

Feb. 7, 1939.

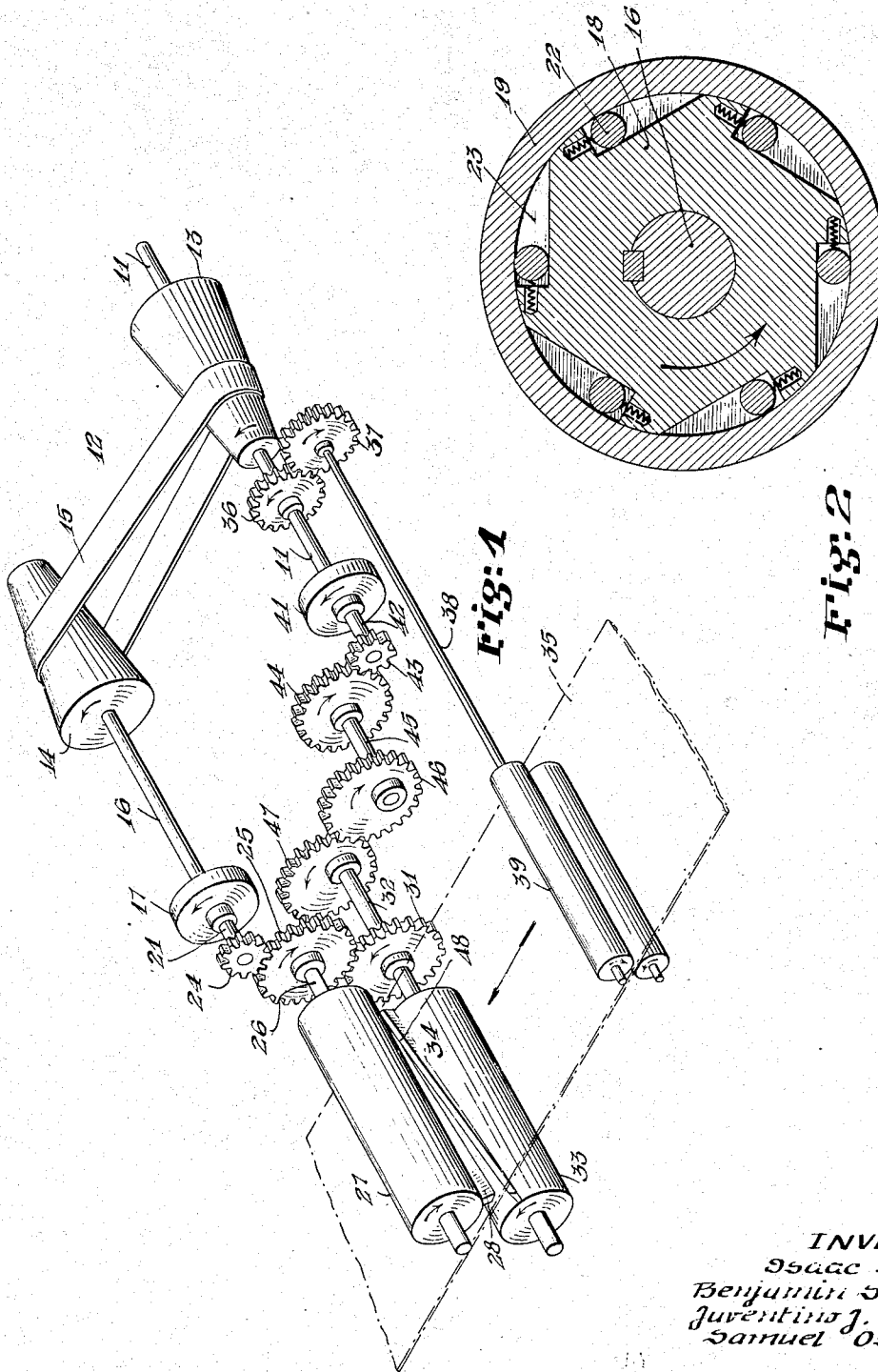
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2,146,274

KNIFE

Filed June 25, 1935

8 Sheets-Sheet 1



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8 Sheets-Sheet 2

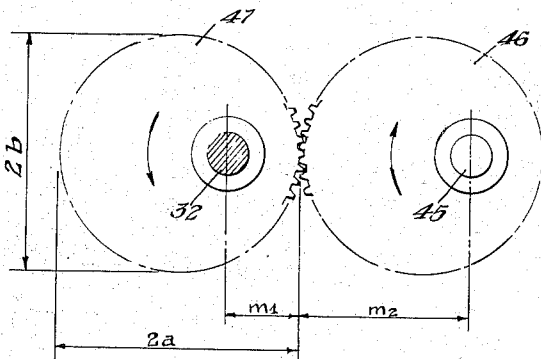


Fig. 3

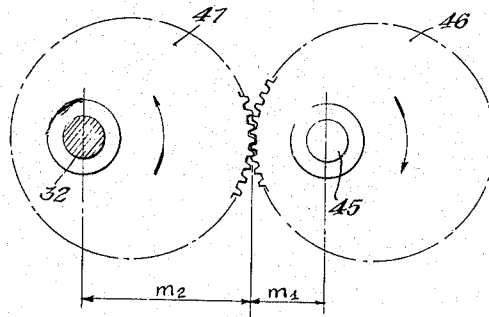


Fig. 5

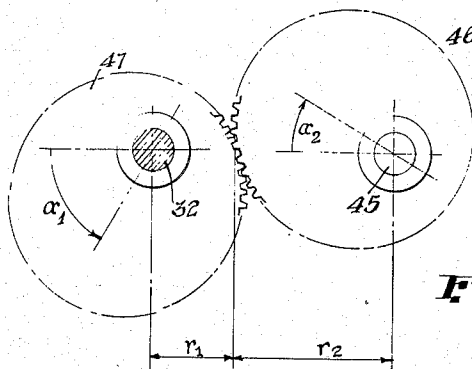


Fig. 4

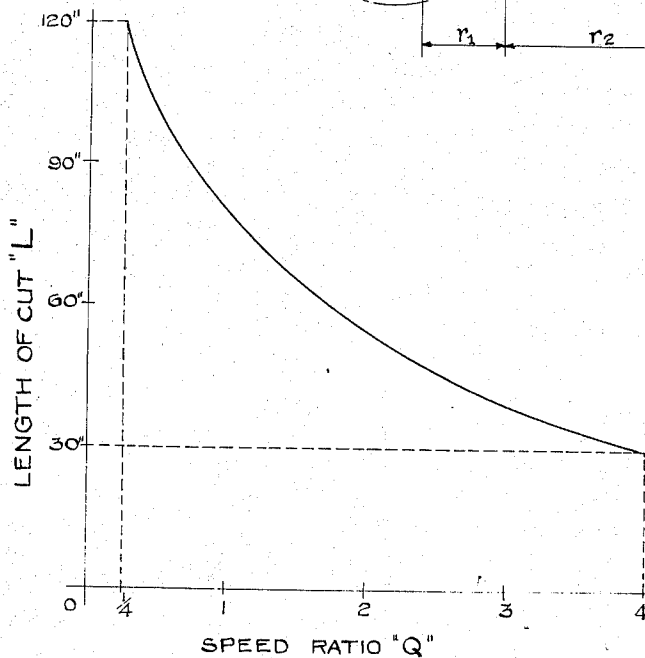


Fig. 7

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8 Sheets-Sheet 3

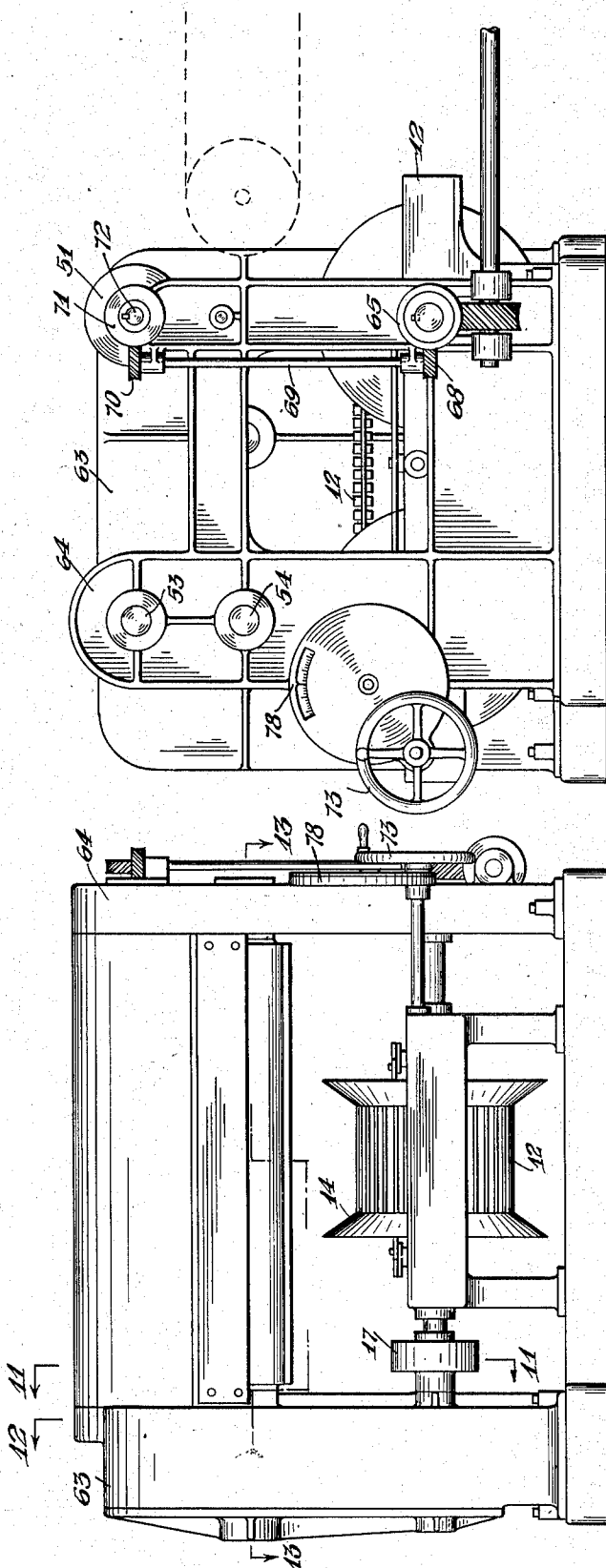


Fig. 9

Fig. 6

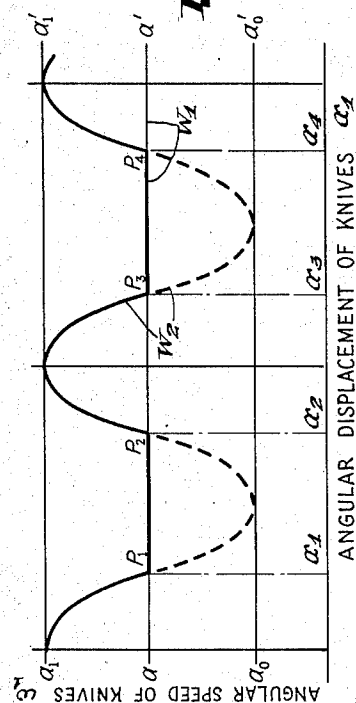


Fig. 10

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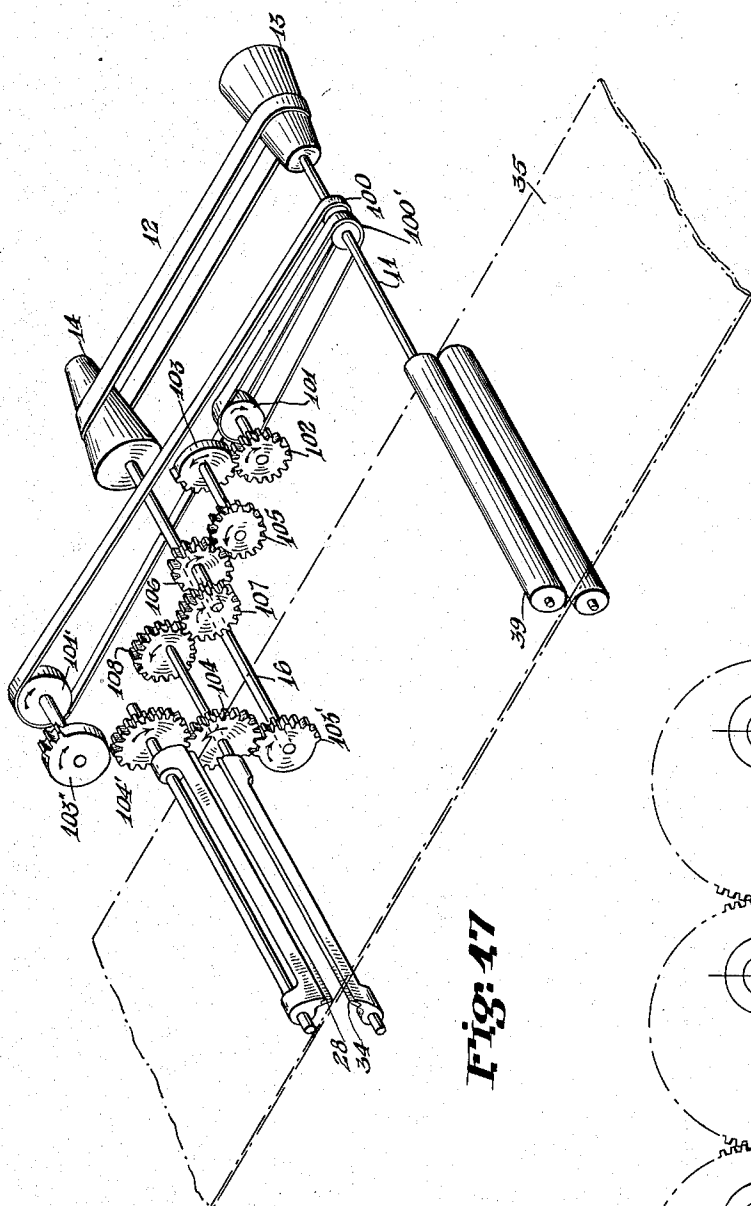


Fig. 47

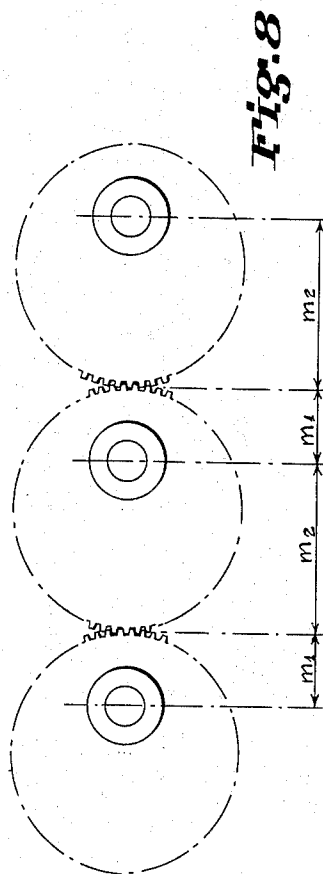


Fig. 8

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8 Sheets-Sheet 5

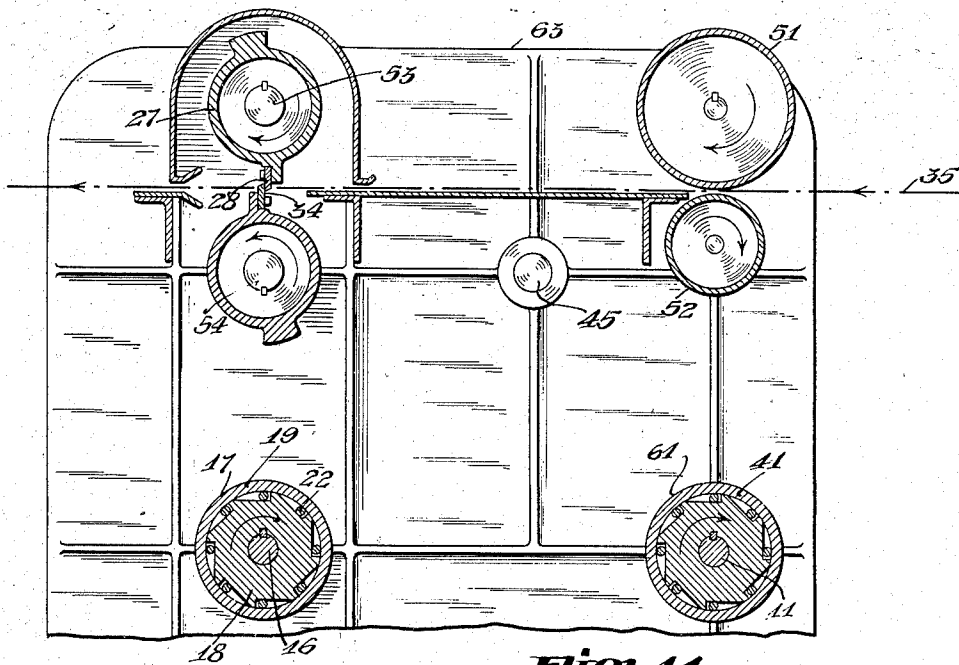


Fig. 11

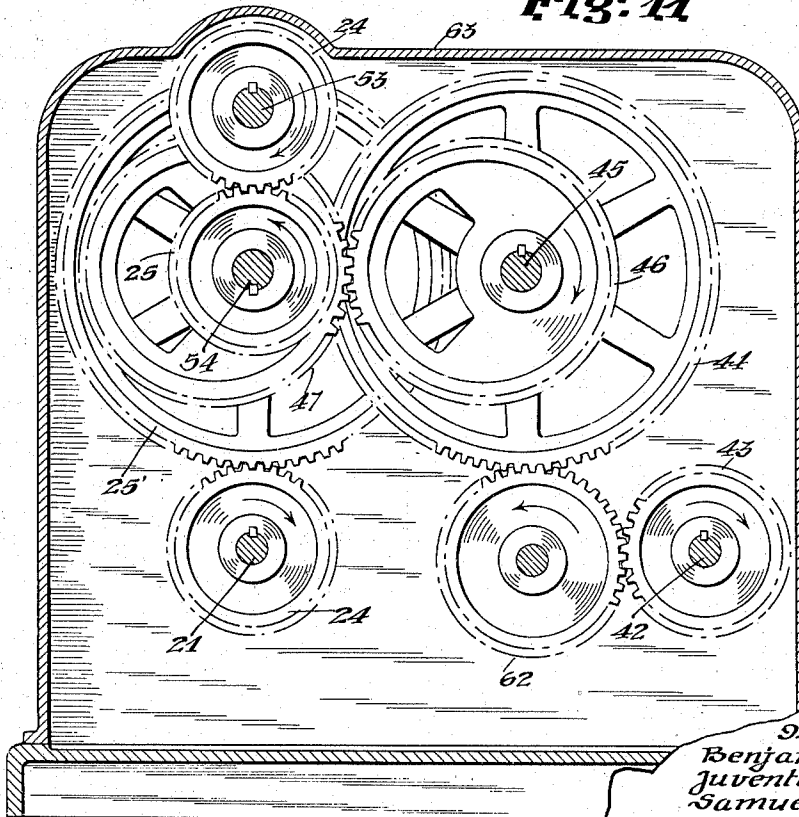


Fig. 12

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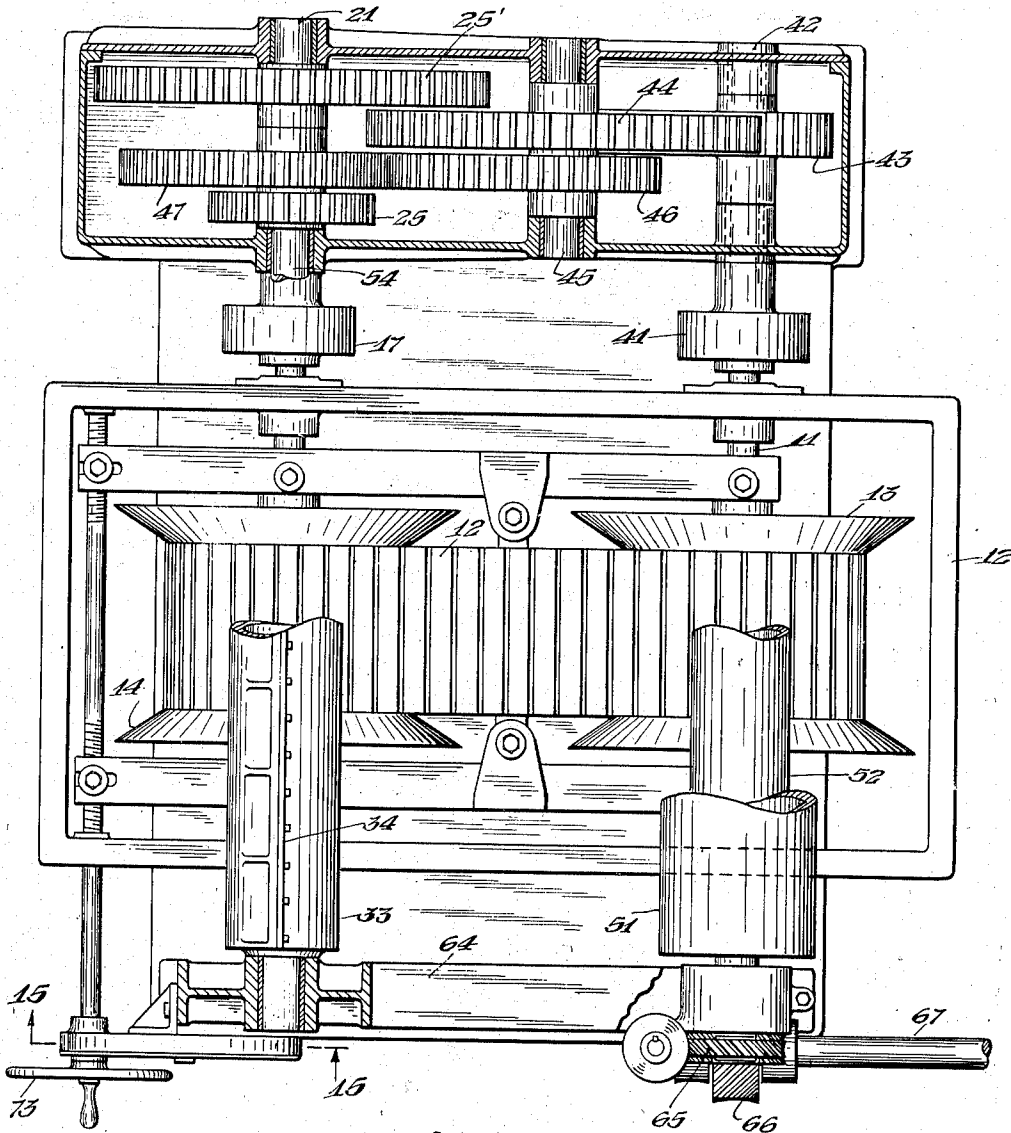


Fig. 13

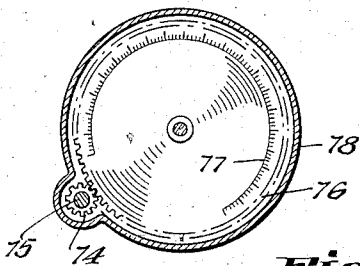


Fig. 15

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8 Sheets-Sheet 7

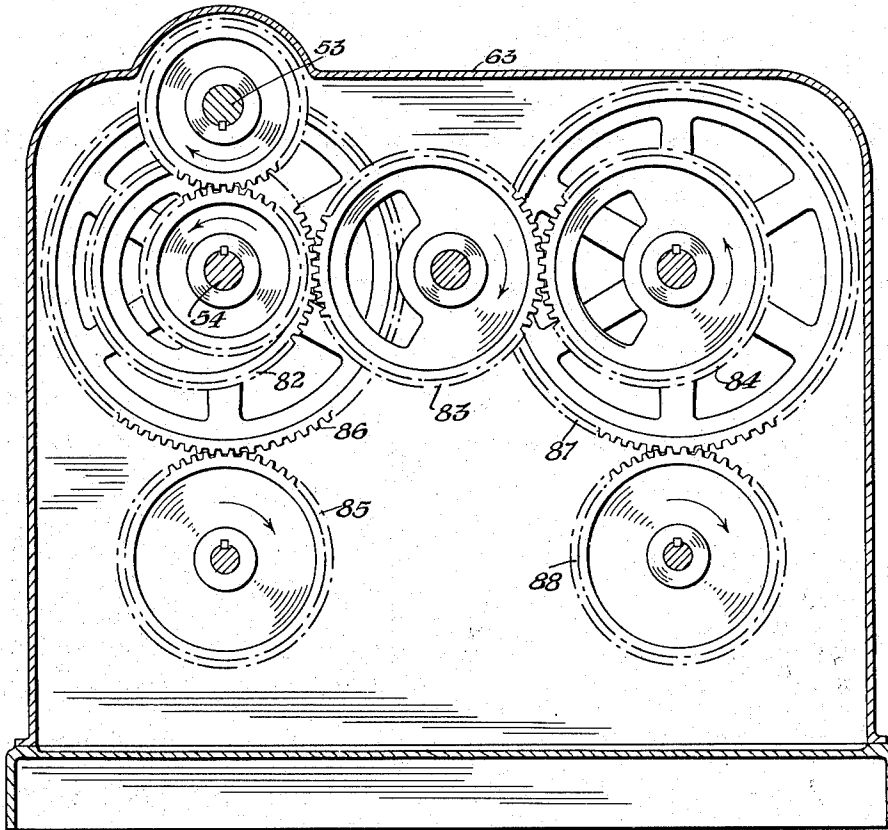


Fig. 14

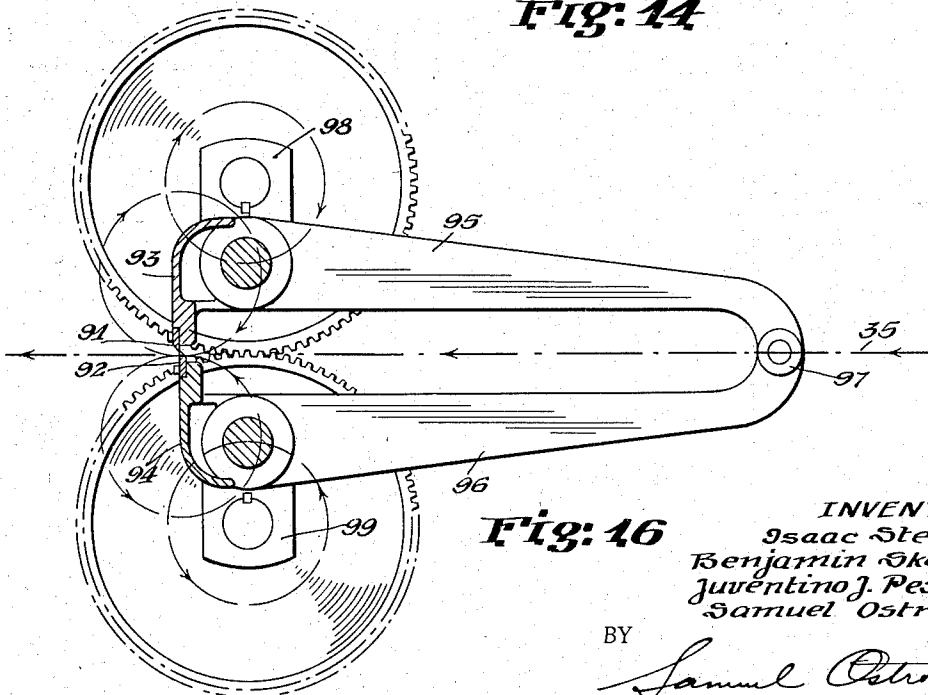


Fig. 16

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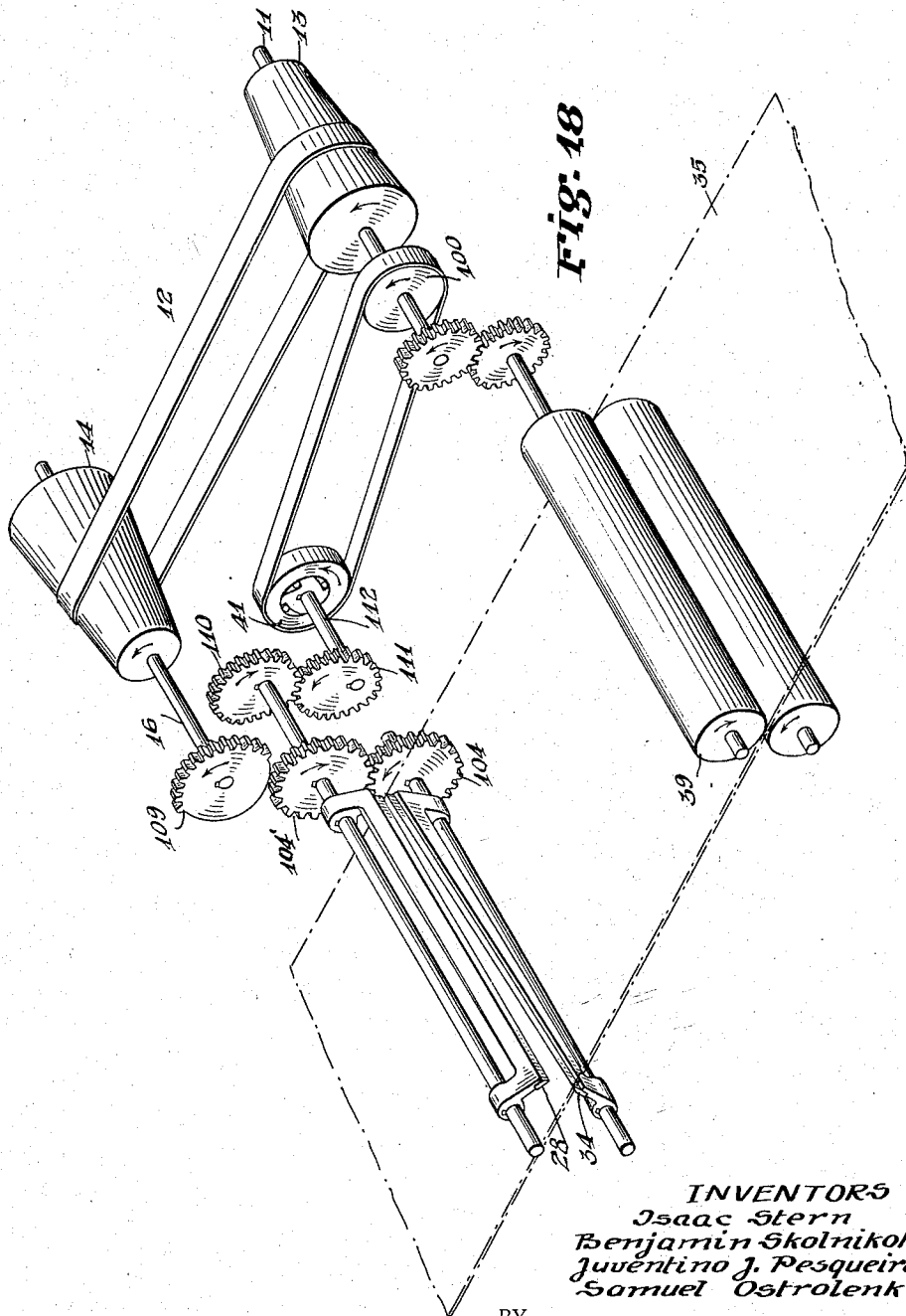
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8 Sheets-Sheet 8



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UNITED STATES PATENT OFFICE

2,146,274

KNIFE

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Application June 25, 1935, Serial No. 28,296

22 Claims. (Cl. 164—68)

Our invention relates to novel apparatus for and methods of cutting fibrous paper boards and more particularly, relates to novel apparatus for and methods of operating knives continuously for cutting varying lengths of fibrous boards.

In the manufacture of fibrous paper material, the paper after it has passed through the corrugating machine and been formed into corrugated board, emerges as a continuous web which is fed to cutting knives at a rate of speed determined by the rate of operation of the machine.

The strip material of the web is then cut into predetermined lengths by the knives which are usually operated in a cycle whose time varies in accordance with the size of cut desired.

The operation of the knives may be broadly divided into two classifications, one, the intermittent operation and, two, the continuous operation.

In the case of the intermittent operation of the knives, either a timing device or a target is provided. The target is engaged by the end of the paper being fed past the knife so that when a predetermined length of paper has been fed past the knives, the forward edge of the paper engages the target which in turn operates to cause an engagement of a clutch through which a driving shaft drives the drum carrying the knife.

The knife drum which up to this point has been stationary now starts its cycle of operation, rotating to a point where the knife engages and cuts the paper and thereafter continues the rotation until the cutting operation has been completed and the drum with the knife thereon has returned to the original stop position at which point the clutch disengages the drum from the driving shaft. A cycle has thus been completed and the drum is prepared for the second cycle when the new edge of the strip material engages the target to again close the clutch.

In this type of operation, due consideration has to be given to the time from the instant when the edge of the paper engaged the target to the beginning of the cut which obviously takes place sometime later. In this interval, there is one variable whose time constant is not predictable, namely, the time from the instant when the clutch engages to connect the driving and driven shaft to bring the drive shaft from a stationary condition to full speed. The clutch, because of the severe strain to which it is subjected in bringing the driven shaft up to the driving shaft speed soon begins to wear so that the time interval between the operation of the target and the engagement of the knife with the paper varies depending upon the slip of the clutch. This results in an error in the size of the paper cut of as much as a quarter of an inch which becomes a very serious factor when a large number of cut sheet material is involved, not only in the loss of paper

but also in the extra trimming operation involved.

The second principle referred to above involves a construction in which the drums carrying the knives are rotated at a continuous speed and at a predetermined position in the cycle of the drum the knives engage the paper to perform the cutting operation.

For different size cuts, provision is made for changing the speed of the knife carrying drum either to a greater or lesser speed depending upon whether a smaller or larger cut size is desired.

During the cutting interval, the knife engages the paper and accordingly must move forwardly with the paper at the same rate of speed as the paper, if it is to avoid either the tearing or buckling of the paper during cutting. While this is a comparatively simple problem for a single time cycle of the cutting knives, the problem is rendered more difficult where the cycle time is changed for different sized cuts.

Heretofore the only solutions proposed for obtaining a synchronous or equal rate of speed of movement of the knives and the paper at the instant of cutting have been based on principles involving complex mechanism and providing only an approximate synchronism.

Thus in the patent to Swift No. 917,503, no detailed solution for this difficulty is suggested. In the patent to Sieg No. 1,897,867, it is proposed to follow the principle outlined in the patent to Harbrecht, No. 1,039,124 by using elliptical gears for driving the knife carrying drums. By reason of these elliptical gear drives, the knife carrying drum is gradually increased from a minimum speed at the beginning of a cycle up to a speed at which the drum is rotating at the speed of the corrugated paper web. At this point the knife engages the paper for cutting operation. At the end of the cutting operation, the drum through the action of the elliptical gears again reduces its speed to the original minimum speed.

In order to change the size of cuts, the time consumed for this cycle is changed as described above. Inasmuch, however, as with the change in time cycle of operation, the knife at the point in the elliptical gear previously described will no longer operate at the same speed as the paper moves, it is necessary to move the relative position of the knife with respect to the elliptical gear to that position of the elliptical gear which at the new time cycle rate, moves at the same speed as the paper.

However, both Harbrecht and Sieg make a fundamental erroneous assumption. An elliptical gear, by definition, is one whose speed is continuously changing. While it is possible to obtain an approximation of uniform speed for cutting at one position of the elliptical gear where it is most nearly circular so that the knives will move at the same speed as the paper throughout the cutting

period this is not possible at a variety of positions of the elliptical gears. Accordingly, when either Harbrecht or Sieg shift the position of the knife with respect to the elliptical gears there results inevitably a non-synchronous condition between the speed of the paper and the speed of the knife at least during a portion of the cutting period.

Thus in both Sieg and Harbrecht, two adjustments are made, namely, one which involves a change in the time cycle of the knife and the other involving a compensation for this change in time cycle by a change in the relative position of the knives and the elliptical gears, the distinction between Harbrecht and Sieg being that in Harbrecht the cutting machine must be brought to a stop for adjusting the elliptical gears with respect to the knives whereas in Sieg this can be done with the machine in operation. In both cases, however, a fundamental fallacy in principle of operation exists.

In accordance with our invention, we contemplate a construction of knives and the operation thereof in which no compensating adjustment of the elliptical gears is necessary or provided. The drum carrying knives are in a fixed and rigid position with respect to the elliptical gear exactly as is obtained in Harbrecht before any adjustment thereof is attempted. The only adjustment is the time cycle adjustment as in Harbrecht, but no change in the relative positions of the drum with respect to the knife is made; instead, as pointed out above, this is maintained rigidly fixed so that that portion of the elliptical gear which is either accurately or approximately circular may be employed for the cutting interval to maintain the knives moving in synchronism with the speed of the paper.

This condition for every time cycle variation is obtained by merely using more or less of the elliptical gear for driving the knife drums.

In accordance with our invention, we drive the knife drums from two sources; first, from a Reeves directly through circular gears whose time interval is changed for obtaining different sized cuts. A second drive for the knife drums is obtained through a pair of elliptical gears which are normally non-operative while the cutting cycle is being determined.

At a predetermined point in the cycle, the elliptical gears become effective to increase the speed of the knife drums to the cutting speed at which point the knives move at the same speed as the paper. Thereafter, the knives are decelerated by the elliptical gears until they reach the speed at which the circular gears again drive the knife drums for repeating the cycle.

Thus as will be more clear from the description to follow, we have made a radical departure both in the principle of operation and the construction. Instead of adjusting elliptical gears which requires complicated mechanism and in the end is inaccurate, we make no adjustment whatsoever on the elliptical gear adjustment but instead provide multiple drives, a principle never heretofore used in this mechanism. The multiple drive in which the function of the timing the cycle is assigned to one drive and the synchronizing to the other drive is far simpler than any other system requiring practically little or no additional parts. At the same time, it is far more accurate in operation.

Accordingly, an object of our invention is to provide a novel construction of knives for strip material in which two separate drives in parallel relation to each other are provided for the knife

drums, one drive determining the time cycle and the other for bringing the knife to the synchronous speed.

Still another object of our invention is to provide knife drums for continuous strip material in which a fixed relation is maintained between the knife drum and the elliptical gears.

Still a further object of our invention is to provide novel apparatus for and methods of cutting strip material in which it is necessary to change the time cycle only and noncompensating adjustments of elliptical gears are required.

There are other objects of our invention which together with the foregoing will appear in the detailed description which is to follow in connection with the drawings.

Figure 1 is a schematic illustration of our invention.

Figure 2 is a detail of a clutch used in our novel device.

Figures 3 to 5 are illustrations of several positions of elliptical gears used in our invention.

Figure 6 is a graph of the angular speeds of the cutting knives plotted against their angular displacements.

Figure 7 is a speed ratio-sheet length curve.

Figure 8 illustrates our invention employing an intermediate elliptical gear.

Figure 9 is a side elevation view of the machine.

Figure 10 is the discharge end view of the machine in elevation.

Figure 11 is a sectional view on line 11—11 of Figure 10.

Figure 12 is a sectional view on line 12—12 of Figure 10.

Figure 13 is a sectional view substantially taken on line 13—13 of Figure 10.

Figure 14 is a sectional view showing a modified form of the gear mechanism.

Figure 15 is a sectional view of the measuring scale mechanism.

Figure 16 is a sectional view of a modified form of the mounting of the cutting knives.

Figure 17 is a schematic illustration of a modified form of our invention.

Figure 18 is a schematic illustration of a further modified form of our invention.

Referring now more specifically to Figure 1, rotating power applied to the shaft 11 rotates the Reeves drive 12 of well-known construction which we have here illustrated schematically by the cone 13 secured for rotation on the shaft 11 and the cone 14 connected to the cone 13 by the chain 15. In the manner well-known in the art, by shifting the chain 15 in a transverse direction from its direction of rotation, the speed of the cone 14 may be varied any desired amount within predetermined limits. Cone 14 is mounted on and drives the shaft 16 which in turn carries the one-way clutch 17 of well-known construction. This clutch is schematically illustrated in Figure 2 and comprises a driver disk 18 mounted on and driven by the shaft 16 and an outer rim 19 mounted on and rotatable with shaft 21. The driver disk 18 has a series of cam indentations 23 around its periphery in which there are seated the individual rollers 22. As is well-known in the art, so long as the rate of rotation of the driver disk 18 is less than the rate of rotation of rim 19, the rollers 22 will tend to remain in the position shown. Thus, no rotating energy can be transmitted from the rim 19 to driver 18.

When, however, the driver 18 tends to rotate faster than the rim 19, the rollers 22 are forced into the smaller portion of the cam as, for exam-

ple, portion 23, thus providing a gripping action between the driven disk 18 and the rim 19 and a driving power is thus transmitted from the driver 18 to the rim 19, maintaining the rim in synchronous rotation with the driver. It will thus be clear that the rim 19, while it may at times rotate at a faster speed than the driver 18, cannot rotate at a lower speed. The importance of this will be clear from the description which is to follow.

Mounted on and rotatable with the shaft 21 is a pinion 24 meshing with a speed reduction gear 25 which is mounted on the shaft 26 of the knife drum 27, carrying the knife blade 28. Gear 25 in turn meshes with the gear 31 mounted on shaft 32, carrying the knife drum 33 on which is mounted the knife 34 which in cooperation with the knife 28 functions to cut the web material 35 in varying lengths in a manner to be described.

The operation of the power transmission described in the above will be obvious. Power normally supplied from the power shaft 11 is transmitted through the Reeves drive 12 to the shaft 16 and thence through the clutch 17, shaft 21, gears 24 and 25, to the knife drums 27 and 33. In order to obtain different sized cuts it is merely necessary to change the rate of rotation of drums 27 and 33 by shifting the chain 15 of the Reeves drive to vary the rate of rotation of the cone 14 with respect to cone 13.

However, as will be recalled, from the description above this alone will not suffice since at any change in speed of drums 27 and 33 the knives 28 and 34 will not move at the same speed as the web 35 and accordingly there will result either a tearing or a buckling of the paper.

To correct for this, we do not drive the drums 27 and 33 throughout the cycle from the power transmission described above but instead provide a multiple or by-pass drive which functions in cooperation with the first mentioned drive to bring the knives to the proper speed relation with respect to the web after the timing of the cycle has been previously determined by the first drive.

Thus, power shaft 11 also carries meshing gears 36 and 37 the latter gear driving the shaft 38 carrying the feed rolls 39 which feed the web 35 at a speed equal to the speed of the corrugating machine through a direct mechanical connection thereto from the power shaft 11 in a manner well-known in the art.

Also mounted on the power shaft 11 is a second clutch 41 similar in construction to the clutch of Figure 2 and whose driver equivalent to the driver 18, is mounted on and driven by the power shaft 11 while the rim equivalent to rim 19 is mounted on and drives shaft 42 in a manner well-known in the art.

Mounted on and rotatable with shaft 42 is a pinion 43 meshing with the gear 44 which is mounted on and transmits rotating power to shaft 45. Mounted on shaft 45 is an elliptical gear 46 meshing with a corresponding elliptical gear 47 which in turn is rigidly mounted on and rotatable with the shaft 32 of the knife drum 33.

In the position shown, the knives 28 and 34 have just come into engagement at the point 48 preparatory for a cutting period in the cycle. At this position, it will be noted, the elliptical gears 46 and 47 are in the position at which maximum speed ratio is obtained. Assuming that at this position the speed ratio is one to four obtained by suitable design of these elliptical gears, then the gear 47 is rotating at four times the speed of

elliptical gear 46 whose speed in turn is determined by the rotation of power shaft 11.

In accordance with our invention, this speed increase in the gear 47 which is transmitted through gears 31 and 25 to pinion 24 and thence to shaft 21 causes the shaft 21 to rotate at a speed which is higher than the maximum speed which can be obtained on shaft 16 for the smallest sized cuts desired.

As a result, inasmuch as clutch 17 is a one way clutch, the shaft 21 will rotate from power supply to shaft 11 through the power transmission including the elliptical gears 46 and 47 at a greater speed than and free from shaft 16.

Accordingly, during the cutting period, the knife carrying drums 33 and 27 are driven from the power supply 11 through clutch 41, gears 43 and 44 and elliptical gears 46 and 47.

The speed of rotation is a predetermined and fixed value determined solely by the gear trains in this latter power transmission system and specifically by the relative position of the elliptical gears 46 and 47. Inasmuch as the cutting position is definitely fixed with respect to these elliptical gears, they can be cut over the cutting arc so that they are substantially circular and therefore provide power for the knife drums at a constant speed during cutting. Moreover, in view of the fixed relation between the elliptical gears and the knives, the angle of cut may be made as large as desired over a substantial arc, limited solely by the range of cutting sizes desired in a manner which will be clear from the description to follow. It is only necessary that whatever cutting angle is employed, the corresponding portion of the elliptical gears shall be made substantially circular.

At the end of the cutting period, that is, when the opposite edges of the knives such as at 48 come into contact, the elliptical gears enter into a position at which the speed ratio begins to change the gear 47 gradually decreasing its rate of rotation with respect to the gear 46 as the speed ratio therebetween gradually reduces from the one to four ratio to a one to one ratio and then finally to a four to one ratio at which the gears 46 and 47 are in a diametrically opposite position from that shown.

As the speed of shaft 32 decreases with the gear 47, the power transmitted through gears 31 and 25, pinion 24, to shaft 21 will gradually reduce the speed of rotation of the shaft 21 until it approaches the rate of rotation of shaft 16. As the speed reduction now continues, the instant the shaft 21 tends to rotate at a lower speed than shaft 16, the rollers 22 will promptly engage in the manner described above and power will now be transmitted from shaft 16 through clutch 17, shaft 21, pinion 24 to gears 25 and 31 thus driving the knife drums 27 and 33 at a rate determined by the Reeves drive 12. Power is transmitted, now, back over shaft 32 through elliptical gears 47 and 46, shaft 45 and gears 44 and 43 to the shaft 42 which in turn carries the one-way clutch described above. Since at this portion of the cycle the elliptical gears 47 and 46 are in reverse position from that originally described, the elliptical gear 46 will rotate at four times the speed of elliptical gear 47 and therefor transmit driving power to the shaft 42 which drives the latter at a greater speed than the power shaft 11. Accordingly, shaft 42 rotates free of power shaft 11. During this entire period, the speed of the knife drums is determined solely by the Reeves drive.

As the rotation continues, the ratio between the elliptical gears 47 and 46 again undergoes a change back to the original value passing from the ratio of four to one between gears 47 and 46 respectively through one to one ratio and then slowly back to the one to four ratio between gears 46 and 47 respectively.

During this change, shaft 42 gradually decreases in speed until it approaches and finally arrives at the speed of power shaft 11. At the instant it tends to go below the speed of shaft 11, clutch 41 becomes operative to again drive the shaft 42. At this instant the speed ratio between elliptical gears 46 and 47 is such as to raise the speed of shaft 21 slightly above the speed of shaft 16 and the shaft 21 is again free of the latter shaft. During this next interval as power is now supplied from power shaft 11 through clutch 41 and elliptical gears 46 and 47, the knife drums are gradually accelerated up to the cutting position at which point cutting again begins and a second cycle of the type described above is repeated.

Summarizing the above, it will now be seen that a complete cycle may be divided into four distinct intervals. There is first the interval of cutting during which the drums are driven from the power supply through clutch 41 and to elliptical gears 46 and 47. At a predetermined position of these elliptical gears at which they are cut circular, the second interval follows in which the speed of the drums is gradually decelerated as the elliptical gears change their speed ratio until the drum reaches its minimum speed at which time the drive is switched from the above described transmission to the Reeves drive 12, clutch 17, shaft 21 and pinion 24. This is the third interval. The latter drive may be varied under control of the Reeves drive in the well-known manner for changing the time of each cycle in order to change the size of cuts. The fourth interval is the period when the power is switched back from the Reeves drive to the first mentioned transmission during which the drums are accelerated to bring the knives to the speed of the web. Inasmuch as the first, second and fourth intervals are of fixed value and unchangeable the time interval therefore can be predetermined, and accordingly by a proper change in the rate of rotation in the third interval through adjustments of the Reeves drive, the complete time interval in each cycle can be predetermined for obtaining different sized cuts of material.

The importance of this arrangement resides in the fact that for all changes in the Reeves drive, no change whatsoever is necessary in the elliptical gears and these remain fixed with respect to the knives thus insuring invariable synchronous movement of the knife with respect to the web.

It will now be clear that the knives are driven alternately by the clutches 17 and 41 respectively in such a manner that when one clutch is driving, the other is free. The source of rotation of the knives will in fact be the faster of the two that may be communicated to them by either clutch.

Clutch 17 which obtains its power through the variable speed Reeves drive, tends to operate the knives at a constant rate while clutch 41 which itself rotates uniformly and is independent of the variable speed drive, tends to operate the knives over a drive in multiple with the first drive through a cycle of varying speed. The pair of elliptical gears interposed between it and the

knives controls the cutting period to within a small portion of the maximum of this varying speed.

This maximum speed is attained when the pair of elliptical gears is in the position shown in Figure 3. Here gear 47 is, of course, rotating m_2/m_1 as fast as gear 44, and it is in the neighborhood of this instant that the knives engage the moving paper web material, the different elements being so proportioned as to make the horizontal component of the linear speed of the knives equal to the speed of the material, or very nearly so.

As the elliptical gears are displaced through certain angles, as shown in Figure 4, gear 47 will slow down with respect to gear 46, since the active radius r_1 of gear 47 has increased, and the active radius r_2 of gear 46 has decreased. The angular speed of gear 47 relative to that of gear 46 will thus go on decreasing until it reaches a minimum, which occurs when both members of the pair have turned through an angle π with respect to the position in Figure 3, as shown in Figure 5. Here gear 47 will then be rotating m_1/m_2 as fast as gear 46. In general, gear 47 rotates r_2/r_1 as fast as gear 46, r_1 and r_2 varying, of course, with the angular displacements α_1 and α_2 of the respective members.

Clutch 41 has a tendency to rotate gear 46 at a uniform angular speed and, consequently, in the absence of clutch 17, gear 46 would always rotate at a constant angular speed, say ω_2 and owing to the elliptical shape of the members, it would drive gear 47 at a varying angular speed $\omega_1 = W_2$, where

$$W_2 = \omega_2 \left[\frac{2a}{p} (1 + \epsilon \cos \alpha_1) - 1 \right] \quad (1)$$

In this equation

$$2a = m_1 + m_2 \quad p = b/a \quad \epsilon = \sqrt{1 + (b/a)^2} \quad b = \sqrt{a^2 - \frac{1}{4}(m_2 - m_1)^2}$$

On the other hand, clutch 17 has a tendency to rotate gear 47 at the constant angular speed $\omega_1 = W_1$ and would do so in the absence of clutch 42 through a complete cycle. Therefore, when clutch 17 is driving, gear 47 has the angular speed $\omega_1 = W_1$, constant. It will be seen, then, that gear 47 and therefore the knives 28 and 34 will be driven either at the angular speed W_1 or at the angular speed W_2 , depending on which is the greater.

During a complete cycle, W_2 would vary from the maximum $(m_2/m_1)\omega_2$ to the minimum $(m_1/m_2)\omega_2$, while W_1 would remain constant. It is clear then that if

$$\frac{m_2}{m_1} \omega_2 > W_1 > \frac{m_1}{m_2} \omega_2$$

there will be in general two instants in the whole cycle in which the two possible angular speeds W_1 and W_2 are equal. It is at these instants that the burden is passed from one clutch to the other without interrupting the march of the machine.

W_1 may be varied at will to suit requirements through the variable-speed Reeves drive 12 as described above, but this variation must lie within the extremes of the inequality above. Hence,

$$\left. \begin{aligned} W_1 \text{ maximum} &= \frac{m_2}{m_1} \omega_2 \\ W_1 \text{ minimum} &= \frac{m_1}{m_2} \omega_2 \end{aligned} \right\} \quad (a)$$

Figure 6 is a sketch of a graph showing the

angular speed w_1 of E_1 plotted against the angular displacements α_1 of the same gear. Here it will be seen that the two possible values W_1 and W_2 of w_1 are equal at the points of intersection $F_1, F_2 \dots$ of the two curves, these points having abscissas $\alpha_1=0, \alpha_1', \alpha_1'' \dots$. w_1 must be the greater of the two possible speeds W_1 and W_2 and therefore w_1 will be variable in the intervals $\alpha_1=0$ to α_1', α_1'' to α_1''' etc., and constant in the intervals α_1' to α_1'', α_1''' to α_1'''' etc. In other words, clutch 41 drives in the intervals 0 to α_1', α_1'' to α_1''' etc., at a varying angular speed, and clutch 17 drives in the intervals α_1' to α_1'', α_1''' to α_1'''' etc., at constant speed. The points $\alpha_1', \alpha_1'' \dots$ are, of course, the roots of the equation $W_1=W_2$, that is, of the equation

$$W_1 = \omega_2 \left[\frac{2a}{p} (1 + \epsilon \cos \alpha_1) - 1 \right] \quad (A)$$

$$\cos \alpha_1 = \frac{1}{\epsilon} \left[\frac{p}{2a} \left(\frac{W_1}{\omega_2} + 1 \right) - 1 \right]$$

The knives engage the material at their maximum angular speed or within a small neighborhood of it, that is, when $w_1=W_2$ maximum. Hence, if w_r and R_r are the angular speed and radius of the feeding roller, and R_c the distance from the axis of rotation of either knife to the material (the "radius" of the knives), we have

$$R_c W_2 \text{ maximum} = R_f \omega_f$$

that is, since

$$W_2 \text{ maximum} = \frac{m_2}{m_1} \omega_2,$$

$$R_c \frac{m_2}{m_1} \omega_2 = R_f \omega_f$$

whence

$$\omega_2 = \frac{R_f m_1}{R_c m_2} \omega_f \quad (2)$$

An examination of Figure 6 will reveal that the higher W_1 is the more ω_1 will take on higher values and, hence, the sooner gear 47 will complete one revolution. Let ω_1 be the mean angular speed of gear 47, and T the time period of one revolution of gear 47. Then

$$\bar{\omega}_1 = \frac{2\pi}{T} \quad (3)$$

Since gear 47 rotates through an angle 2π (one revolution) for every cut made, and since angular speeds are proportional to angular displacements

$$\frac{\bar{\omega}_1}{\omega_f} = \frac{2\pi}{\delta}$$

where δ is the angular displacement of the feeding roller per cut made. Now, if L is the length of the pieces of material being cut, we have

$$L = R_f \delta$$

and furthermore

$$\frac{\bar{\omega}_1}{\omega_f} = \frac{2\pi R_f}{L} \quad (3')$$

or, by (3)

$$T = \frac{L}{R_f \omega_f} \quad (4)$$

Since

$$dt = \frac{d\alpha_1}{\omega_1}$$

$$T = \int_0^{2\pi} \frac{d\alpha_1}{\omega_1} = \int_0^{\alpha_1'} \frac{d\alpha_1}{W_2} + \int_{\alpha_1'}^{\alpha_1''} \frac{d\alpha_1}{W_1} + \int_{\alpha_1''}^{\alpha_1'''} \frac{d\alpha_1}{W_2}$$

$\alpha_1''=2\pi-\alpha_1'$, and, for reasons of symmetry, the last equation may be written in the form

$$T = 2 \left\{ \int_0^{\alpha_1'} \frac{d\alpha_1}{W_2} + \int_{\alpha_1'}^{\pi} \frac{d\alpha_1}{W_1} \right\}$$

Equation (1) may be written

$$W_2 = \omega_2 (A + B \cos \alpha_1)$$

where

$$A = \frac{2a}{p} - 1 \quad B = \frac{2a}{p} \epsilon$$

Hence

$$\int_0^{\alpha_1'} \frac{d\alpha_1}{W_2} = \frac{1}{\omega_2} \int_0^{\alpha_1'} \frac{d\alpha_1}{A + B \cos \alpha_1} = \frac{2}{\omega_2 \sqrt{A^2 - B^2}} \tan^{-1} \left(\frac{\sqrt{A^2 - B^2}}{A + B} \tan \frac{1}{2} \alpha_1' \right) = \frac{2}{\omega_2} \tan^{-1} \left(\frac{\tan \frac{1}{2} \alpha_1'}{A + B} \right)$$

since $A^2 - B^2 = 1$, as may be easily verified.

W_1 is constant, and therefore

$$\int_{\alpha_1'}^{\pi} \frac{d\alpha_1}{W_1} = \frac{\pi - \alpha_1'}{W_1}$$

Hence

$$T = \frac{4}{\omega_2} \tan^{-1} \left(\frac{\tan \frac{1}{2} \alpha_1'}{A + B} \right) + \frac{2(\pi - \alpha_1')}{W_1} = \frac{L}{R_f \omega_f} \text{ by (4)}$$

or

$$L = 2R_f \omega_f \left\{ \frac{2}{\omega_2} \tan^{-1} \left(\frac{\tan \frac{1}{2} \alpha_1'}{A + B} \right) + \frac{\pi - \alpha_1'}{W_1} \right\} \quad (5)$$

This last equation indicates the correspondence between the values of W_1 and L , and therefore makes possible the calibration of the variable-speed drive for the different L 's desired. Thus, assuming an arbitrary value for W_1 , α_1' is obtained from Equation (A), and from Equation (5) is obtained the corresponding value of L . An accurate graph (or table) may then be made, giving calculated values of L against assumed values of W_1 .

Assuming that it is required to cut sheets varying in such lengths that the longest is N times the shortest, from (3') it will be seen that

$$L = 2\pi R + \frac{\omega_f}{\omega_1}$$

The shortest sheet is cut when $\bar{\omega}_1$ is the fastest, that is, when

$$\bar{\omega}_1 = W_1 \text{ maximum} = \frac{m_2}{m_1} \omega_2$$

Hence

$$L \text{ minimum} = 2\pi R_f \frac{m_1 \omega_f}{m_2 \omega_2} \quad (5')$$

The longest sheet on the other hand, is cut when W_1 is the slowest, that is, when

$$\bar{\omega}_1 = \omega_2$$

hence

$$L \text{ maximum} = 2\pi R_f \frac{\omega_f}{\omega_2} \quad (5'') \quad 65$$

Therefore, since $L \text{ maximum}/L \text{ minimum} = N$,

$$N = \frac{m_2}{m_1} \quad (6) \quad 70$$

and the pair of elliptical gears may now be proportioned by giving m_1 or m_2 a suitable arbitrary value. For instance, if $L \text{ maximum} = 120''$ and $L \text{ minimum} = 30''$, we get $N = 4$. If we make $m_1 = 4''$, we get $m_2 = 16''$, and the major axis of

the ellipses will be $2a = m_1 + m_2 = 20''$. The minor axis will be

$$2b = 2\sqrt{a^2 - \frac{1}{4}(m_2 - m_1)^2} = 16''$$

the latus rectum

$$2p = 2\frac{b^2}{a} = 12.8''$$

and the eccentricity

$$e = \sqrt{1 - \left(\frac{b}{a}\right)^2} = 0.6$$

To find the capacity of the variable-speed drive Equation (a) may now be written

$$W_1 \text{ max.} = N\omega_2$$

15

$$W_1 \text{ min.} = \frac{\omega_2}{N}$$

Hence

$$W_1 \text{ maximum}/W_1 \text{ minimum} = N^2$$

20 and if the lengths of cut range from 30'' to 120'', for which $N=4$, the above ratio becomes 16. Therefore, in this example, the variable-speed drive may be chosen as having a range of speed ratios of 1:1 to 1:16, or 2:1 to 1:8, or 4:1 to 1:4, etc.

25 Assuming that the drive is required to cut pieces of from 30'' to 120'' in length, then by (6),

$$N = 120/30 = m_2/m_1 = 4$$

30 If $m_1 = 4''$, $m_2 = 16''$, the other elements of the elliptical gears will be as determined. Putting $R_f = R_c$ in (2)

$$\frac{\omega_f}{\omega_2} = 4$$

35 for the ratio of the angular speed of the feeding roller to that of gear 46. From (5')

$$120 = 2\pi R_f \times 4$$

that is

$$R_f = \frac{15}{\pi} = 4.775''$$

40

for the radius of the feeding roller. Also $R_c = 4.775''$, since R_f and R_c are assumed to be equal in this example. Let $P_1, P_2, G_1, G_2, G_3, G_4$ stand for the diameter (or number of teeth) of gears 24, 43, 31, 25, 36 and 37 respectively in Figure 1. Then

45

$$\frac{\omega_f}{\omega_2} = \frac{G_3}{G_4} \times \frac{G_2}{P_1} = 4$$

and if $G_3 = G_4$, $G_2/P_1 = 4$. Let ω_d' be the angular speed of cone 14 of the variable speed drive, and ω_d that of cone 13. The capacity of the variable speed drive is $N^2 = 16$. Now, if a drive having a range of speed ratios of from 4:1 to 1:4 is chosen, then

55

$$\omega_d' \text{ max.} = 4\omega_d = 4\omega_f$$

since $G_3 = G_4$. And similarly,

$$\omega_d' \text{ min.} = \frac{1}{4}\omega_f$$

60

From Equation (2)

$$W_1 \text{ maximum} = 4\omega_2 = \omega_f$$

$$W_1 \text{ minimum} = \frac{1}{4}\omega_2 = \frac{1}{16}\omega_f$$

Hence

$$P_1/G_1 = W_1 \text{ maximum}/\omega_d' \text{ maximum} = W_1 \text{ min.}/\omega_d' \text{ min.} \\ = \frac{W_1}{\omega_d'} = \frac{1}{4}\omega_f = \frac{1}{4}$$

70 Thus far, the gear ratios, the shape of the ellipses, the radii of the feeding roller and knives respectively, and the range of the variable speed drive have been found. To find now expressions that will enable calibration of the variable speed drive, let

75

$$2 = \frac{\omega_d'}{\omega_d}$$

be the speed ratio of the variable speed drive to which it is to be set for cutting a piece of length L. Since

$$\frac{P_1}{G_1} = \frac{W_1}{\omega_d'} = \frac{1}{4}$$

it follows that

$$W_1 = \frac{1}{4}\omega_d' = \frac{1}{4}Q\omega_d = \frac{1}{4}\omega_f Q$$

Furthermore, $\omega_2 = \frac{1}{4}\omega_f$, as shown at the beginning of this example; and, according to the proportions found for the elliptical gears, $A-B=4$, as may be verified. Hence Equation (5) will become, remembering that

$$R_f = \frac{15}{\pi}$$

$$L = \frac{120}{\pi} \left[2 \tan^{-1} \left(\frac{\tan \frac{1}{2}\alpha_1'}{4} \right) + \frac{\pi - \alpha_1'}{Q} \right]$$

or, if α_1' is given in degrees,

$$L = \frac{2}{3} \left[2 \tan^{-1} \left(\frac{\tan \frac{1}{2}\alpha_1'}{4} \right) + \frac{180 - \alpha_1'}{Q} \right] \quad (7)$$

With the values for $p (=6.4'')$ and $e (=0.6)$ already known the second of Equations (A) will become

$$\cos \alpha_1' = 0.5333Q - 1.1333 \quad (8)$$

Equations (7) and (8) are the expressions that were to be found to calibrate the variable speed drive. A graph of Equation (7) is given in Figure 7.

With so high a value as 4 for m_2/m_1 , the elliptical gears may appear to be too elongated. It is possible to interpose between gears 46 and 47 another elliptical gear, thereby reducing the eccentricity of the ellipses. An arrangement of a system of three elliptical gears is shown in Figure 8 in the position for the maximum angular speed of 47. It is clear here that the maximum angular speed of 47 will be

$$\left(\frac{m_2}{m_1} \right)^2 \omega_2$$

the minimum

$$\left(\frac{m_1}{m_2} \right)^2 \omega_2$$

The motion of 47 in general is

$$W_2 = \omega_2 (A_1 + B_1 \cos \alpha) \quad (9)$$

where

$$A_1 = \frac{4a(2a-p)}{p^2} - \frac{4a-p}{p}$$

$$B_1 = \frac{4a(2a-p)}{p^2} e$$

Equation (9) above takes the place of (1) in the above. Equation (a) will now become

$$W_1 \text{ max.} = \left(\frac{m_2}{m_1} \right)^2 \omega_2$$

$$W_1 \text{ min.} = \left(\frac{m_1}{m_2} \right)^2 \omega_2 \quad (b)$$

whereas the second of Equations (A) will now be

$$\cos \alpha_1' = \frac{1}{B_1} \left(\frac{W_1}{\omega_2} - A_1 \right) \quad (B) \quad 65$$

Equation (2) will change into

$$\omega_2 = \frac{R_f}{R_c} \left(\frac{m_1}{m_2} \right)^2 \omega_f \quad (10)$$

and Equation (5) will undergo a slight change in notation:

$$L = 2R_f \omega_f \left[2 \tan^{-1} \left(\frac{\tan \frac{1}{2}\alpha_1'}{A_1 + B_1} \right) + \frac{\pi - \alpha_1'}{W_1} \right] \quad (11)$$

In deriving Equation (11) it is found that

$A_1^2 - B_1^2 = 1$, as was the case with similar symbols in the derivation of Equation (5). Equations (5') and (6) will now become

$$L \text{ min.} = 2\pi R_f \left(\frac{m_1}{m_2} \right)^2 \frac{\omega_f}{\omega_2} \quad (12')$$

$$N = \left(\frac{m_2}{m_1} \right)^2 \quad (13)$$

whereas Equation (5'') remains the same:

$$L \text{ max.} = 2\pi R_f \frac{\omega_f}{\omega_2}$$

All equations in the above not involving the ratio m_1/m_2 will remain unchanged, and those involving this ratio will remain unchanged but for the expression $(m_1/m_2)^2$ which is to be inserted in place of m_1/m_2 .

Let $L \text{ minimum} = 30''$, $L \text{ maximum} = 120''$. Then, from Equations (12') and (14)

$$L \text{ maximum} / L \text{ minimum} = 4 = (m_2/m_1)^2$$

Hence

$$m_2/m_1 = 2$$

Making $m_1 = 4''$, the proportion of the elliptical gears becomes $m_2 = 8''$, $2a = 12''$, $2b = 11.314''$, $2p = 10.667''$, $e = 0.333$. Following the same steps assume $R_f = R_c = 15/\pi = 4.775''$, $G_4/G_3 = 2$, $P_1/G_1 = 1/2$, range of variable speed drive: 4:1 to 1:4, calibration of drive: as given by Equations (7) and (8).

Equations (1) and (9) were derived from the polar equation of the ellipse, the well-known properties of the figure, and the fact that angular speeds are inversely proportional to active radii. Angles and angular speeds are supposed to be in radians and radians per second, respectively, in the above discussion in order to facilitate the analysis.

In the above, the invention has been described in connection with a schematic illustration of the invention. In the following the invention is described with specific reference to a construction.

Referring to Figure 11, the web 35 to be cut, is travelling between the feeding rollers 51, 52 at a uniform speed, towards the cutting knives 28, 34 which are mounted on drums 27 and 33 respectively. Drums 27 and 33, are, in turn, mounted on shafts 53 and 54. The knives shafts are geared to each other to revolve in opposite directions by equal spurs 25 and 31, also rigidly mounted on shafts 53 and 54 respectively, Figure 12. The knives receive their power either from shaft 16 or shaft 42 depending on certain conditions as described above. Shaft 16 forms part of the driven member of a variable speed transmission 12, such as Reeves transmission, upon one of whose ends the inner or driving part 18 is rigidly mounted. The outer or driven part 19 is keyed to shaft 21 in line with shaft 16 and is driven by outer member 19 whenever its speed of rotation is not greater than the speed of rotation of part 18, due to the wedging effect of rollers 22 as is well known in the art. Shaft 21 carries spur gear 24 which meshes with and at times drives spur gear 25 which is keyed to shaft 54.

Shaft 11 is part of the driving member 13 of the variable speed transmission and carries on one end the inner or driving part, a clutch 41 similar in construction to clutch 17. Driven part 61 of this clutch is keyed to shaft 42 onto which spur gear 43 is rigidly mounted. Spur gear 43 cooperates with spur gear 44 through idler 62. Spur gear 44 is keyed to shaft 45 to which is also keyed member 46 of a pair of elliptical

gears, the other member 47 being keyed to shaft 54. Clutch 41 drives shaft 42 as in the first clutch 25 whenever the angular speed of shaft 42 is not greater than the angular speed of shaft 11.

The whole train of gears described above is enclosed in box 63 which also forms the bearing support of the different shafts of said gears. The opposite ends of shaft 53 and 54 are borne by bearings forming part of opposite support 64. For safety purposes, the revolving knives may be enclosed in hoods.

Shaft 11 is extended to go through support 64 to the outside where it is provided with means to receive power such as the helical gear 65, which engages helical gear 66 mounted on driving shaft 67.

Upper feeding roller 51 is positively related to shaft 11 by any well known means. In the drawings, the driving of this feeding roller is accomplished by means of helical gear 68 engaging helical gear 65 and is keyed to lower end of vertical shaft 69. To the upper end of 69 is keyed helical gear 70 which meshes with helical gear 71 driving thus shaft 72 on which 71 and feeding roller 51 are rigidly mounted. In cases where this kind of cut-off mechanism is used immediately at the discharge end of the machine manufacturing the web to be cut, the feeding rollers above may be dispensed with. However, the cut-off mechanism should then be positively related to the machine producing the web in order to assure synchronism.

The speed ratio of the variable speed transmission may be adjusted and measured by turning the hand wheel 73. As shown in Figure 15, pinion 74 is mounted on shaft 75 to which wheel 73 is keyed, and meshes with large spur 76 on which a scale 77 conveniently graduated is placed and rotates therewith, the reading being indicated by the stationary pointer 78 (Figure 9).

In the absence of clutch 17, the angular speed of the knives would be entirely variable throughout a complete revolution, due to the interposition of the pair of elliptical gears between the knives shaft 54 and the driving shaft 11. This variable speed is graphically illustrated by the sinusoidal curve in Figure 6, plotted against the angular displacements of the knives. On the other hand, in the absence of clutch 41, the angular speed of the knives would be constant with respect to the angular displacements of the knives throughout a complete revolution.

This constant speed is shown in Figure 6 as represented by the horizontal line $a-a'$. If, however, both clutches are present, the angular speeds of the knives will be variable in some intervals of the cycle, and constant in others. This is shown by the heavy solid curve in Figure 6, which is composed of portions of the variable and constant speeds that the knives may partake of, joined at the points $P_1, P_2, \dots$ where the variable speed equals the constant speed.

The variable speed transmission may be adjusted to increase or decrease the angular speed of the knives in the intervals of constant speeds within the minimum indicated by the horizontal line $a_0-a'_0$ and the maximum indicated by the horizontal line $a_1-a'_1$ (Figure 6), which go through the minimum and maximum points of the sinusoidal curve, respectively. The cutting knives are so located angularly that the cutting is made at the points of maximum angular speeds, whereas the sweeping radius of these knives is so determined that their linear speeds substan-

tially correspond to the speed of the travelling web at the time of cutting.

Scale 77 (Figure 15) may be graduated to read lengths of cuts directly.

5 Since the eccentricity of the ellipses in a pair of elliptical gears increases with the ratio of the maximum to the minimum speeds of the follower, when a large ratio is desired in order to obtain a wide range of cuts, the gears may be too elongated for good performance. The obliquity of the resultant force on the teeth would be in this case too pronounced, and there would be a strong tendency in some portions of the rim to throw the teeth out of mesh. In order to reduce the eccentricity of the gears, a train of three or more elliptical gears may be used that will give the same kinematical results as in the case of two elliptical gears.

15 Figure 14 shows the application to the invention of a train of three elliptical gears 82, 83 and 84. Here spur gears 85, 87 and 88 have the same function as the corresponding gears of Figure 12. The idler, however, is absent.

20 The description of the cut-off mechanism above was made in connection with a revolving type of knives. Several other types may also be used. In Figure 16, I have shown a knife consisting of cutting edges 91 and 92, mounted on the front members 93 and 94 of frames 95 and 96 which are hinged at 97 and carried around on the drops of the cranks 98 and 99 as they revolve in opposite directions. The hinges 97 oscillate horizontally while the cutting edges travel in very nearly circular paths keeping themselves substantially in vertical position during their motion. Frames 95 and 96 are self-supporting. It will be understood that the cranks 71 and 72 are driven by the mechanism described above for driving the knife drums so that the time cycle may be varied but the cranks at instant when the knife edges are cutting the paper, move in synchronism with the paper.

30 In Figure 17 I have illustrated a modified form of my invention in which I have eliminated the clutch mechanism 17 and 41 of Figure 1. The same drive and speed control through the Reeves is obtained as in the previous modification. Secured to shaft 16, however, and rotatable therewith is a mutilated gear 103' which has teeth only about a portion of the circumference, this portion being that part of each cycle during which the knives 28 and 34 are to be driven at a predetermined speed in accordance with the size of cuts to be made. In the multiple drive connection, shaft 11 is connected through the pulleys 100 and 101 for driving gear 102 meshing with the mutilated gear 103. Gear 103 like gear 103' has teeth about only a portion of its circumference, namely that portion in the cycle during which the knives 28 and 34 are to be accelerated and decelerated from a speed below cutting speed up to the cutting speed and then back to the original speed.

35 In normal operation, the gear 103' meshing with the drum gear 104 will drive the knives 28 and 34 at a predetermined speed determined by the Reeves drive 12. This rate of speed during the period while gear 103' meshes with gear 104 determines the size of the cut sheets. A third mutilated gear 103'' meshing with gear 104' provides a third multiple drive for the knives 34 and 28.

40 In operation, at the beginning of the cycle gear 103' drives the knives as described above during that portion of the cycle when the speed

of the drum is maintained constant and determined by the Reeves drive 12 as explained above. At the end of this interval, the teeth of gear 103' are about to disengage from the teeth of gear 104. At the instant that the last tooth of gear 103' passes from engagement with gear 104, the first tooth of gear 103 which up to this point has been driven through the gear chain including the elliptical gears, engages with the tooth of gear 102.

45 From this point on in the cycle, driving power is supplied through gears 102, 103 and the elliptical gears 107 and 108. As the gears rotate, the gear ratio between the gears 107 and 108 gradually undergo a change in the manner described in detail above as the small part of gear 107 meshes with the large part of gear 108 until a one to four ratio is obtained. At this time the knives 34 and 28 are rotating at their maximum speed at which point they are rotating at approximately the speed of the paper.

50 Just before the knives engage the paper for cutting, gear 103 for a sort interval disengages from gear 102 while gear 103'' meshes with gear 104'. During this latter interval, while these circular gears are in mesh, the knives start their cutting operation. During this period, the knives are being driven by the circular gears and at a fixed and invariable speed which is always the same as the speed of the paper.

55 At the end of the cutting interval, gear 103'' disengages gear 104' while gear 103 again meshes with gear 102 and as the elliptical gears continue to rotate, the gear ratio between gears 107 and 108 gradually undergoes a change until knives 34 are again rotating at their minimum speed. At this speed the first tooth of gear 103' again meshes with a tooth of gear 104 to repeat the above described cycle.

60 Inasmuch as the speeds of gears 103', 103 and 103'' are predictable, their teeth may be so cut that they will invariably properly mesh with their corresponding gears as they come into meshing contact. However, we recognize that this may create a problem and that there are, therefore, certain advantages in employing the power transmission systems utilizing the clutch described in our first modification.

65 To overcome the problem of these gear structures, we have provided a further modification shown in Figure 18, in which the mutilated gear 109 driven through the Reeves drive 11, in turn drives the gears which drive the knives 28 and 34.

70 During the interval while the teeth of gear 109 are in meshing relation with their corresponding gear teeth, the knives 28 and 34 are driven at a constant speed which determines the size of the cuts of the material. Although this is the minimum speed of the knives 28 and 34, the gear ratio between the gears 110 and 111 is such that the shaft 112 rotates at a faster speed than the driver of clutch 41. Accordingly, clutch 41 rides freely and does not transmit any driving power.

75 When, however, the last tooth of gear 109 passes from engagement with the tooth of the gear driving the knife 28, the driver of clutch 41 becomes effective and drives the elliptical gears 111 and 112. During this portion of the cycle, the gear ratio between gears 111 and 112 increases in the manner described above, accelerating the knives until they reach the speed of the paper. During this interval the knives engage and begin to cut the paper. As in the previous case, the elliptical gears are made as

nearly as possible circular so that during the cutting interval, the knives are operated at a constant speed equal to the speed of the paper. At the end of the cutting interval and as the drums continue to rotate, they are decelerated due to the reverse change in speed ratio of elliptical gears 111 and 112.

When the drums have been decelerated to the original speed, the first tooth of gear 109 meshes with the tooth of the drum gear and the above described cycle is repeated. In this case, inasmuch as the time interval from the instant when the last tooth of gear 109 passes out of engagement with the drum gear to the instant when the first tooth again engages is a constant and predictable interval, the gear teeth of gear 109 can be designed so that they will always mesh with the drum gear although in this case also the first modification is found preferable because of simpler design problems.

Although we have not shown or described any of the details of the knife construction, it will be obvious that we may use any of the well-known arrangements of knives. It will be clear to those skilled in the art that the drums carrying the knives are mounted at a slight angle with respect to the direction of movement of the paper so as to produce straight cuts and that the knives themselves are so curved as to provide straight cuts.

Although for purposes of illustration we have chosen to illustrate our invention mainly as applied to knives mounted on drums it will be obvious to those skilled in the art that we may employ other well known constructions of knives.

Moreover, although the invention is described specifically as applied to knives for cutting corrugated board, it will be clear that it may be applied to knives for cutting any other material which is being fed at a continuous rate or wherever synchronism during a period of a variable cycle is desired between two members.

The inventive concept resides as will now be clear dividing the time of a cycle into four distinct periods, one, the period when synchronism is desired, two, the decelerating period, three, the period which controls the time of the cycle, and four, the accelerating period and in so arranging the mechanism for carrying this out, such as the elliptical gear here used for purposes of illustration, that the only variable is the mechanism which controls the time of the cycle in the third period so that no changes of any kind are necessary in the elliptical gears or their equivalent.

By thus providing only one adjustment, the accelerating period, the decelerating period and what is of greatest importance, the cutting period, all remain at a fixed value consuming an invariable fixed interval of time.

Not only are we thus able to provide more accurate cuts than have heretofore been possible, but our mechanism is greatly simplified and is made relatively inexpensive.

In illustrating our invention, we have not shown any of the details of the corrugators but have merely schematically illustrated feed rolls which determine the speed of the paper being fed to the knives and with which speed the knives must be maintained in synchronism during cutting. This speed is determined by driving the speed rolls from the same source of power described above, which drives the knives.

We claim:

1. In a device for cutting strip material, knife cutting means; means for feeding the strip mate-

rial to be cut at a constant speed past the knife cutting means; means for continuously operating said knife cutting means in cycles to engage and cut the strip material periodically; the cycle of the knife cutting means comprising an interval during which the knife is operated at a constant speed, an interval during which the knife cutting means is accelerated to a speed synchronous with the speed of the strip material, a cutting interval during which the knife cutting means is operated continuously and in synchronous speed with the strip material, and an interval during which the knife cutting means is decelerated to the first mentioned constant speed; and means for varying the speed during said constant speed interval for varying the length of cuts of said strip material.

2. In a device for cutting strip material, knife cutting means; a source of power for operating said knife cutting means; two multiple power transmitting paths from said source of power to said knife cutting means; a one way clutch in each path; and means for selectively operating said clutches for transmitting power selectively over either of said paths.

3. In a device for cutting strip material, knife cutting means; a source of power for operating said knife cutting means; two multiple power transmitting paths from said source of power to said knife cutting means; a one way clutch in each path; means for selectively operating said clutches for transmitting power selectively over either of said paths; means whereby said knife cutting means are operated at a constant speed over one of said paths; and means for adjusting the speed of operation over said path for varying the length of cuts of said strip material.

4. In a device for cutting strip material, knife cutting means; means for feeding the strip material to be cut at a constant speed past the knife cutting means; means for continuously operating said knife cutting means in cycles to engage and cut the strip material periodically; the cycle of the knife cutting means comprising an interval during which the knife is operated at a constant speed, an interval during which the knife cutting means is accelerated to a speed synchronous with the speed of the strip material, a cutting interval during which the knife cutting means is operated continuously and in synchronous speed with the strip material, and an interval during which the knife cutting means is decelerated to the first mentioned constant speed; and means for varying the interval of said constant speed for varying the length of cuts of said strip material.

5. In a device for cutting strip material, knife cutting means; means for feeding the strip material to be cut at a constant speed past the knife cutting means; means for continuously operating said knife cutting means in cycles to engage and cut the strip material periodically; the cycle of the knife cutting means comprising an interval during which the knife is operated at a constant speed, an interval during which the knife cutting means is accelerated to a speed synchronous with the speed of the strip material, a cutting interval during which the knife cutting means is operated continuously and in synchronous speed with the strip material, and an interval during which the knife cutting means is decelerated to the first mentioned constant speed; and means for varying the speed and interval of said constant speed interval for varying the length of cuts of said strip material.

6. In a device for cutting strip material, knife cutting means; means for feeding the strip material to be cut at a constant speed past the knife cutting means; means for continuously operating said knife cutting means in cycles to engage and cut the strip material periodically; the cycle of the knife cutting means comprising an interval during which the knife is operated at a constant speed, an interval during which the knife cutting means is accelerated to a speed synchronous with the speed of the strip material, a cutting interval during which the knife cutting means is operated continuously and in synchronous speed with the strip material, and an interval during which the knife cutting means is decelerated to the first mentioned constant speed; means for varying the speed and interval of said constant speed interval for varying the length of cuts of said strip material; and calibrated means for indicating the change in speed of said constant speed interval necessary for different sized cuts.

7. In a device for cutting strip material, knife cutting means; a source of power; a first and second multiple power transmitting path from said source of power to said knife cutting means; means for transmitting power from said source of power to said knife cutting means over said first path for operating said knife cutting means at a constant speed; and means in said second path for transmitting power from said source of power to said knife cutting means for accelerating and decelerating said knife cutting means from and to said constant speed.

8. In a device for cutting strip material, knife cutting means; a source of power; a first and second multiple power transmitting path from said source of power to said knife cutting means; means for transmitting power from said source of power to said knife cutting means over said first path for operating said knife cutting means at a constant speed; means in said second path for transmitting power from said source of power to said knife cutting means for accelerating and decelerating said knife cutting means from and to said constant speed; and means in said first path for varying said constant speed at which the knife cutting means is operated from said source of power.

9. In a device for cutting strip material, knife cutting means; a source of power for driving said strip material at a constant speed past said knife cutting means; a first and second multiple power transmitting path from said source of power to said knife cutting means; means for transmitting power from said source of power to said knife cutting means over said first path for operating said knife cutting means at a constant speed; means in said second path for transmitting power from said source of power to said knife cutting means for accelerating said knife cutting means to the speed of said strip material and decelerating said knife cutting means to said constant speed; and means in said first path for varying said constant speed at which the knife cutting means is operated from said source of power.

10. In a device for cutting strip material, knife cutting means; a source of power for driving said strip material at a constant speed past said knife cutting means; a first and second multiple power transmitting path from said source of power to said knife cutting means; means for transmitting power from said source of power to said knife cutting means over said first path for operating said knife cutting means at a constant speed; means in said second path for transmitting

power from said source of power to said knife cutting means for accelerating said knife cutting means to a speed synchronous with the speed of said strip material at the instant of cutting said strip material and for decelerating said knife cutting means to said constant speed; and means in said first path for varying said constant speed at which the knife cutting means is operated from said source of power.

11. In a device for cutting strip material, knife cutting means; a source of power for driving said strip material at a constant speed past said knife cutting means; a first and second multiple power transmitting path from said source of power to said knife cutting means; means for transmitting power from said source of power to said knife cutting means over said first path for operating said knife cutting means at a constant speed; means including elliptical gears in said second path for transmitting power from said source of power to said knife cutting means for accelerating said knife cutting means to a speed synchronous with the speed of said strip material at the instant of cutting said strip material and for decelerating said knife cutting means to said constant speed; and means in said first path for varying said constant speed at which the knife cutting means is operated from said source of power.

12. In a device for cutting strip material, knife cutting means; a source of power for driving said strip material at a constant speed past said knife cutting means; a first and second multiple power transmitting path from said source of power to said knife cutting means; means for transmitting power from said source of power to said knife cutting means over said first path for operating said knife cutting means at a constant speed; means including elliptical gears in said second path for transmitting power from said source of power to said knife cutting means for accelerating said knife cutting means to a speed synchronous with the speed of said strip material at the instant of cutting said strip material and for decelerating said knife cutting means to said constant speed; means in said first path for varying said constant speed at which the knife cutting means is operated from said source of power; and means for alternately rendering said first and second multiple power transmitting paths operative for each cycle of operation.

13. In a device for cutting strip material, knife cutting means; a source of power for driving said strip material at a constant speed past said knife cutting means; a first and second multiple power transmitting path from said source of power to said knife cutting means; means including a one way clutch mechanism for transmitting power from said source of power to said knife cutting means over said first path for operating said knife cutting means at a constant speed; means including elliptical gears and a one way clutch mechanism in said second path for transmitting power from said source of power to said knife cutting means for accelerating said knife cutting means to a speed synchronous with the speed of said strip material at the instant of cutting said strip material and for decelerating said knife cutting means to said constant speed; means in said first path for varying said constant speed at which the knife cutting means is operated from said source of power; and calibrated means for indicating the speed variations for each predetermined size of strip material to be cut.

14. In a device for cutting strip material, knife

cutting means; a source of power; a first and second multiple power transmitting path from said source of power to said knife cutting means; means for transmitting power from said source of power to said knife cutting means over said first path for operating said knife cutting means at a constant speed; means in said second path for transmitting power from said source of power to said knife cutting means for accelerating and decelerating said knife cutting means from and to said constant speed; means in said first path for varying said constant speed at which the knife cutting means is operated from said source of power; and calibrated means for indicating the speed variations for each predetermined size of strip material to be cut.

15. In a device for cutting continuously advancing strip material, a cyclically operable knife cutting means for periodically engaging said strip material for cutting; a source of power for operating said knife cutting means; means for varying the frequency of operation of said knife cutting means for changing the sizes of strip material cut; and non-adjustable automatic means for invariably bringing said knife cutting means to synchronous speed with said strip material during the cutting operation for every size of strip material cut, said means comprising a pair of elliptical gears.

16. In a device for cutting continuously advancing strip material, a cyclically operable knife cutting means for periodically engaging said strip material for cutting; a source of power for operating said knife cutting means; means for varying the frequency of operation of said knife cutting means from said source of power for varying the sizes of strip material cut, said last mentioned means being operable only during the interval between cutting operations; and automatic means for controlling the speed of operation of said knife cutting during a predetermined portion of the cycle of operation including the cutting interval for invariably bringing said knife cutting means to synchronous speed with said strip material during the cutting interval, said last mentioned means being non-operative to control said knife cutting means during the remaining interval of the cycle.

17. In a device for cutting continuously advancing strip material, a cyclically operable knife cutting means for periodically engaging said strip material for cutting; a source of power for operating said knife cutting means; means for varying the frequency of operation of said knife cutting means from said source of power for varying the sizes of strip material cut, said last mentioned means being operable only during the interval between cutting operations; and elliptical gear means for controlling the speed of operation of said knife cutting means during a predetermined portion of the cycle of operation including the cutting interval for invariably bringing said knife cutting means to synchronous speed with said strip material during the cutting interval, said last mentioned means being non-operative to control said knife cutting means during the remaining interval of the cycle.

18. In a device for cutting continuously advancing strip material, a cyclically operable knife cutting means for periodically engaging said strip material for cutting; a source of power for operating said knife cutting means; means for varying the frequency of operation of said knife

cutting means for changing the sizes of strip material cut; and elliptical gear means for transmitting driving power to said knife cutting means to bring its speed to synchronous speed with said strip material at an invariable predetermined rate, the cutting operation invariably occurring at a predetermined position of said elliptical gears irrespective of the variation in the frequency of the cutting cycle.

19. In a device for cutting continuously advancing strip material, a cyclically operable knife cutting means for periodically cutting said strip material; a source of power for operating said knife cutting means; means for varying the frequency of operation of said knife cutting means for changing the sizes of strip material cut; and a speed changing means for invariably bringing said knife cutting means to the same speed as said strip material at the period of cutting for every frequency of operation of said knife cutting means.

20. In a device for cutting continuously advancing strip material, a cyclically operable knife cutting means for periodically cutting said strip material; a source of power; means connecting said source of power to said knife cutting means for driving said knife cutting means; means for varying the frequency of operation of said knife cutting means for changing the sizes of strip material cut; and speed changing means included in said first-mentioned means for invariably bringing said knife cutting means to the same speed as said strip material at the period of cutting for every frequency of operation of said knife cutting means.

21. In a device for cutting continuously advancing strip material, a cyclically operable knife cutting means for periodically cutting said strip material; a source of power; means connecting said source of power to said knife cutting means for driving said knife cutting means; means for varying the frequency of operation of said knife cutting means for changing the sizes of strip material cut; and speed changing means included in said first-mentioned means for invariably bringing said knife cutting means to the same speed as said strip material at the period of cutting for every frequency of operation of said knife cutting means, the rate of speed change being different for each frequency of operation of said knife cutting means, whereby the knife cutting means is brought to the same speed at the cutting period for all sizes of strip material.

22. In a device for cutting continuously advancing strip material, a cyclically operable knife cutting means for periodically cutting said strip material; a source of power; means connecting said source of power to said knife cutting means for driving said knife cutting means; means for varying the frequency of operation of said knife cutting means for changing the sizes of strip material cut; and speed changing means included in said first-mentioned means for invariably bringing said knife cutting means to a fixed predetermined gear ratio in response to the source of power for driving the knife to the same speed as said strip material at the period of cutting for every frequency of operation of said knife cutting means.

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