United States Patent [19]

Wing

[11] **3,762,699**

[45] **Oct. 2, 1973**

[54] **FAN FOLD APPARATUS**

[76] Inventor: **James M. Wing,** 529A Southampton Dr., Silver Spring, Md.

[22] Filed: **Dec. 2, 1970**

[21] Appl. No.: **94,249**

[52] **U.S. Cl.** **270/73**

[51] **Int. Cl.** **B65h 45/16**

[58] **Field of Search** 270/70–73, 63, 65, 74, 75, 39, 79

[56] **References Cited**

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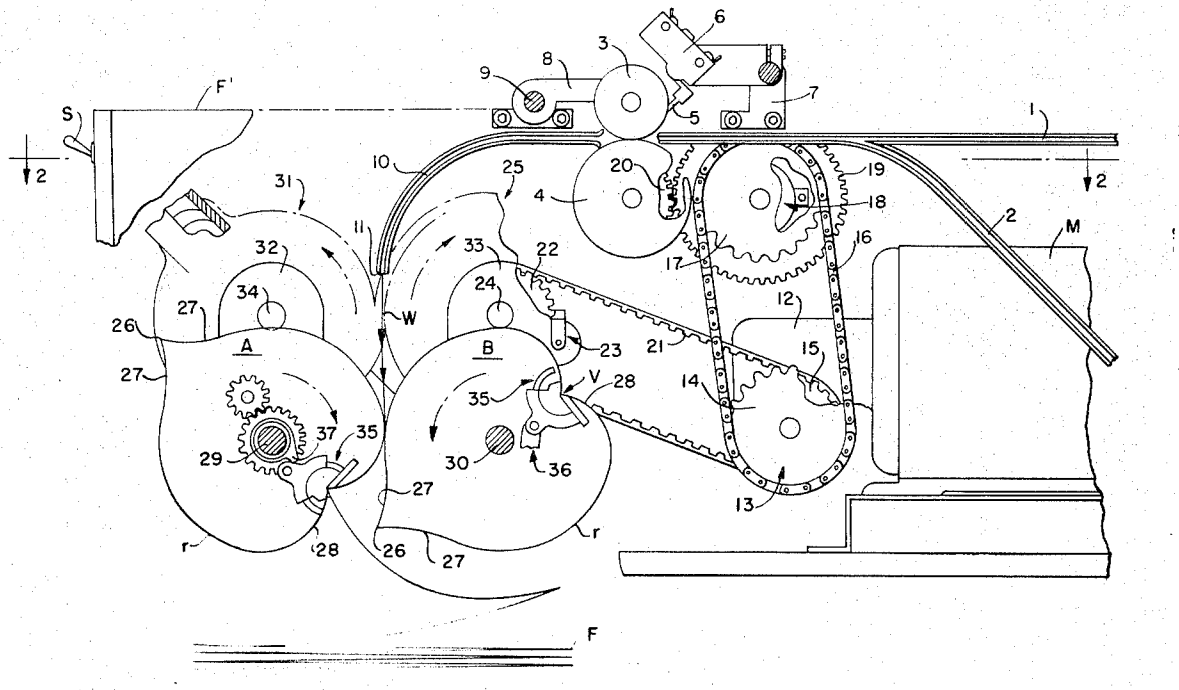
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Primary Examiner—Robert W. Michell
Assistant Examiner—A. Heinz
Attorney—Emory L. Groff and Emory L. Groff, Jr.

[57] **ABSTRACT**

An apparatus for fan-folding web material includes a pair of contra-rotating folding rollers having an irregular yet congruent configuration comprising a heart-shaped profile whereby the grain of the web is broken as each roller point forces the web into the "V" of the adjacent roller. Means are provided to rotate one roller at a constant angular speed while the second roller is driven at a variable angular speed to insure a constant tangency between the rollers without any slippage therebetween. The final creasing of the web is achieved by means of a clamping unit adjacent each roller "V" which is actuated by epicyclic gearing and cams within the roller.

23 Claims, 29 Drawing Figures

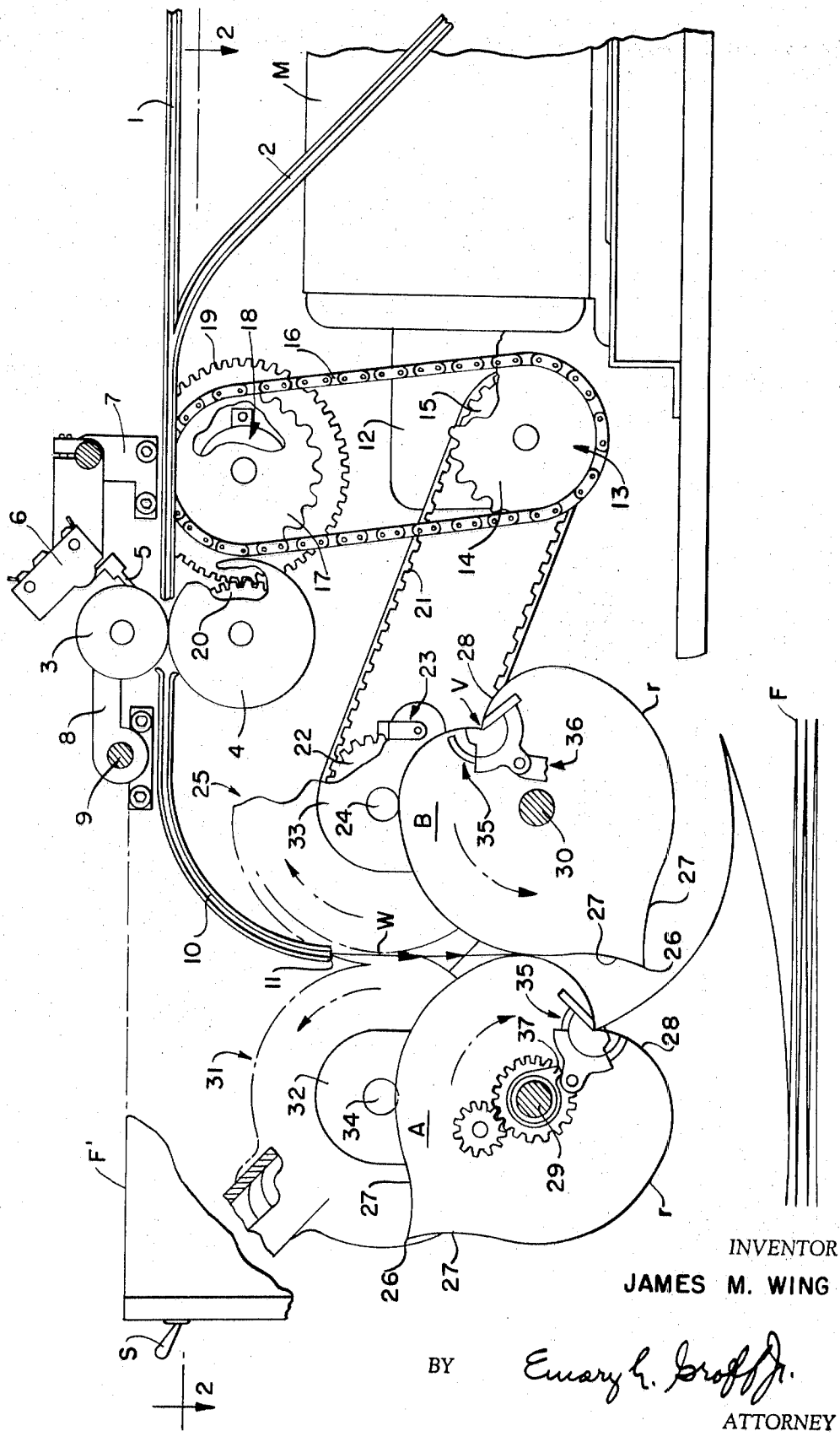


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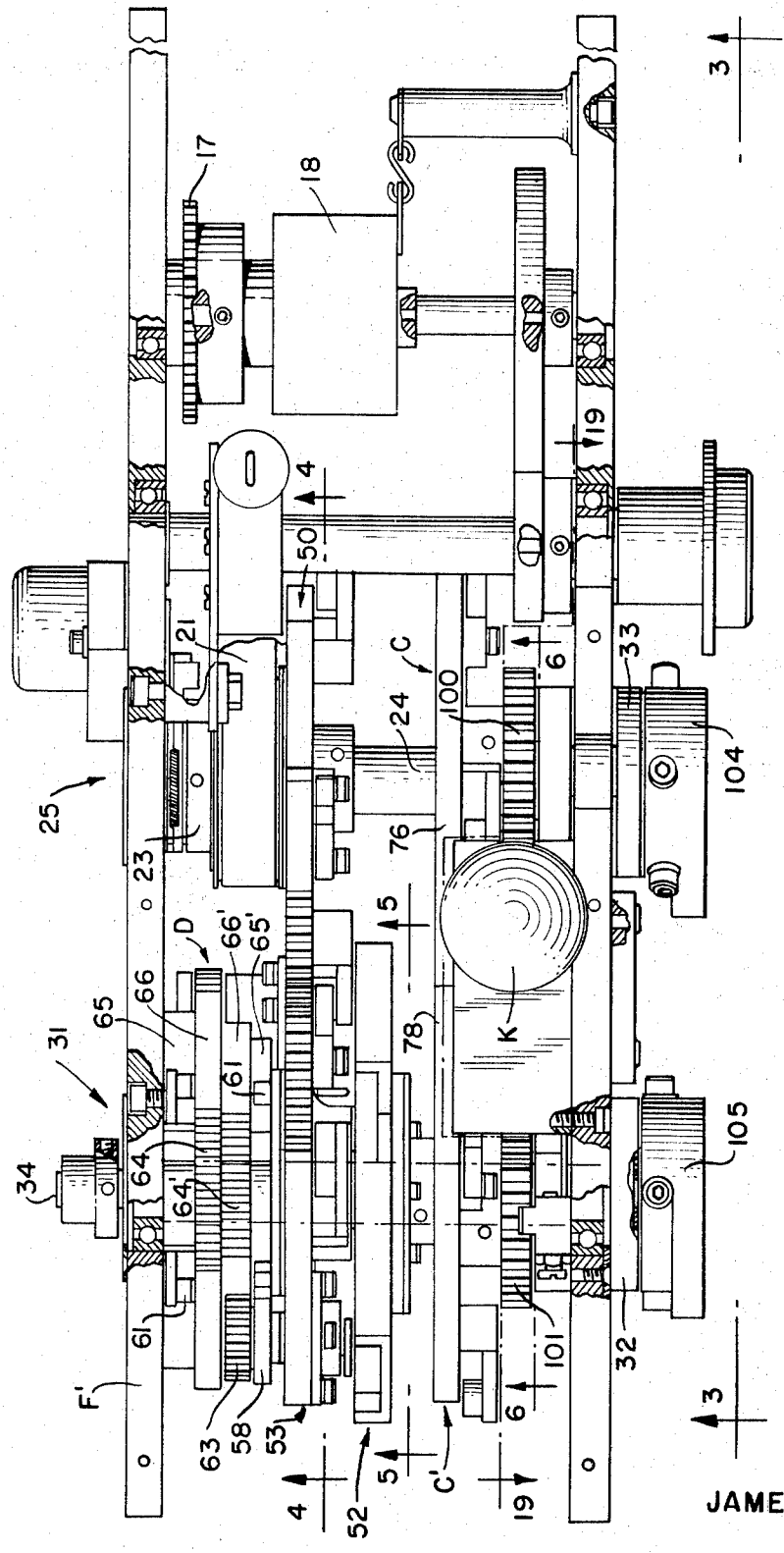
FIG. 1.



INVENTOR
JAMES M. WING

BY Emery L. Groff Jr.
ATTORNEY

FIG. 2.



INVENTOR
JAMES M. WING

BY Emory L. Groff Jr.
ATTORNEY

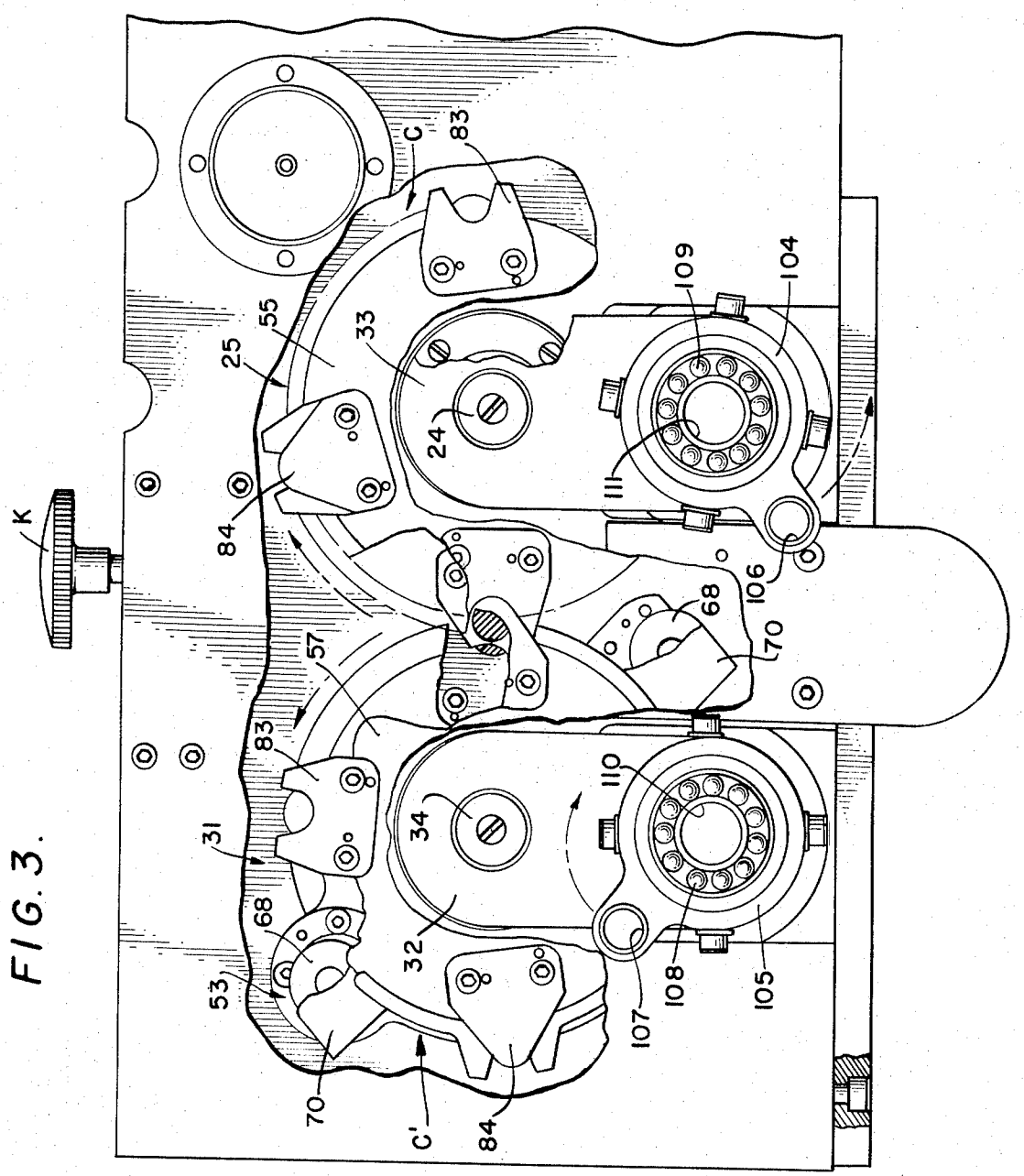


FIG. 3.

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JAMES M. WING

BY Emory L. Groff Jr.
ATTORNEY

FIG. 4.

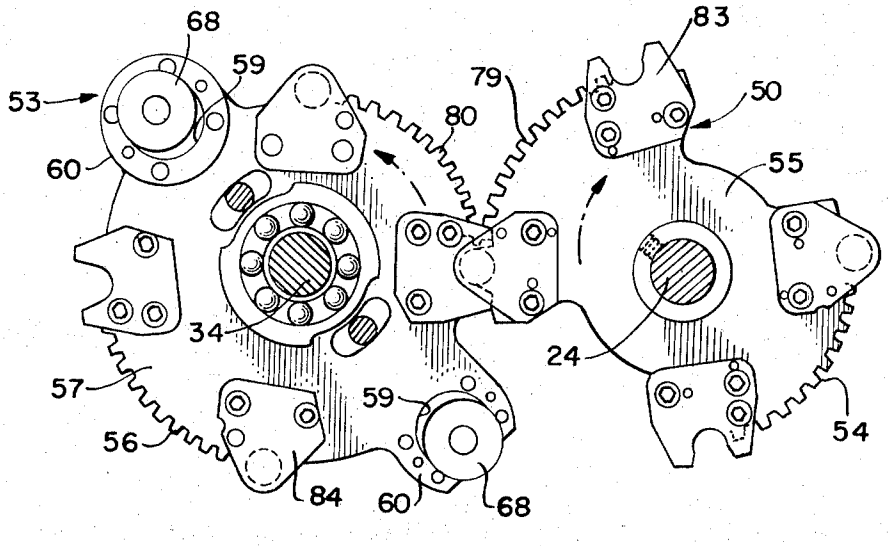


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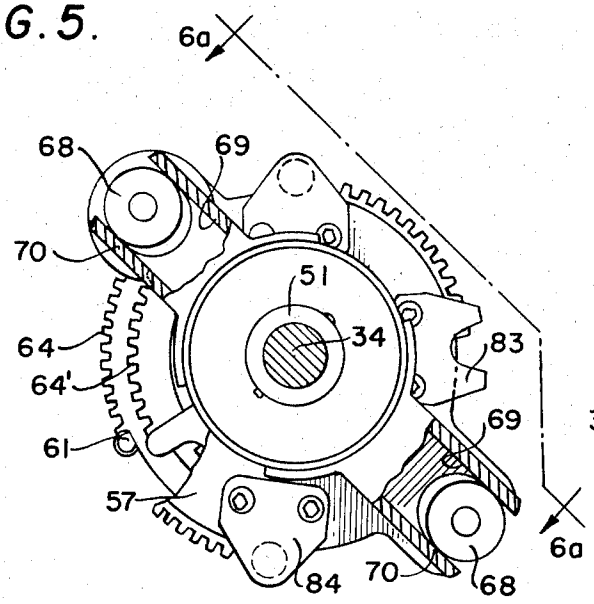
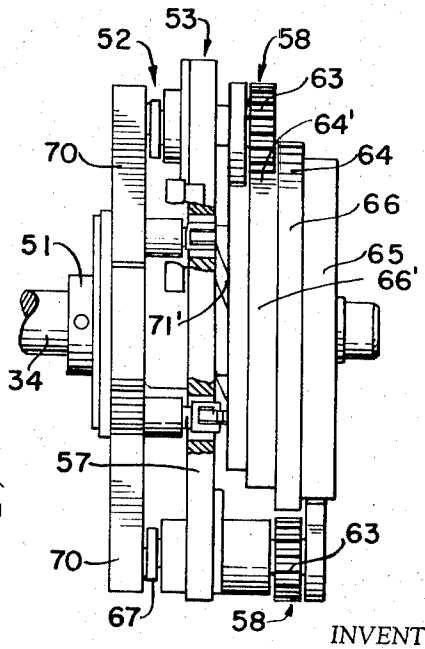


FIG. 6a.



INVENTOR
JAMES M. WING

BY Emory L. Groff Jr.
ATTORNEY

FIG. 6b.

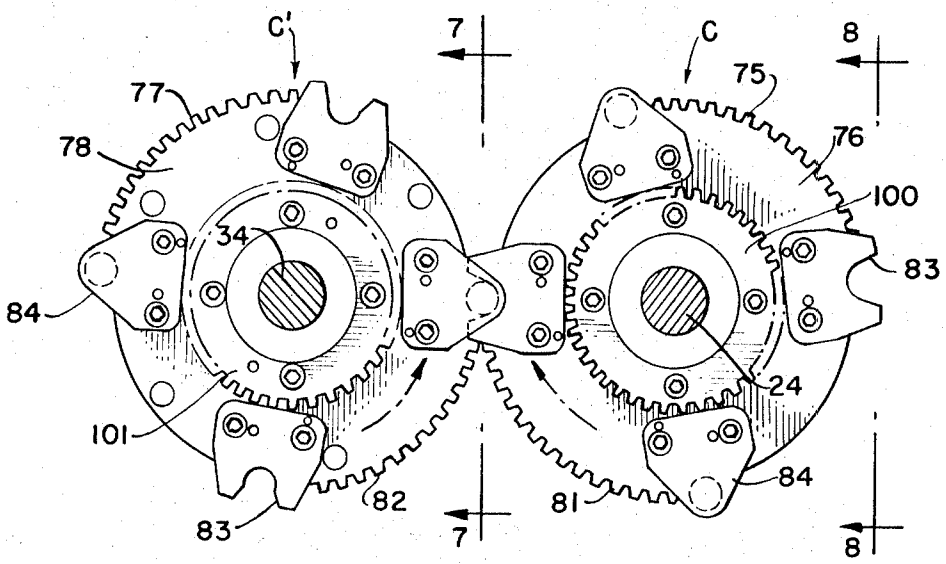


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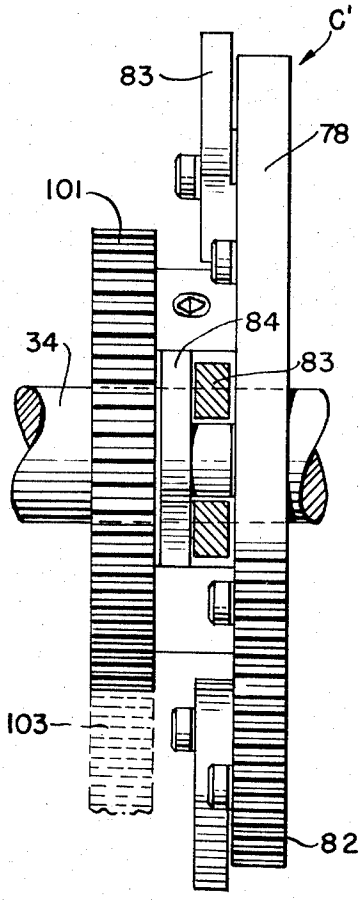


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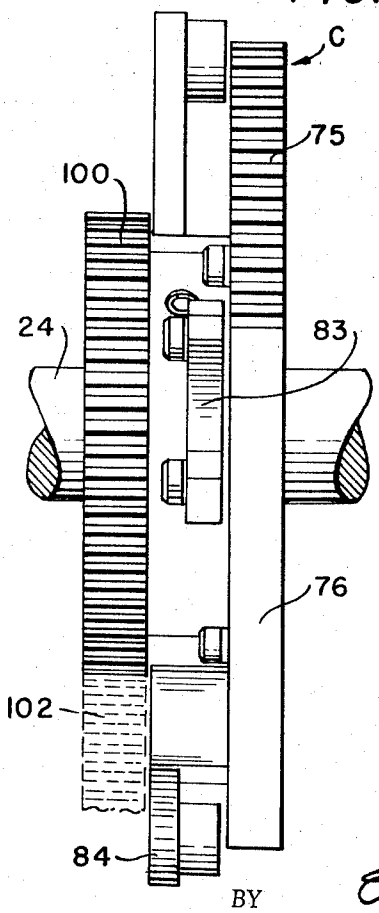


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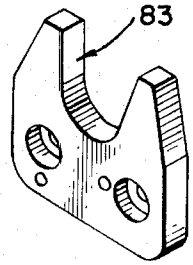
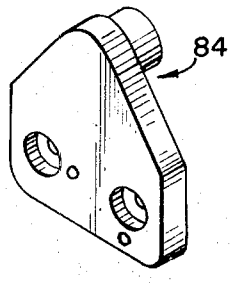


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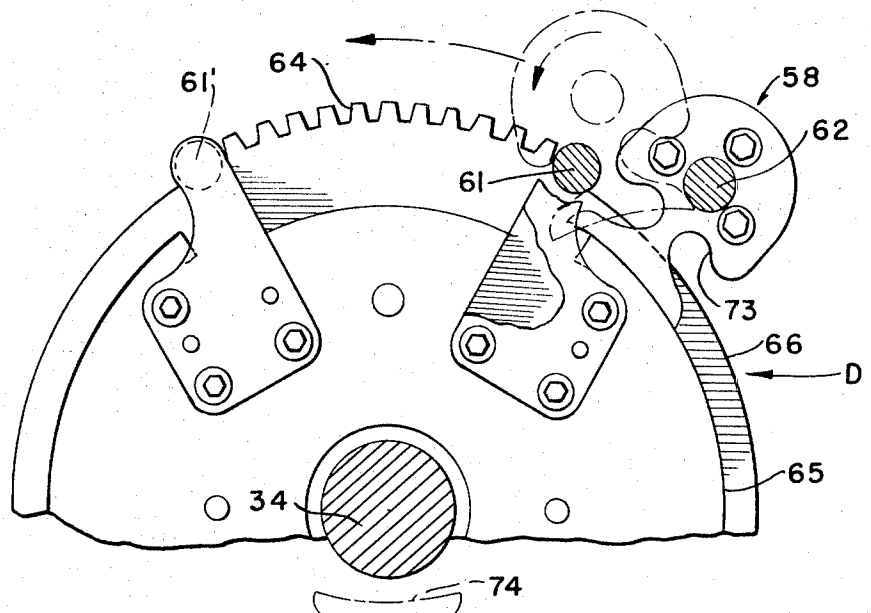


INVENTOR
JAMES M. WING

BY

ATTORNEY

FIG. 11.



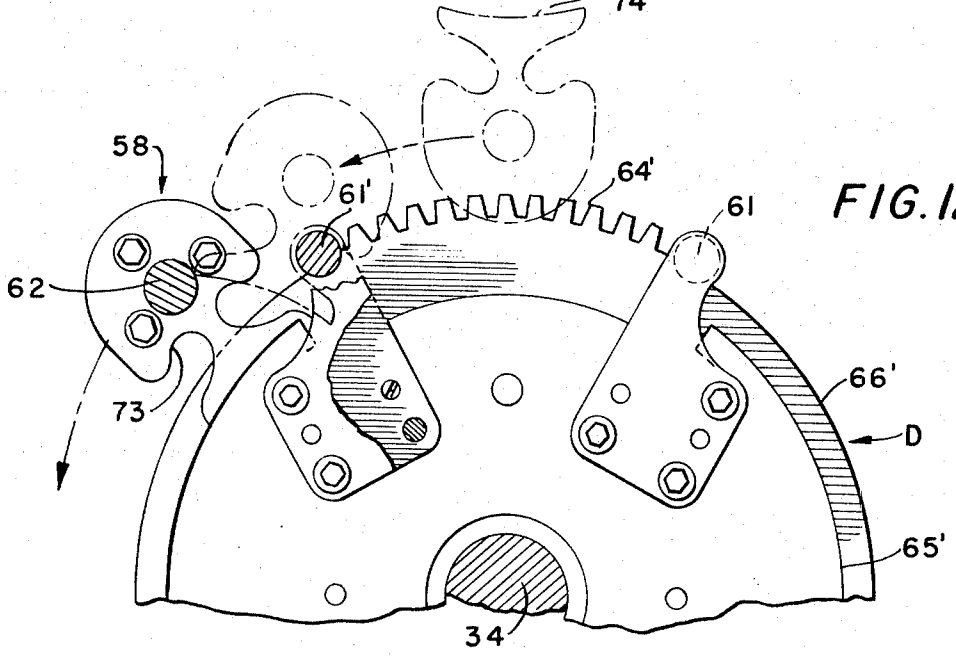


FIG. 12.

FIG. 13.

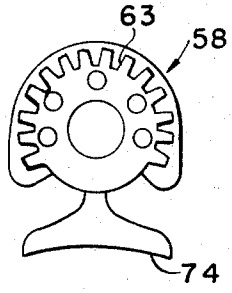
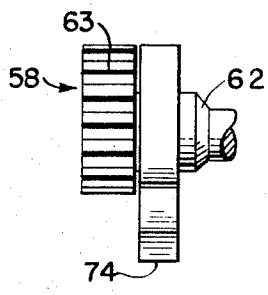


FIG. 14.



INVENTOR

JAMES M. WING

BY Emery L. Groff Jr.

ATTORNEY

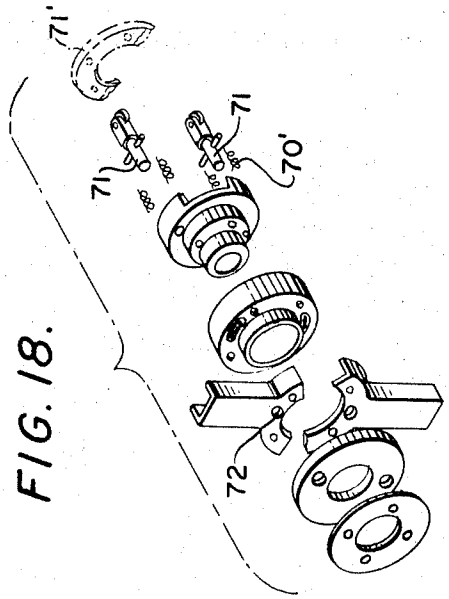


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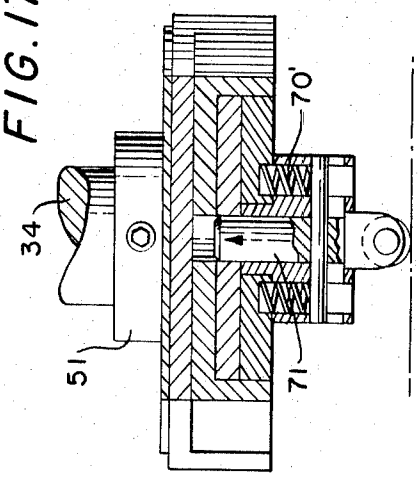


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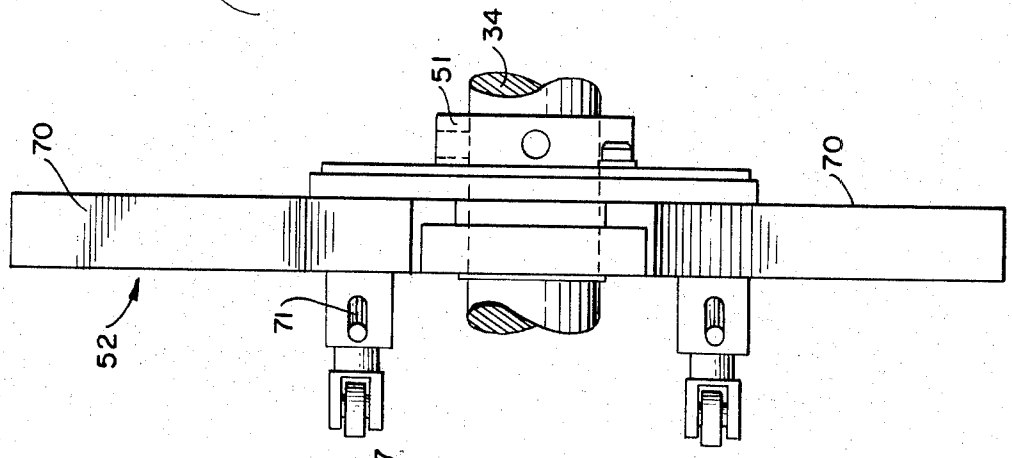


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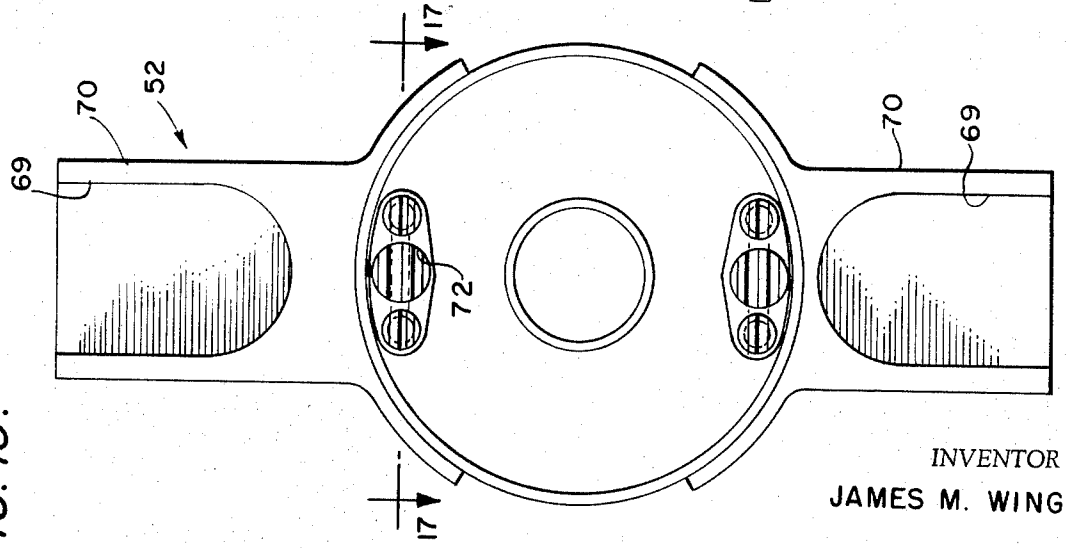


FIG. 15.

INVENTOR
JAMES M. WING

BY Emery L. Groff Jr.
ATTORNEY

FIG. 19.

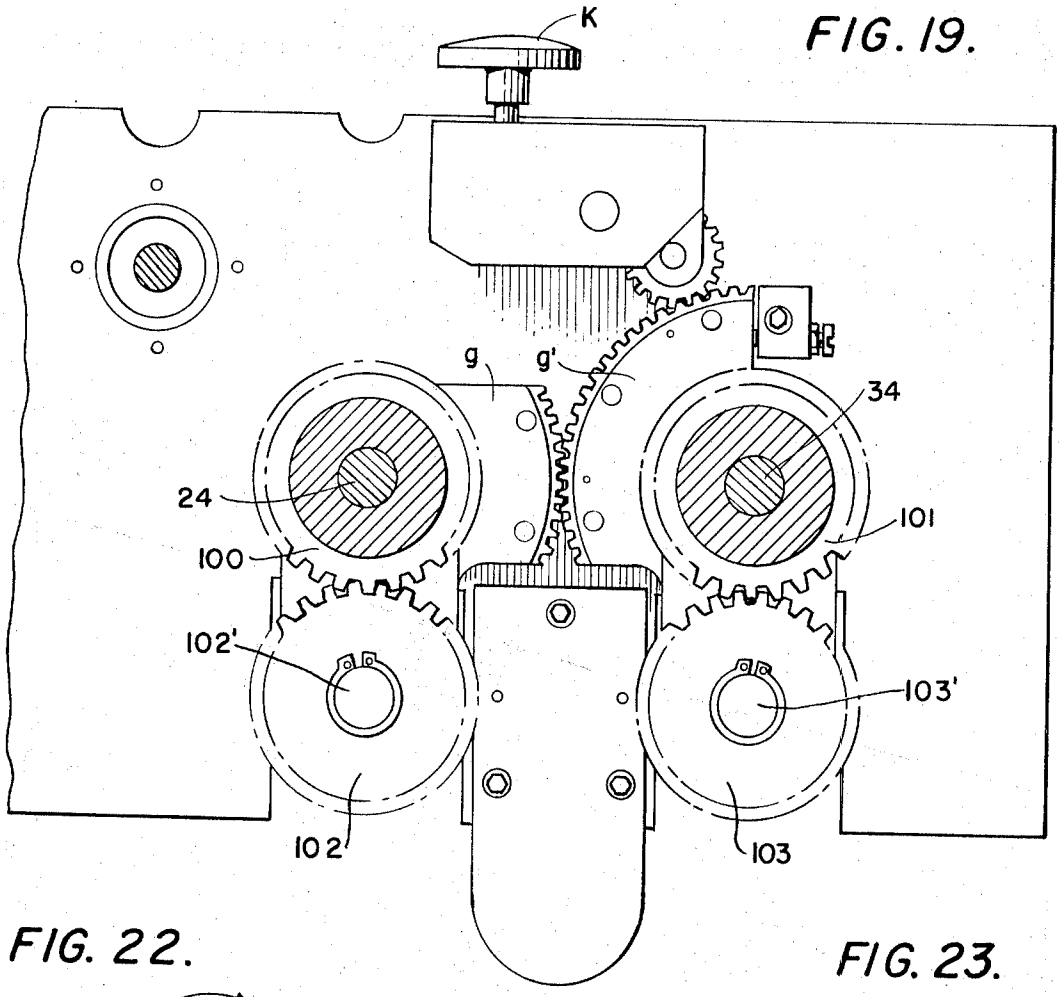


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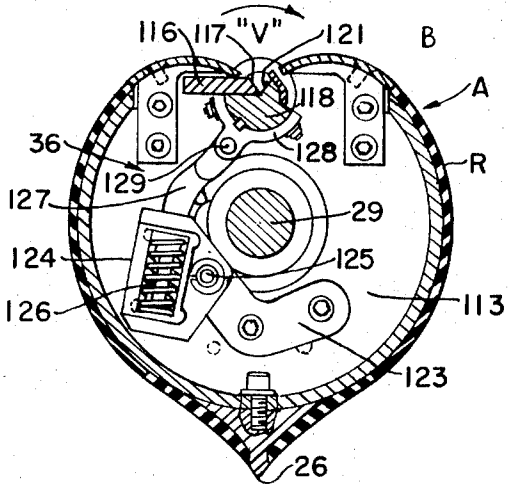
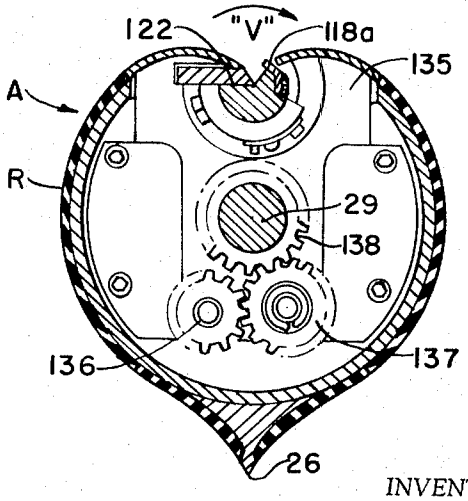


FIG. 23.



INVENTOR
JAMES M. WING

BY Emory L. Groff Jr.
ATTORNEY

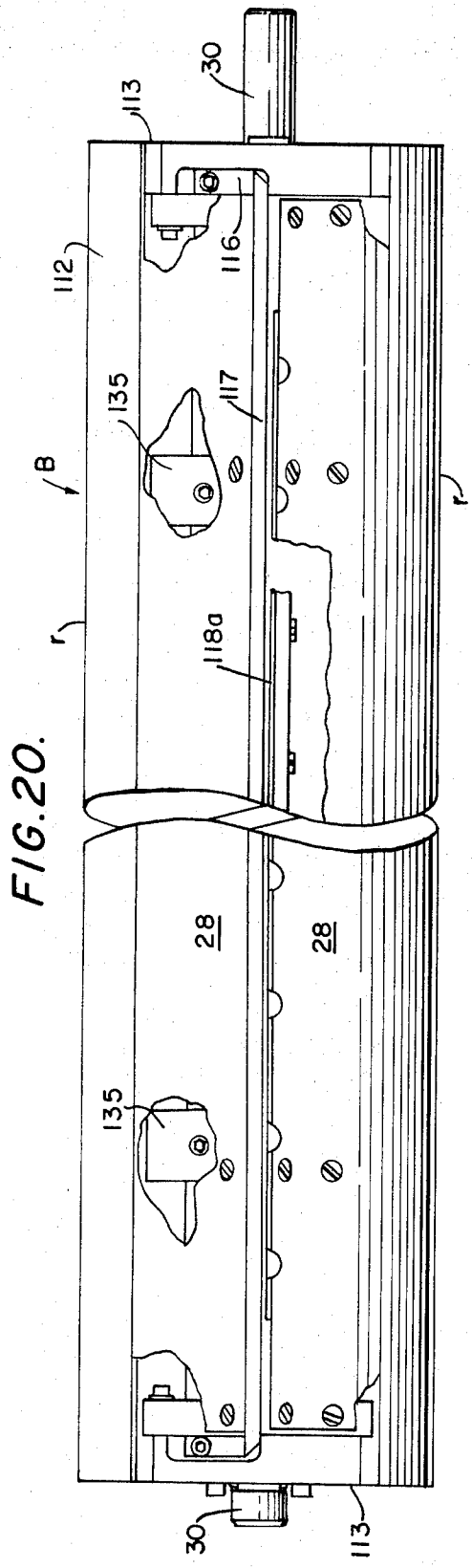


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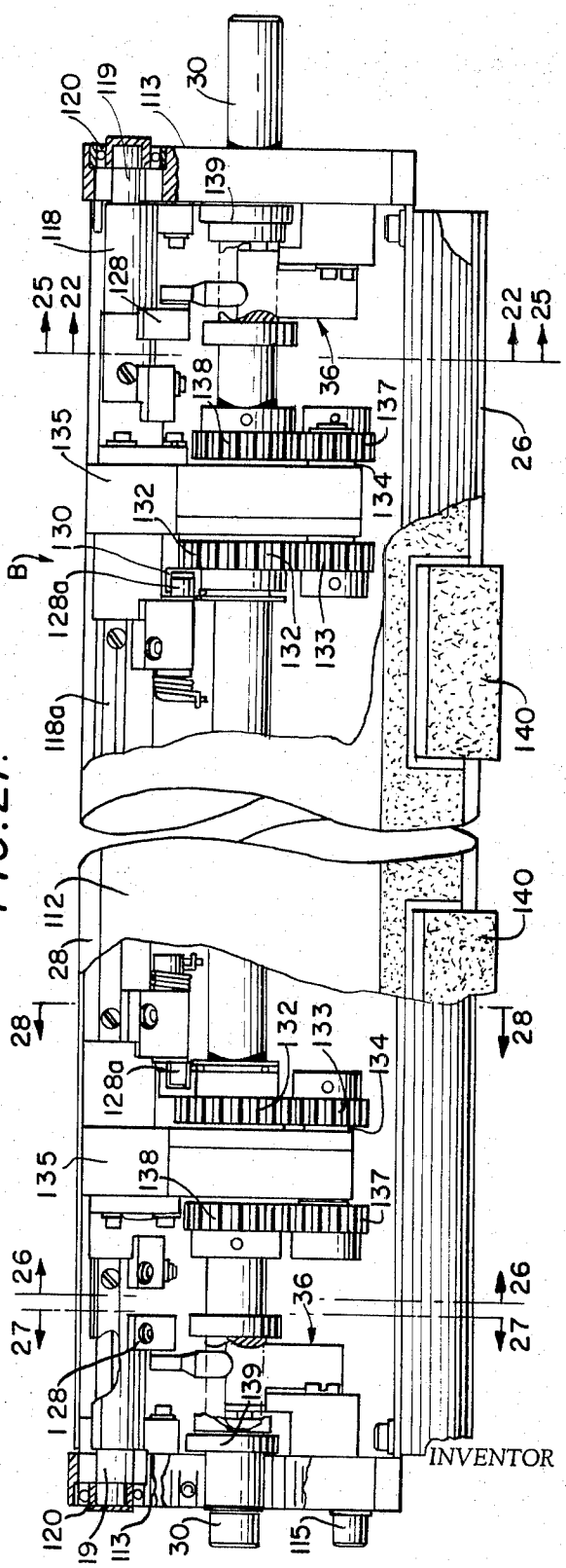


FIG. 21.

INVENTOR
JAMES M. WING
BY
Emery L. Groff Jr.
ATTORNEY

FIG. 24.

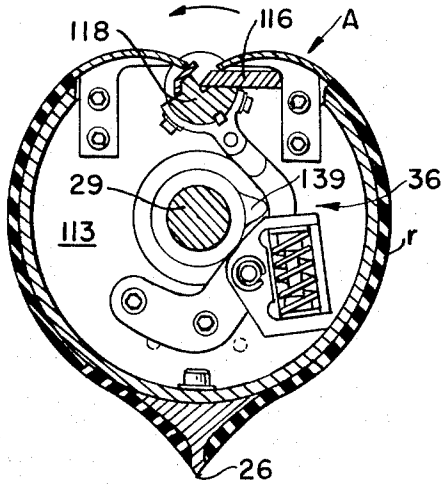


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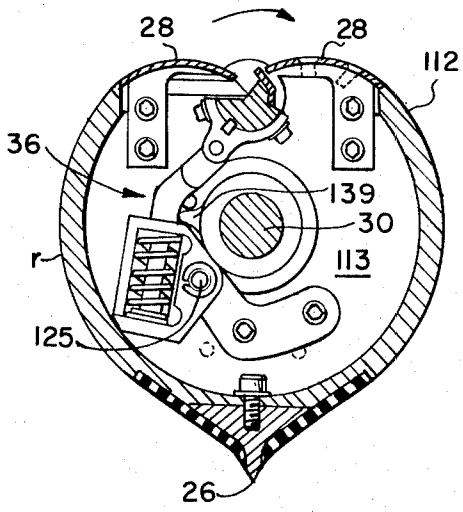


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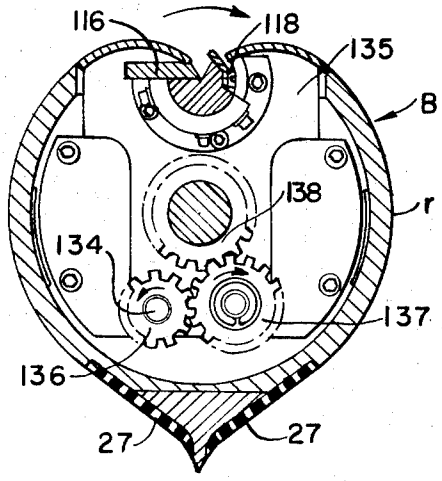
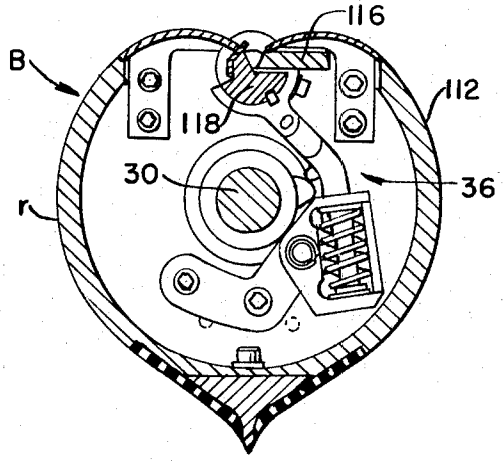


FIG. 27.



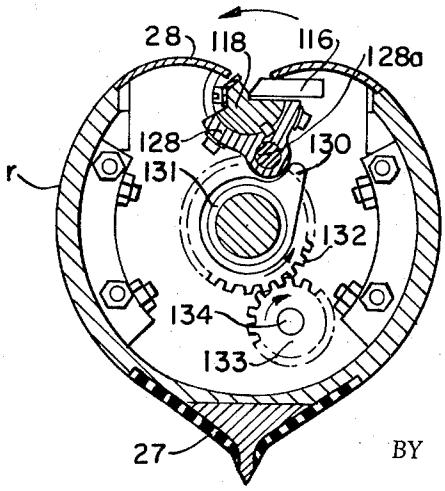


FIG. 28.

INVENTOR
JAMES M. WING

BY Emery H. Groff Jr.
ATTORNEY

FAN FOLD APPARATUS

This invention relates generally to rotary folding devices and more particularly to an apparatus for folding or creasing endless or continuous webs of material, such as paper, in accordian or zig-zag fashion.

Many types of fan fold mechanisms have been produced in the past, yet certain objectionable characteristics have almost always been present with these machines. Heretofore, this type of fold has most often been accomplished by producing a series of adjacent perforated holes transversely of the web at the point of the crease, but it will be appreciated that such perforations can be objectionable and the provision thereof only means the use of additional apparatus which requires continued maintenance and somewhat limits the output speed of the continuous web. The present improved apparatus provides a machine wherein folds are produced in a continuous web by means of a pair of heart-shaped contra-rotating rollers of congruent peripheral construction, but which include an irregular curvature. Each roller includes a movable clamping unit adjacent its "V" and by a unique drive arrangement, the folding rollers are rotated to intermesh the mating portions of their peripheries against the opposite surfaces of a continuous web, whereby the male point portion of one roller cooperates with the female "V" portion of the other roller to produce the fold or crease therein. More specifically, as the point of one roller enters the " V" of the other roller, the web is pressed into the cavity and the grain is broken. Then as the point passes through the center of the "V" and rolls out, a rubber gripper included with the clamping unit holds the web in the "V." When the point of the roller has rotated sufficiently to allow the clamping unit to close without interference, it proceeds to fully close, pressing a sharp crease in the web. Although especially adapted to operate upon the web of paper issuing as the print-out of a computer, it will be readily appreciated that this apparatus may be used in combination with any other type of device such as offset or letter press printing machines and likewise, the apparatus is not limited to the fan folding of a paper web but may also be used to operate upon metal foil, plastics, or other materials.

The most prevalent objection to many of the prior known devices which employ folding rollers is that the web is subject to frequent tearing or bursting, which is due to the pull or tension which is intermittently applied to the web as the creasing elements perform their function. This tearing action is additionally aggravated due to rubbing action between the two opposed roller peripheries, which action, however minimal, is extremely difficult to prevent when two constant speed folding rollers are employed.

The foregoing objections found in many of the prior art devices are overcome by the instant arrangement wherein a pair of congruently shaped folding rollers are combined with an improved driving arrangement so that as one of the folding rollers is driven at a constant speed, the second or adjacent folding roller will be driven at a variable speed, yet with an identical net r.p.m. as the constant speed folding roller. The intricacies of such an arrangement should be readily appreciated when it is realized that the constant speed rotation of an irregularly shaped roller results in a variable surface speed of the periphery of that roller past any given

fixed point, and therefore, in order to insure the exact mating of a similarly shaped adjacent folding roller without any relative slippage between the juxtaposed surfaces of the two rollers, it will be seen that an exacting drive mechanism must be provided for the similarly irregularly shaped variable speed folding roller.

Accordingly, one of the primary objects of the present invention is to provide an improved fan fold apparatus including a pair of heart-shaped folding rollers.

Another object of the present invention is to provide an improved fan fold apparatus including means for feeding a continuous web of material at a constant speed to a point between a pair of adjacent heart-shaped folding rollers.

A further object of the present invention is to provide an improved fan fold apparatus including a pair of heart-shaped folding rollers associated with a drive arrangement wherein one of the rollers is rotated at a constant angular velocity while the second of said rollers is rotated at a variable angular velocity to insure a precise relationship between the two roller peripheries at all times.

Still another object of the present invention is to provide an improved fan fold apparatus including a pair of irregularly shaped folding rollers, each of which is provided with an external point defined by a pair of lateral generated curves, and an oppositely disposed internal "V," defined by a pair of adjacent epicycloidal curves.

Another object of the present invention is to provide an improved fan fold apparatus including a pair of heart-shaped folding rollers, each rotatably displaced about fixed axial shafts with a first drive means rotating one of the folding rollers at a constant angular speed and a second drive means rotating the second folding roller at a variable angular speed insuring continuous point tangency between the two contra-rotating rollers.

A further object of the present invention is to provide an improved fan folding roller assembly rotatably driven about a stationary shaft and having an internal clamping unit sequentially and automatically opened and closed as the folding roller is rotated about the stationary shaft.

Still another object of the present invention is to provide an improved fan fold apparatus including an epicycloidal motion generating device for driving one of the folding rollers at a variable angular speed.

With these and other objects in view which will more readily appear as the nature of the invention is better understood, the invention consists in the novel construction, combination and arrangement of parts hereinafter more fully described, illustrated and claimed.

A preferred and practical embodiment of the invention is shown in the accompanying drawings, in which:

FIG. 1 is a side elevation, partly in section, and illustrates the general arrangement of the fan fold apparatus of the present invention.

FIG. 2 is a top plan view, partly in section, and illustrates the drive mechanisms shown in FIG. 1, with the folding rollers omitted for clarity.

FIG. 3 is a side elevation, with portions broken away, of the constant and variable speed drive mechanism for the two folding rollers as taken along the line 3—3 of FIG. 2.

FIG. 4 is a side elevation of the two-speed drive gear and differential unit included in the variable speed generating mechanism for the two folding rollers and taken along the line 4—4 of FIG. 2.

FIG. 5 is a side elevation, with portions broken away, of the variable speed generating mechanism as viewed along line 5—5 of FIG. 2.

FIG. 6*a* is a right side projection of the variable speed generating mechanism of FIG. 5 as viewed along the line 6*a*—6*a*.

FIG. 6*b* is a side elevation of the radial motion cluster gears as viewed along line 6*b*—6*b* of FIG. 2.

FIG. 7 is an end view of the driven cluster gear as viewed along line 7—7 of FIG. 6*b*.

FIG. 8 is an end view of the drive cluster gear as viewed along line 8—8 of FIG. 6*b*.

FIG. 9 is an enlarged perspective view of one of the locator plates as used on the cluster gears of FIG. 6*b*.

FIG. 10 is an enlarged perspective view of one of the locator buttons as used on the cluster gears of FIG. 6*b* and which mesh with the locator plates.

FIG. 11 is a view of the rear geared star wheel mechanism on the drum of the variable speed generating mechanism as shown in FIG. 6*a*.

FIG. 12 is a view of the front geared star wheel mechanism on the drum of the variable speed generating mechanism as shown in FIG. 6*a*.

FIG. 13 is a side elevation of the geared star wheel as shown in FIGS. 11 and 12.

FIG. 14 is an end elevation of the star wheel shown in FIG. 13.

FIG. 15 is a rear view of the epicyclic crank element.

FIG. 16 is an end elevation of the crank element of FIG. 15.

FIG. 17 is a sectional view of the epicyclic crank arm as indicated in FIG. 15 showing the follower carried thereby.

FIG. 18 is an exploded view of the epicyclic crank element of FIG. 16.

FIG. 19 is a rear side elevation of the right end roller support taken along the line 19—19 of FIG. 2 and illustrates the adjustable mechanism for regulating the pressure between the two folding rollers.

FIG. 20 is a top plan view, with portions broken away, of the plain folding roller.

FIG. 21 is a vertical sectional view, with portions broken away, of the plain folding roller and illustrates the mechanism therein for controlling the opening and closing of the crease forming clamping unit of the roller.

FIG. 22 is a cross-sectional view as would be taken along the line 22—22 of FIG. 21 in the case of the blanket roller and illustrates the clamping unit in the open position and its toggle mechanism for opening the clamping unit.

FIG. 23 is a transverse sectional view as would be taken along the line 26—26 of FIG. 21 in the case of the blanket roller and illustrates the epicyclic gear train and center support.

FIG. 24 is a transverse sectional view as would be taken along the line 27—27 of FIG. 21 in the case of the blanket roller and illustrates the clamping unit and toggle mechanism similar to that shown in FIG. 22 but which is located at the opposite end of the roller.

FIG. 25 is a transverse sectional view taken along the line 25—25 of FIG. 21 and illustrates the clamping unit and toggle mechanism as found in the plain roller.

FIG. 26 is a transverse sectional view taken along line 26—26 of FIG. 21 and illustrates the epicyclic gear train mounted on the center support.

FIG. 27 is a transverse sectional view taken along line 27—27 of FIG. 21 and shows the clamping unit and toggle mechanism.

FIG. 28 is a transverse sectional view through the plain roller taken along line 28—28 of FIG. 21 and illustrates the cam and gear combination mounted on a bushing pressed in the support.

Similar reference characters designate corresponding parts throughout the several figures of the drawings.

Referring now to the drawings, particularly FIG. 1, the fan fold apparatus of the present invention will be seen to comprise means for guiding, feeding and folding a continuous length of material such as the web W, all of the various components of which may be enclosed within or supported by a suitable framework or casing generally designated C. The apparatus shown in this figure may be positioned adjacent a print-out station of a computer or may be associated with any other type of apparatus such as a printing press. Regardless of the source of supply for the continuous web W which is to be fan-folded, it will be understood that the leading edge of the web is introduced to the apparatus by means of the web guide 1, which may comprise any suitable structure such as a pair of spaced apart plates adapted to receive and align a moving sheet of material. The present device will readily accept and saisfactorily operate upon sheet material of various thicknesses, for example, between 0.002 and 0.006 inches in thickness, and will even fan fold a two-ply web. In this latter regards, a secondary web guide 2 is provided which will be seen to merge with the primary web guide 1 at a point preceding the juxtaposed pressure roller 3 and feed roller 4. The nip formed by the co-acting rollers 3 and 4 is disposed within the plane of the throat defined by the web guide 1, as is also the actuating arm 5 of a single pole double throw micro-switch 6 suitably attached to the apparatus frame or casing F' by means of a switch support 7. The axial shaft of the feed roller 4 will be understood to be fixedly attached with respect to the casing F'. The pressure roller 3 is journalled in the free end of a roller support 8 which is suitably pivotally attached to the casing F' as at 9 in a manner to allow adjustment of the pressure brought to bear by the periphery of the roller 3 upon the periphery of the feed roller 4.

The web guide extension 10 leads from the exit area of the rollers 3 and 4 and curves downwardly to terminate in a free end portion 11 disposed above the nip formed by the co-acting folding rollers generally designated A and B. For reasons which will become obvious hereinafter, the free end portion 11 of the web guide extension 10 is disposed well above the nip defined by the two folding rollers, and in fact, it is even higher than the highest point reached by the periphery of the folding rollers during their rotation.

Motive power for operating the apparatus is provided by means of the gear motor M having an output box 12 to which is attached a combination pulley 13 comprising adjacent and concentrically mounted elements comprising the chain sprocket 14 and timing belt sheave 15. A roller drive chain 16 leads from the chain sprocket 14 to the sprocket 17 of a magnetic clutch assembly generally designated 18. The output side of the magnetic clutch assembly includes a feed roller drive gear 19 constantly meshing with the feed roller gear 20, whereby when the main apparatus switch S is closed, the motor M is operated to drive the chain 16 and thus

the feed roller 4 and its juxtaposed pressure roller 3. A timing belt 21 is disposed about the sheave 15 on the one hand, and engages on the other hand a constant drive speed sheave 22, which in turn is coupled by means of a mechanical clutch assembly 23 to the shaft 24 of the constant feed drive assembly 25. It will be understood that the mechanical clutch 23 is normally open while the magnetic clutch assembly 18 is normally closed or in the engaged condition by reason of having its circuitry completed through the micro-switch 6. With the foregoing in mind, the initial sequence of operation of the apparatus may now be related.

When the switch S is moved to the "on" position the gear motor M is energized, and the circuit through the SPDT micro-switch 6 is in its normally closed position completing the circuit thru the magnetic clutch 18 causing the feed rollers 3 and 4 to rotate. The folding rollers A and B are stationary at this time being correctly positioned by the single revolution mechanical clutch 23. As a web of material is fed between the pressure roller 3 and feed roller 4 the arm 5 is pushed up causing the SPDT switch 6 to change to its normally open position. This closes the circuit to the mechanical clutch 23 causing the folding rollers to start turning. By an auxilliary circuit the feed drive is activated long enough to take the web down the web guide extension 10 to the folding rollers. It will thus be understood that when the leading edge of the web has been fed to the area of the nip formed by the two folding rollers A and B that all subsequent movement of the web W is caused solely by the juxtaposed peripheral surfaces of the two folding rollers.

An initial description of the two folding rollers and their attendant drive assemblies will now follow. As far as their exterior configuration is concerned, the roller A and B are substantially identical. Roller A is termed the blanket roller, inasmuch as its periphery is provided with a covering of rubber R overlying its two radial surfaces while the roller B is referred to as the plain roller, since a significant portion of its periphery is of exposed metal. The two rollers A and B will be seen to be generally of heart-shaped configuration when viewed in end elevation and include mateable male and female areas. The peripheries of the rollers define an irregularly curved configuration and include an exteriorly projecting point 26 formed on each of its adjacent sides by a generated curve 27, while the diametrically opposed portion of each roller is provided with an interior "V" or cavity formed on each adjacent side thereof by an epicycloidal curve 28. The irregular curvature of the two rollers are congruent, and except for an intermediate area on both sides of each roller, described by a radial surface *r* the curvature of the periphery thereof will be seen to be formed by an ever-increasing or ever-decreasing radius. The rollers A and B are mounted for rotation about the stationary shafts 29 and 30, respectively, and the means for providing a contra-rotary motion to the two rollers comprises an epicycloidal motion drive assembly 31 and a constant speed drive assembly previously identified as 25. The stationary shafts 29 and 30 are supported at one end by the lower portions of a pair of swingable roller supporting arms 32 and 33 while the opposite ends of the roller stationary shafts are supported by a pair of similar swingable arms (not shown). Extending through the supporting arm 32 is a variable speed drive shaft 34 which drives adjacent gear means connected to the far end of the blanket roller A for causing rotation of this roller about its fixed shaft 29. At the same time, the constant speed drive shaft 24 passing into the supporting arm 33 drives similar gear means connected to the far end of the plain roller B to rotatably drive this roller about its fixed shaft 30.

By means of the above-referenced structure, it will be appreciated that constant tangency is insured between the peripheral surfaces of the two folding rollers during the simultaneous contrarotation thereof. With the realization that as one of the rollers is rotating, its peripheral surface juxtaposed that of the adjacent roller may be increasing in radius such as would be the case when considering the folding roller A as shown in FIG. 1. It will follow that the surface speed at this point of the periphery would therefore be decreasing, although the roller B is rotating at a constant angular velocity. This will occur since the epicycloidal curve 28 of the roller A has passed its point of tangency with the generated curve 27 of roller B and the point of tangency between the two rollers is now at their radial sections. With this in mind, one will more radily appreciate the necessity of providing a variable speed drive for the roller A, so that its irregularly shaped peripheral surface will at all times maintain a point of tangency with that of the roller B without any slippage therebetween.

As will be seen later on, the internal construction of the two rollers A and B is similar. Each roller includes a clamping unit 35 disposed adjacent the apex of the "V" and which is maintained in either an open or closed position by means of a toggle mechanisms, generally designated 36, while a cam 37 mounted upon the stationary shaft 29 or 30 serves to actuate the clamping unit 35 to move it to a closed position. As each clamping unit 35 moves around to a point below the end portion 11 of the web guide extension 10, it will be in an open position so that as the point 26 of the other folding roller is rotated towards a mating position with the open clamping unit 35, the web W will be urged into the "V" of the one roller and finally into the open jaws of the clamping unit with the maximum projection of one point 26 into the juxtaposed jaws of the clamping unit occurring when these two components intersect the horizontal plane passing through the centers of the two stationary shafts 29 and 30. At this stage the grain is broken as the point forces the web into the "V." Continued contra-rotary movement of the two rollers will of course cause the point 26 to be retracted from within the open jaws of the clamping unit, at which time these jaws will close to clamp a crease across the entrapped web material and thereby form the fold. The relative positioning of the two rollers as shown in FIG. 1 illustrates the condition of the apparatus at this time. Further rotation of the rollers will cause other cams (not shown) to open the clamping unit 35, thus permitting the folded web section to fall onto the top of the stacked fan-folded sheet F. As the two rollers rotate, it will be seen that the described creasing operation will be performed alternately by one folding roller and then the other. The folding operation will continue as long as the master switch S is on, or until the trailing end of a specific length of web W passes between the pressure roller 3 and feed roller 4, at which time the actuating arm 5 of the micro-switch 6 will drop to its initial position, thereby disconnecting the circuit controlling the mechanical clutch 23 which in turn disconnects the folding roller drive assemblies, while at the same time,

the circuit to the magnetic clutch assembly 18 is closed in order to actuate the drive feed roller 4 to advance another length of web material.

Having described the general sequence of operation, the mechanism for transmitting the rotation of the two shafts 24 and 34 to the two folding rollers A and B will now be described together with the specific construction of these rollers. As previously mentioned in connection with the description of the overall apparatus as it appears in FIG. 1, each of the drive shafts 24 and 34 is provided with a swingable roller supporting arm 32 or 33 which arms are illustrated more in detail in FIGS. 3 and 19 of the drawings, these two views looking at opposite sides of the structure. Rotation of the shafts 24 and 34 causes a corresponding rotary displacement of the concentrically disposed drive gear 100 and driven gear 101 which gears comprise a fixed part of their respective cluster gear assemblies C and C' to transmit their rotary movement to a pair of mating transfer gears 102 and 103, which transfer gears are mounted upon independent shafts journalled in the lower portion of the swingable arms. In this manner it will be seen that the clockwise rotation of the drive shaft 24 and the counter-clockwise rotation of the drive shaft 34 as viewed in FIG. 1 or 3 now appears as a reverse rotation of the transfer gears 102 and 103 and their respective shafts 102' and 103'. Associated with each transfer gear is a drive arm 104 or 105 attached to the opposite end of the shaft 102' or 103' which rotates exteriorly of the casings comprising each of the swingable roller support arms 32 and 33 in the directions indicated by the arrows of FIG. 3. Projecting from the periphery of each drive arm is a suitably supported drive bushing 106 or 107. Mounted on the outside of each drive arm is a bearing of 108 or 109 axially aligned with the shaft 102' or 103' and which serve to support one end of each roller shaft 29 or 30 by means of their inner race 110 or 111. To obtain the desired initial pressure setting between the two folding rollers the supporting arm casings 32 and 33 may be pivotally adjusted by means of the meshing gear segments *g* and *g'* (FIG. 19) which are controlled through suitable gearing actuated upon rotation of the pressure adjustment knob *k*.

With the foregoing understanding it will be observed that the constant rotation of the drive shaft 24 will be transmitted as a constant angular speed of rotation of the drive bushing 106 about the axis of the bearing 109 while on the other hand the varying speed of rotation of the drive shaft 34 will be transmitted as a varying speed of rotation of the drive bushing 107 about its related center passing through the axis of the bearing 108.

Turning now to FIGS. 20 through 28 together with FIG. 1, the operation of the rotation of the two folding rollers A and B will now be described together with the internal mechanism associated with each of these rollers which automatically causes the two clamping units 35—35 to open and close with each rotation of the rollers. As previously mentioned the basic construction of the two rollers is identical and although similar structure appears in each of the two rollers it will be apparent that the sole significant distinction is that many of the internal components of the two rollers will be reversed in their manner of attachment therein or in their direction of rotation in view of the contra-rotary movement of the two rollers. Accordingly, it is necessary only to describe the construction of one of these rollers, such as the plain roller B, which is illustrated most fully in FIGS. 20 and 21 of the drawings. The roller B is formed with the aforementioned shell or peripheral surface 112 which is closed at each end by an end wall 113 having a centrally disposed bearing 114 mounted therethrough. Passing through this bearing is the shaft 30 which extends beyond both of the end walls 113 and is suitably supported at both ends in a manner to preclude any movement thereof. One end of the shaft 30 will be inserted through the inner race 111 of the bearing 109 carried by the lower portion of the swingable roller support arm 33 while the opposite end of the shaft 30 is fixedly secured to a similar swingable roller support arm mounted on the adjacent side of the casing C, this latter supporting means also being associated with a suitable swingable support arm capable of being adjusted in the same manner as the above-described adjustment provided for the swingable arms 32 and 33. The end wall 113 adjacent the end of the shaft 30 which is supported by the bearing 109 is also provided with a drive post 115 projecting outwardly therefrom as shown in FIG. 21. This drive post is engaged within the drive bushing 106 on the constant speed drive arm 104 whereupon it will be understood that means have now been described for rotating the roller B at a speed exactly regulated by the speed of the constant speed drive shaft 24.

Not only is the internal construction of the rollers A and B similar as above related, but also, as will be seen in FIG. 21, the components in one half of the one roller B are duplicated in the other half of this roller so that identical coinciding movements are generated within the roller as it is rotated about the stationary shaft 30 in order to cause a positive or forceful operation of the opening and closing of the clamping unit 35.

Each clamping unit 35 will be seen to comprise a stationary jaw 116 which is fixedly mounted within the shell 112 adjacent the "V" and includes a bar type element having a bevel edge 117 with its lowermost portion serving as the pivot axis for the rotatable jaw 118. Both components of the clamping unit 35, namely the stationary jaw 116 and rotatable jaw 118 extend substantially the length of the roller shell 112 as shown in FIGS. 20 and 21. The rotatable jaw 118 is provided with a stub axle 119 at each end thereof which is journalled for arcuate movement within bearings 120 attached to each end wall 113 off the roller. The upper portion of the rotatable jaw 118 is provided with a short clamp edge 121 and a longer stop edge 122 which intersect one another at a point corresponding to the center axis of the bearings 120 and these edges will be seen to describe an obtuse angle the apex of which pivots about the near-most portion of the bevel edge 117 of the stationary jaw 116. Attached to the outer portion of the rotatable jaw is a gripper bar 118*a* which will be seen to have an upper edge overlying the subjacent clamp edge 121 of the rotatable jaw. This gripper bar is preferably of hard rubber construction and serves to insure a positive creasing of the web upon closing of the clamping unit 35.

Means are provided in the form of the plurality of toggle mechanisms 36 for insuring that the rotatable jaw 118 will be maintained either in the fully opened position or in a fully closed position at all times when no external force is acting upon the toggle mechanisms. Each toggle mechanism 36 includes a support bracket 123 fixedly mounted on the endwall 113 in such man-

ner as to function freely about the shaft 30. A casing 124 is pivotally attached to the support bracket 123 as at 125 and contains the compression spring 126 which normally biases downwardly upon urging the crank toggle arm 127. The opposite end of the toggle arm 127 is in turn pivotally connected to the cardle 128 of the rotatable jaw at the pivot point 129. The cardle 128 is rigidly attached to the rotatable jaw 118 by means of suitable fasteners as shown in FIGS. 22 – 25 so that it will be seen that when an exterior force acts upon the depending cradle 128 to pivot it about the stub axles 119 of the rotatable jaw the toggle mechanism will pivot about both of the pivot points 125 and the center axis of the rotatable jaw 118 and in view of the offset location of the pivot 125 and the crank construction of the toggle arm 127, there will be produced a positive spring-urged force designed to forcefully retain the rotatable jaw 118 in either the open position as illustrated, or in the pivoted closed position with the clamp edge 121 of the rotatable jaw juxtaposed the bevel edge 117 of the stationary jaw.

The mechanism provided for closing the clamping unit 35 comprises a plurality of gears which cause a cyclic rotation of the closing cam 130 to bring it into engagement with the push bar 128*a* attached to the cradle 128. This cam is mounted for rotation about the fixed shaft 30 by means of a sleeve bushing 131 around the shaft and is fixedly attached to the exterior of this sleeve bushing together with the adjacent cam gear 132 as shown most clearly in FIGS. 21 and 28. Meshing with the gear 132 is the cam driving gear 133 which is fixedly attached to its own driving shaft 134. This driving shaft passes through a center support 135 fixedly disposed within the shell 112 and projects from the opposite side thereof to fixedly support the intermediate gear 136 as shown in FIG. 26. The intermediate gear is driven by the idler gear 137 which will be seen to be driven in turn by means of the sun gear 138 anchored to the shaft 30. Following the sequences of operations as the roller B is rotated about the stationary shaft 30 it will be observed that the stationary sun gear 138 causes sequential rotation first of the idler gear 137 and then the smaller intermediate gear 136 which latter gear transmits this rotation to the cam driving gear 133 by means of their common shaft 134. The driving gear 133 then in turn rotates the sleeve mounted cam gear 132 and its juxtaposed cam 130 to cause closing of the rotatable jaw 118 each time its nose strikes the push bar 128*a* on the cradle 128 as shown in FIGS. 21 and 28. Thus, it will be seen that an epicyclic gear train is utilized to derive a cyclic rotation of the cam 130 to sequentially close the rotatable jaw 118 each time the roller B is rotated 360°. It is, of course, by the selection of the size of each of the gear elements of the epicyclic gear train and the initial location of the cam nose that the precise operation of the cam 130 is achieved at the proper moment following insertion of the web into the "V" of one roller by the point 26 of the other roller to produce the desired crease in the web.

Upon closing the clamping unit 35 as above described, the roller A or B continues to rotate approximately 30°, carrying with it the creased web. At this point a cam 139 fixedly mounted to the stationary shaft 29 or 30 adjacent each end wall 113 engages the toggle casing 124 to force it outwardly and thereby causes the rotatable jaw 118 to rotate to the open position with the toggle mechanisms 36 acting to provide a positive snap action of the clamping unit from its closed to open position.

To preclude any tendency of the web from following the point of one folding roller and not remaining in the "V" of the other roller so as to be creased thereby, the generated curve areas 27 of each roller shell are provided with sponge insert blocks 140 adjacent the trailing side of the roller point 26 to assist in pushing away the web material from each point as the rollers pass through the point of tangency thereby encouraging the web to remain within the "V" of the other roller and be creased.

The variable speed drive shaft 34 received all its power by gear motion as derived from rotation of the constant speed driver shaft 24. At all times, the two drive assemblies 25 and 31, associated with the drive shafts 24 and 34, respectively, are locked together by a gear train, and it will be recalled that the constant speed shaft 24 will be continuously rotated when the mechanical clutch assembly 23 is engaged. During one revolution of the constant speed shaft 24, there is a change in the point of application of gearing four times: twice to the variable speed generating mechanism 31 to vary its shaft 34 motion to compensate for the changing surface speed as the rollers mate at their point contour 27 and epicycloidal contour 28, and twice to the cluster gears C and C' of FIGS. 2, 3 and 6*b* to produce a radial motion for the fixed radius of the radial peripheral contours *r*.

Before explaining the cycle of the speed control operation, it is necessary to understand which of the plurality of elements are fixed to their respective shafts 24 and 34. On the constant speed shaft 24 the speed change drive gear 50 of FIGS. 2 and 4 is fixed, as is the drive cluster gear C of FIGS. 2 and 6*b*. On the variable speed shaft 34, the hub 51 of the crank element 52 of FIG. 16 is fixed as is the driven cluster gear C' of FIG. 6*b*. In the variable motion generating mechanism of the variable speed shaft 34 the drum assembly D is attached to the frame F' while the related differential unit 53 of FIG. 4 is bearing mounted. The general arrangement of these parts are shown in the top plan view of FIG. 2.

Generally, the operation is as follows: the first fold in the web is made by rotating the point profile 27 of the variable speed roller A through the point of tangency to mate with the epicycloidal curve 28 of the constant speed roller B. The following components perform this operation. The slow speed gear segment 54 (FIG. 4) of the speed change drive gear plate 55 causes the differential unit 53 to turn at a reduced velocity as the segment 54 meshes with the slow speed gear segment 56 of the differential gear plate 57. At the same instant, a star wheel 58 carried in the slot 59 of the differential arm 60 engages a pivot post 61 on the fixed drum assembly D causing the star wheel to rotate about its shaft 62 as its attached gear section 63 meashes with the tooth section 64 on the drum. The construction of the drum assembly D will be most readily apparent from a review of FIGS. 5 and 6*a*. This assembly comprises a plurality of fixed components including a rearmost first rim plate 65 of one diameter and a second rim plate 65' of a lesser diameter between which are sandwiched first and second speed change plates 66 and 66', likewise of different diameters. The tooth section 64 is formed on the periphery of the plate 66 while the adjacent periph-

ery of the smaller plate 66' is provided with a similar tooth section 64'.

On the other end of the geared star wheel shaft 62 is an eccentric arm 67 supporting a roller 68 disposed within the radial trackway 69 of each crank element arm 70. By the simple harmonic motion movement of the eccentric roller 68 in the crank arm trackway 69 an acceleration or deceleration of the arm is produced. During this motion, the crank arm 70 is locked to its hub 51 by means of a follower pin 71 (FIGS. 6*a*, 16, 17 and 18) which is carried by the hub 51 and is urged into locking engagement with the crank arm 70 by means of a cam segment 71' attached to the rim plate 65'. The free end of each pin 71 is forced into the lock opening 72 in the arm 70 against the force of the return springs 70'. The crank arm 70 on the opposite end is free and moves with the bearing mounted differential plate 57 while the other crank arm 70 is being actuated by the star wheel assembly 58 and its related eccentric roller 68 to arcuately displace the drive shaft 34.

The start wheel 58 makes a complete revolution by the time it has been driven across the tooth section 64 or 64' and is returned to its inoperative position by the other pivot post 61' which is engaged by the second of two notches 73 in the star wheel assembly. When thus positioned, the arcuate shoe 74 of the star wheel is free to slide around the smooth portion of the rim plate 65 or 65'.

Immediately after the above revolution of the star wheel the first gear segment 75 of the drive cluster gear plate 78 (FIG. 6*b*) to rotate the shaft 34 and thus rotate the radial surface *r* of the variable speed roller A. During this rotation the shaft 24 and shaft 34 rotate at the same speed to accommodate the fixed radius of the radial surfaces *r* of the two rollers A and B.

The second fold, formed 180° from the first fold, is made by rotating the epicycloidal contour 28 of the variable speed roller A through the point of tangency to mate with the point profile 27 of the constant speed roller B. The same sequence of mechanical movements takes place as above described with respect to the first variable speed operation except of course different rates of speed increase and decrease are produced in view of the different diameters between the speed change plates 66 and 66' which independently and alternately actuate the two star wheel assemblies 58—58' and their related eccentric rollers 68—68'. Initially, the fast speed gear segment 79 of the driver gear plate 55 meashes with the fast speed gear segment 80 of the driven differential gear plate 57 at the time when the first gear segments 75 and 77 of the two cluster gear plates 76 and 78 have terminated their meshed relationship. Thereafter, rotation of the differential gear plate 57 causes actuation of the second one of the star wheels 58 and its eccentric roller to drive its related crank arm 70 and the variable speed drive shaft in the manner as set forth in connection with the first described crank arm.

Following this operation, the second gear segments 81 and 82 of the cluster gear plates 76 and 78 mesh to rotate the drive shaft 34 at a speed equal to that of the drive shaft 24 as the other two radial surfaces of the rollers A and B mate in tangency. It will be noted that the two cluster gear plates 76, 78 as well as the speed change drive gear plate 55 and its related differential gear plate 57 are provided with means insuring positive orientation therebetween comprising alternately disposed female locator plates 83 and male locator buttons 84 which sequentially mate as shown in FIGS. 4 and 6*b*.

From the foregoing description, it will be seen that improved means have been provided to insure perfect tangency between a pair of contra-rotating folding rollers of irregular peripheral contour without any surface slippage whereby, when the epicycloidal contour of a constant speed folding roller is passing through the point of tangency, a point profile is being generated on the variable speed folding roller and when the point profile of the constant speed folding roller is passing through the point of tangency, an epicycloidal contour is being generated on the variable speed roller.

I claim:

1. A web folding apparatus including, a pair of folding rollers of congruent and symmetrical cross-sectional configuration, said rollers each having a periphery defined by alternate epicycloidal, generated and constant radial curve portions generally providing each roller with a contour including mateable male and female areas, means supporting each of said rollers for rotation about a central axis, means for feeding web material between said rollers, and means for driving said rollers in a contra-rotating manner, said driving means including means rotating one of said rollers at a constant angular speed while concurrently rotating the other of said rollers at a variable angular speed whereby, said two rollers repetitively mate at points of web folding when respective said male and female areas are juxtaposed and said rollers constantly maintain a point of tangency between their peripheries without any slippage or interference therebetween.

2. A web folding apparatus according to claim 1 wherein, said folding rollers are each heart-shaped.

3. A web folding apparatus according to claim 1 wherein, each said folding roller periphery includes a pair of constant radial portions adjacent a pair of generated curve portions.

4. A web folding apparatus according to claim 1 wherein, each said folding roller periphery male area includes an exteriorly projecting point and said female area includes an interior "V" and said point is defined by a pair of said generated curve portions.

5. A web folding apparatus according to claim 4 wherein, said curve portions defining said "V" are epicycloidal.

6. A web folding apparatus according to claim 1 including, a web clamping unit carried by each said folding roller, said clamping unit comprising a stationary jaw and a rotatable jaw, said roller supporting means including a fixedly disposed shaft within said roller, and means within said roller operable by rotation of the roller about said shaft to displace said rotatable jaw to open and close said clamping unit.

7. A web folding apparatus according to claim 6 wherein, said means within said roller displacing said rotatable jaw includes a toggle mechanism having an arm attached to said rotatable jaw, and spring means urging said arm to normally retain said clamping unit in a closed or open position.

8. A web folding apparatus according to claim 7 including a cam fixed to said fixedly disposed shaft and adapted to cyclically open said rotatable jaw.

9. A web folding apparatus according to claim 7 including, a cam mounted about said fixedly disposed shaft for free movement therearound and adapted to

cyclically close said rotatable jaw, an epicyclic gear train having a sun gear fixed to said fixedly disposed shaft, and a cam gear connected to said freely mounted cam.

10. A web folding apparatus according to claim **9** wherein, said cam and cam gear are fixed to a sleeve slidable about said fixedly disposed shaft and said epicyclic gear train includes intermediate gears transmitting rotation from said fixed sun gear to said freely mounted cam gear.

11. A web folding apparatus according to claim **1** wherein, said driving means includes, a constant speed drive shaft having means for rotating same at a fixed speed, an adjacent variable speed drive shaft, and means on said two shafts for driving said variable speed shaft alternately at a constant speed and at a variable speed for each revolution of said constant speed shaft.

12. A web folding apparatus according to claim **11** wherein, said driving means on said two shafts includes a drive cluster gear plate fixed to said constant speed shaft and a driven cluster gear plate fixed to said variable speed shaft, each said two plates provided with angularly spaced apart mateable gear segments whereby, when said gear segments of said two plates are meshed said variable speed shaft is driven at a speed equal to said constant speed shaft.

13. A web folding apparatus according to claim **12** including, a speed change drive plate fixed to said constant speed shaft adjacent a differential unit freely mounted upon said variable speed shaft, said differential unit including a driven gear plate, said speed change drive plate and differential plate having angularly spaced apart mateable gear segments, said differential unit provided with variable speed motion generating means operable when said speed change plate segment meshes with said differential plate semgent to rotate said variable speed drive shaft at a variable speed.

14. A web folding apparatus according to claim **13** wherein, said generating means includes means alternately locking and unlocking said freely mounted driven gear plate to said variable speed drive shaft.

15. A web folding apparatus according to claim **14** wherein, said alternately locking and unlocking means includes a pair of crank arms, means radially mounting said crank arms adjacent said variable speed shaft in a normally free manner, a follower pin displaceable to lock each said crank arm to said variable speed shaft, said generating means including an eccentrically mounted roller engaging each said crank arm, and means driving said crank arm roller to arcuately move said crank arm when said crank arm is locked to said variable speed shaft by said follower pin.

16. A web folding apparatus according to claim **15** including a drum assembly fixedly disposed around said variable speed shaft adjacent said differential unit, said drum assembly including a speed change element and rim plate, said generating means provided with a star wheel gear assembly connected to each said crank arm roller by an eccentric shaft, and said crank arm roller drive means includes a tooth section on said fixed speed change element.

17. A web folding apparatus according to claim **16** including cam means on said drum assembly engageable by said follower pin to lock said crank arm to said variable speed drive shaft when said star wheel gear assembly engages with and is rotated by said tooth section.

18. A web folding apparatus according to claim **16** wherein, said star wheel assembly includes a gear section, and pivot means on said drum assembly engaged by said star wheel assembly to rotate said gear section into mesh with said tooth section.

19. A web folding apparatus according to claim **18** including, a shoe on said star wheel assembly slidable on said rim plate when said gear section is not meshed with said tooth section.

20. A web folding apparatus according to claim **18** wherein, said drum assembly includes a separate and different diameter fixed speed change element and rim plate for each star wheel assembly whereby, different variable speed motions are transmitted to said variable speed drive shaft upon the alternate actuation of said two star wheel assemblies.

21. A web folding apparatus according to claim **1** wherein, said folding roller supporting means includes a non-rotatable shaft.

22. A web folding apparatus according to claim **1** wherein, each said folding roller periphery male area is provided with a point and said female area includes a diametrically disposed "V," and a movable clamping unit is mounted within said roller adjacent said "V."

23. A web folding apparatus according to claim **1** including, a pair of swingable support arms between said driving means and said roller supporting means whereby, adjustment of said arms varies the contact pressure between said rollers.

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