.

There are many other methods of inter-connecting this adjusting mechanism which will now be clear; the method here described is but one of several methods for accomplishing this result.

In the slight modification of Figure 2, I have shown a means whereby the gears 31 and 32 of Figure 1 may be dispensed with by a modification of the drum 16 of Figure 1. The drum 15 retains the same relative circumference in both Figures 1 and 2 while the drum 16' of Figures 2 and 3 instead of being of the same circumference and diameter as drum 15 is twice the circumference thereof.

By placing knife blades 14' and 14'' along the drum 16' and 180° removed from each other, it becomes possible without doubling the speed of shaft 30' with respect to the shaft 28 to utilize both of the maximum and minimum cyclic speeds induced by the universal joint. That is, each of the two maximum speeds obtained during one cycle by reason of the interposition of the universal joint between the two shafts is utilized during a single cycle of the drum 16' (where for

instance the cutting operation is to take place at the interval of maximum speed). Thus at one maximum interval knife 14' will be in engagement with knife 13', while at the second maximum interval during the same cycle knife 14' will be in engagement with knife 13'.

Drum 15 may in one embodiment have the same diameter as drum 16' and a pair of knives 180° removed from each other in the same way to engage with the two knives of drum 16'. However it is possible and I prefer that the drum 15 have but the single knife 13' to engage once during each revolution of drum 15 with one of the knives of drum 16' and to engage once during each revolution of 16' alternatively with both of the knives of the latter drum.

For this purpose drum 15 (of Figure 2) should rotate so that the knife 13' is adjacent the sheet twice during every revolution of drum 16' and accordingly drum 15 should revolve at twice the speed of drum 16'.

Consequently gears 34' and 35' are in exact 2 to 1 ratio in order to double the speed of drum 15 with respect to drum 16'. Cyclic variations in speed may of course be accomplished in exactly the same manner and by the same apparatus as previously described in connection with Figure 1.

Various modifications and alternations of the form in which the universal joint is used are, of course, possible, the underlying essential element being at all times the interposition of the universal joint so that the angle between the power transmitting shaft and the driven shaft of the knife drum is variable for the purpose of varying cyclic speed.

Thus in the form shown in Figures 4 and 5, I have shown a modification in which the Reeves drive connections and other connections of the apparatus may be the same as that for Figures 1 to 3 inclusive but wherein a compound universal joint arrangement is used so that the variation of the angle may be accomplished without moving shafts out of a single horizontal plane and wherein each joint is subjected to only half the angle of Figure 1 while producing the same overall angle. All of the apparatus (not shown) of Figure 4 up to and including the power shaft 25 is exactly the same as that hereinbefore described.

Shaft 30' of the knife drum terminates in a universal joint 80 which connects the shaft 30' with the shaft 81. Shaft 81 also terminates in a universal joint 82 which connects the shaft 81 with the power transmitting shaft 28'. Power transmitting shaft 28' rotates within the sleeve 83 which is a part of the sliding frame member 84. The opposite end of power transmitting shaft 28' carries the bevel gear 85. Bevel gear 26' rotated by the power shaft 25 meshes with the bevel gear 85 and thus causes a rotation of the shaft 28' which through universal joints 80 and 82 and shaft 81 results in the rotation of knife drum shaft 30' and therefore of the knife drums.

It will be seen that sliding of the frame member 84 back or forth in the direction indicated by the arrows will result in a change of the angles which the universal joints 80 and 82 assume between their respective shafts.

The important angle of course is that between shafts 81 and 30'. But as shown, the universal joints 80 and 82 are so arranged that they are continuously in similar relationship to their respective shafts, that is, when one universal joint is in position to result in a maximum speed increase during any particular cycle between the

power transmitting and operating shafts then the other universal joint is in exactly the same relationship. Thus in the position shown in Figure 4, the universal joint 82 is at a position between power transmitting shaft 28' and the operated shaft 81 at that moment of cyclic operation when the operated shaft 81 has reached its maximum cyclic speed.

Thus the two universal joints 82 and 80 do not cancel the effect of each other but rather tend to multiply their effect producing a desired maximum speed with less angularity for each of the two universal joints than would be required in the case of a single universal joint direct connection between the power transmitting shaft and the knife carrying shaft.

It is, of course, obvious that when the power transmitting shaft 28' is at a position furthest removed from coaxial relationship with the shaft 30' there is a greater distance between them than when the shaft 28' has reached a position substantially coaxial with shaft 30'. The universal joint 80 is therefore not connected directly to shaft 81 but is rather connected to a sleeve 86 which is slidably connected to shaft 81 by means of a feather key registering with the slot 87 of the shaft 81 in such manner that the sleeve 86 rotates with the shaft 81 but is free to move longitudinally thereof and thus in effect to lengthen and shorten said shaft and thus further compensate for any change in distance between shafts 28 and 30' occasioned by movement of the slide 84 and the shaft 28' in the directions indicated by the arrows.

It should be noted that in the present modification the end of the power shaft 25 shown in the drawing of Figure 5 rotates in the bearings 88 and 89 of the frame 90. The frame 90 carries the slide member 84 by means of suitable trackways or grooves 91 in the frame 90 which register with members of the slide 84 so that the frame 90 provides a key way or track way within which the slide member 84 may travel in a direction longitudinal to the shaft 25. By reason of these guides, the slide member 84 is fixed with respect to the frame 90 and does not rotate with the shaft 25, the shaft 25 rotating also in bearings 92 and 93 of the slide member 84.

The bevel gear 26' is not mounted directly on the shaft 25 but rather is mounted on a sleeve 94 which is carried between the pillars 95, 96 of the slide member 84 and which may rotate with respect thereto. The sleeve 94 carrying the bevel gear 26' is connected by feather key 97 to the shaft 25 so that although it may slide longitudinally with respect to the shaft 25, it necessarily must rotate therewith. In this way, the bevel gear 26' rotates under the influence of the shaft 25 in the same manner as if it had been directly connected thereto but it is free to be moved longitudinally of the shaft 25. The sleeve 94 serves accurately to fix the bevel gear 26' in a continuously fixed relationship to the end pillars 95 and 96 of the slide member 84 and hence in a continuously fixed relationship to the bevel gear 85 which is likewise supported by the slide member 84 so that the two gears 26' and 85 are always in mesh.

The slide member 84 may be moved with respect to the frame 90 for the purpose of changing the angles of the universal joints 80 and 82 by means of the control shaft 98. Control shaft 98 is fixed to rotate in bearings 99 and 100 of the frame member 90 but in such a manner that the control shaft 98 is fixed within the frame mem-

ber so that it cannot move longitudinally with respect thereto. Control shaft 98 carries threads 101 which register and are in engagement with similar threads 102 of a perforation of an extension 103 of the slide member. Rotation of the control shaft 98 results obviously in rotation of the threads 101 and by reason of the engagement therewith by the threads 102 of the slide member necessarily results in movement of the slide member with respect to the control shaft. Rotation of the control shaft 98 therefore results in movement back and forth of the slide member 84 in a direction in accordance with the rotation of the control shaft.

I have here described but one means for moving the slide member 84; any other suitable means for accomplishing this purpose may be used. The control shaft 98 may be interconnected and integrated with the control of the Reeves drive in a manner substantially similar to that shown in Figure 1. By this means, a cyclic variation or a plurality of cyclic variations may be obtained in the speed of rotation of the knife drums for the purposes hereinbefore described. In this way, the use of two universal joints, each in the same relative position between their respective shaft and each arranged so that they will always make the same angle between their respective shafts and thereby have an additive effect which will thus create the desired variation in cyclic speed with a smaller adjustment.

It should be noted that owing to the fact that shafts 28' and 30' are so fixed with relation to each other that when they are not coaxial they must necessarily be parallel to each other insures that the shaft 81 which constitutes a straight line intersecting these two parallel shafts must always in every adjustment form angles of equal degrees with respect to each shaft 28' and 30', thereby assuring that universal joints 80 and 82 will always be at the same angle.

In Figure 6 I have illustrated a slight modification of the construction of Figure 4 wherein the same double universal joint connection is used but wherein a gear segment instead of the sliding frame member arrangement of Figure 4 is used in order to obtain the adjustment. However, the power transmitting and ultimate power receiving shaft of the knife drum are continually and must necessarily remain in parallel relation to each other for the reasons before described.

Power transmitting shaft 25 of Figure 6 terminates in gear 110 which meshes with gear 111 which therefore rotates the power transmitting shaft 128. The rotation of gear 111 and power transmitting shaft 128 results in rotation of the shaft 81 through the universal joint 82, the rotation of shaft 81 through universal joint 80 results in rotation of shaft 30' for the purposes hereinbefore described.

These shafts and universal joints operate in exactly the same manner as hereinbefore described; but here the control mechanism of Figure 1 is used in connection with the universal joint combination of Figure 4 in order to obtain the variations desired. Thus shaft 128 is mounted on a casting 129 which is pivoted by sleeve 130 on or with respect to the shaft 25. Rotation of the casting 129 about the shaft 25 will result in a displacement of the power transmitting shaft 128 with respect to the ultimate power receiving shaft 39 and thereby results in placing the universal joint 82 and 80 at the angles between shafts 128 and 81 and shafts 30'

and 81 in order to obtain the cyclic variations in speed hereinbefore described.

It should be noted, of course, that shaft 128 rotates in sleeve 131 which is mounted on or connected to the casting 129. A rack 132 in arcuate form is an integral part of or secured to the casting 129. Control shaft 133 carries worm 134 at the end thereof which mesh with the teeth of the worm gear 132. Rotation of the control shaft 133 results in a corresponding movement of the gear 132 and therefore in a corresponding rotation of the casting 129 and a corresponding displacement of the shaft 128 and therefore in a placement of the shaft 81 at an angle with respect to both shafts 128 and shaft 30' so that the universal joints 80 and 82 are at the respective angles.

The control shaft 133 may, if desired, be integrated with the Reeves drive control mechanism in a manner shown in connection with Figure 1.

In all of the embodiments herein described, the sole function and operation of the mechanism is to place the ultimate power transmitting shaft at an angle with respect to the knife drum shaft so that cyclic variations in speed may occur.

The apparatus may be so arranged or set that the knife will engage the web to be cut when maximum cyclic speed is reached or when minimum cyclic speed is reached if that is desired (depending on whether the circumferential speed of the knife drums is greater or less than the linear speed of movement of the web to be cut) or any stage between the maximum and minimum cyclic speed may be selected.

Of course, it should be noted that the cutting operation is not here instantaneous so that the very instant of, for instance, maximum cycle speed cannot be selected for the cutting operation, but rather an average interval for cutting may be selected at the maximum speed where the average speed of rotation of the knife drums is less than that of the linear movement of the web.

Thus, as shown in the diagrammatic view of Figure 7, which is a diagram of the possible movements of the construction shown in Figure 6, the solid lines indicate a position of maximum speed of the knife drum 16.

It should be noted that the position for maximum speed may be selected at any point in the cycle, that is, the knife and the adjustments thereof may be so arranged that whatever the position of the shafts with respect to each other, the maximum speed may occur when the knives are in a vertical plane or it may even be arranged to occur when the knives are in a horizontal plane or at any intermediate point. The cutting knives first meet the sheet and begin to enter the same at a point somewhat removed from the vertical plane and the cut is completed when the knives have reached the vertical plane so that where it is desired to obtain maximum speed of the cutting knives at the time they are actually in engagement with the sheet material, such maximum speed should be attained when the knives first begin to engage the sheet of paper. This is the reason, therefore, that the preferred position of the knives for maximum speed is approximately that shown in the solid lines of the diagram of Figure 7.

In actual practice, however, and in order to distribute whatever errors may occur even though such errors may not be of extreme importance,

the cutting knives may be arranged to reach their maximum speed when they have already partially entered the web, and accordingly, the preferred position of maximum speed for the cutting knives may be that shown by the dotted lines of Figure 7.

Various other methods for utilizing universal joint connections in the manner herein described will now be obvious to those skilled in the art and various other means for supporting the movable shafts will also be clear. Accordingly, I do not intend to be limited by the specific disclosure herein, but only by the appended claims.

I claim:

1. A means for cyclically varying the speed of rotation of a shaft while maintaining a constant average speed of rotation thereof; said means comprising a power transmitting shaft rotatable at unvarying cyclic speed, a universal joint connection between said power transmitting shaft and said first mentioned shaft, and means for varying the angle between said shafts.

2. A shaft rotatable at a constant average speed for each cycle of rotation, means for reducing the speed thereof during part of said cycle and increasing the speed thereof during the other portions of said cycle while maintaining the constant average speed for each cycle, said means comprising a power transmitting shaft rotatable at unvarying cyclic speed, the end of said latter shaft being adjacent the end of said first mentioned shaft and disposable at an angle thereto, and a universal joint connection between said shafts.

3. A shaft rotatable at a constant average speed for each cycle of rotation, means for reducing the speed thereof during part of said cycle and increasing the speed thereof during other portions of said cycle while maintaining the constant average speed for each cycle, said means comprising a power transmitting shaft rotatable at unvarying cyclic speed, the end of said latter shaft being adjacent the end of said first mentioned shaft and disposable at an angle thereto, a universal joint connection between said shafts; and means for changing the degree of cyclic variation from average speed of said latter shaft.

4. A shaft rotatable at a constant average speed for each cycle of rotation, means for reducing the speed thereof during part of said cycle and increasing the speed thereof during other portions of said cycle while maintaining the constant average speed for each cycle, said means comprising a power transmitting shaft rotatable at unvarying cyclic speed, the end of said latter shaft being adjacent the end of said first mentioned shaft and disposable at an angle thereto, a universal joint connection between said shafts; means for changing the degree of cyclic variation from average speed of said latter shaft comprising means for changing the angle between said two shafts.

5. A method for creating cyclic variations in speed of rotation of a rotatable shaft operable from a power transmitting shaft, said method comprising the interposition of a universal joint between said shafts and placing said shafts at an angle of less than 180° and more than 90° to each other and means for selectively varying said angle.

6. An apparatus for successively severing sheets of predetermined length from a continuously moving web, said apparatus comprising a knife mounted on a rotatable shaft, a power source comprising a shaft and means connecting said

power source and said rotatable shaft, means for selecting an average speed of rotation for said rotatable shaft, and means for cyclically varying the speed of rotation of said rotatable shaft, said means comprising a universal joint between said rotatable shaft and a portion of said means connecting the power shaft thereto and means for varying the angle between said rotatable shaft and said power shaft.

7. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft, a secondary shaft, and an auxiliary shaft, adjustable power transmission means connecting said power shaft and said secondary shaft for varying the average speed of rotation of said secondary shaft, an adjustable power connection between said secondary shaft and said auxiliary shaft, a universal joint connection between said auxiliary shaft and said knife shaft, said auxiliary shaft being normally coaxial with said knife shaft and means for placing said auxiliary shaft at an angle to said knife shaft.

8. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft and an auxiliary shaft, an adjustable power connection between said power shaft and said auxiliary shaft, a universal joint connection between said auxiliary shaft and said knife shaft, said auxiliary shaft being normally coaxial with said knife shaft, and means for placing said auxiliary shaft at an angle to said knife shaft.

9. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft, a secondary shaft and an auxiliary shaft, adjustable power transmission means connecting said power shaft and said secondary shaft for varying the average speed of rotation of said secondary shaft, an adjustable power connection between said secondary shaft and said auxiliary shaft, a universal joint connection between said auxiliary shaft and said knife shaft, said auxiliary shaft being normally coaxial with said knife shaft, means for placing said auxiliary shaft at an angle to said knife shaft, said auxiliary shaft being mounted in a sleeve perpendicular to said secondary shaft, said sleeve being rotatable about said secondary shaft, and means for rotating said sleeve carrying said auxiliary shaft.

10. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft, a secondary shaft and an auxiliary shaft, adjustable power transmission means connecting said power shaft and said secondary shaft for varying the average speed of rotation of said secondary shaft, an adjustable power connection between said secondary shaft and said auxiliary shaft comprising a bevel gear on each of said shafts, said shafts being perpendicular to each other and said bevel gears meshing with each other, a universal joint connection between said auxiliary shaft and said knife shaft, said auxiliary shaft being normally coaxial with said knife shaft, means for placing said auxiliary shaft at an angle to said knife shaft, said auxiliary shaft being mounted in a sleeve perpendicular to said secondary shaft, said sleeve being rotatable about said secondary shaft, and means for rotating said sleeve carrying said auxiliary shaft.

11. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft, a secondary shaft and an auxiliary shaft, adjustable power transmission means connecting said power shaft and said secondary shaft for varying the average speed of rotation of said secondary shaft, an adjustable power connection between said secondary shaft and said auxiliary shaft, comprising the mounting of said auxiliary shaft perpendicular to said secondary shaft and rotatable thereabout and a gear connection therebetween, a universal joint connection between said auxiliary shaft and said knife shaft, said auxiliary shaft being normally coaxial with said knife shaft, and means for placing said auxiliary shaft at an angle to said knife shaft.

12. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft, a second shaft and an auxiliary shaft, adjustable power transmission means connecting said power shaft and said secondary shaft for varying the average speed of rotation of said secondary shaft, an adjustable power connection between said secondary shaft and said auxiliary shaft, comprising the mounting of said auxiliary shaft perpendicular to said secondary shaft and rotatable thereabout and a gear connection therebetween, a universal joint connection between said auxiliary shaft and said knife shaft, said auxiliary shaft being normally coaxial with said knife shaft, means for placing said auxiliary shaft at an angle to said knife shaft, said auxiliary shaft being mounted in a sleeve perpendicular to said secondary shaft, said sleeve being rotatable about said secondary shaft, and means for rotating said sleeve carrying said auxiliary shaft.

13. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft, a secondary shaft and an auxiliary shaft, adjustable power transmission means connecting said power shaft and said secondary shaft for varying the average speed of rotation of said secondary shaft, an adjustable power connection between said secondary shaft and said auxiliary shaft, a universal joint connection between said auxiliary shaft and said knife shaft, said auxiliary shaft being normally coaxial with said knife shaft, means for placing said auxiliary shaft at an angle to said knife shaft, said auxiliary shaft being mounted in a sleeve perpendicular to said secondary shaft, said sleeve being rotatable about said secondary shaft, and means for rotating said sleeve carrying said auxiliary shaft, said means comprising a gear segment carried by said sleeve, a gear meshing therewith, and means for rotating said gear.

14. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft and an auxiliary shaft, an adjustable power connection between said power shaft and said auxiliary shaft, a universal joint connection between said auxiliary shaft and said knife shaft, said auxiliary shaft being normally coaxial with said knife shaft, and means for placing said auxiliary shaft at an angle to said knife shaft, said means comprising a slidable mounting for said auxiliary shaft.

15. An apparatus for successively severing

5 sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft, a secondary shaft, an auxiliary shaft, and an additional shaft, an adjustable power connection between said secondary shaft and said auxiliary shaft, a universal joint connection between said auxiliary shaft and said additional shaft, and a universal joint connection between said additional shaft and said knife shaft, said auxiliary and additional shafts being normally coaxial with said knife shaft, means for shifting said auxiliary shaft to non-coaxial position while its axis remains parallel to the knife shaft axis and placing said additional shaft at an angle to both said shafts.

16. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft, a secondary shaft, an auxiliary shaft, and an additional shaft, an adjustable power connection between said secondary shaft and said auxiliary shaft, a universal joint connection between said auxiliary shaft and said additional shaft, and a universal joint connection between said additional shaft and said knife shaft, said auxiliary and additional shafts being normally coaxial with said knife shaft, means for shifting said auxiliary shaft in an arcuate path to non-coaxial position while its axis remains parallel to the knife shaft axis and placing said additional shaft at an angle to both said shafts.

17. An apparatus for successively severing sheets of selected length from a continuously moving web, said apparatus comprising a rotatable knife shaft, a power shaft, a secondary shaft, an auxiliary shaft, and an additional shaft, an adjustable power connection between said secondary shaft and said auxiliary shaft, a universal joint connection between said auxiliary shaft and said additional shaft, and a universal joint connection between said additional shaft and said knife shaft, said auxiliary and additional shafts being normally coaxial with said knife shaft, means for shifting said auxiliary shaft to non-coaxial position while its axis remains parallel to the knife shaft axis, said additional shaft being at an angle to said auxiliary shaft and said knife shaft when said auxiliary shaft is shifted, the two universal joints secured between their respective shafts having the same orientation with respect to each other.

18. An apparatus for successively severing sheets of predetermined length from a continuously moving web, said apparatus comprising a knife mounted on a rotatable shaft, a power source and means connecting said power source and said rotatable shaft, means for varying the average speed of rotation of said rotatable shaft, means for cyclically varying the speed of rotation of said rotatable shaft, said means comprising a universal joint between said rotatable shaft and a portion of said means connecting the power source thereto, said means for varying the average speed of rotation of the variable shaft and said means for cyclically varying the speed of rotation of said rotatable shaft being interrelated by an additional adjustable means for varying the two means simultaneously said rotatable shaft being movable to different angles with respect to said power source.

19. An apparatus for successively severing sheets of predetermined length from a continuously moving web, said apparatus comprising a knife mounted on a rotatable shaft, a power

source and said rotatable shaft, means for varying the average speed of rotation of said rotatable shaft, means for cyclically varying the speed of rotation of said rotatable shaft, said means comprising a universal joint between said rotatable shaft and a portion of said means connecting the power source thereto, said means for varying the average speed of rotation of the variable shaft and said means for cyclically varying

the speed of rotation of said rotatable shaft being inter-related by an additional adjustable means for varying the two means simultaneously, said last-mentioned additional means comprising a pair of shafts connected together by worm gears by which they are locked in selected position.

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