

[54] **SHEET FEEDER DRIVE MECHANISM**
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 [51] Int. Cl. B65h 3/06, F16h 55/18
 [58] Field of Search 271/21, 22, 23;
 74/214-216, 409, 440, 411

[56] **References Cited**
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[57] **ABSTRACT**
 A drive mechanism for controlling the separating and forwarding function of a sheet feeding device for imparting an asynchronous multi-directional motion to the sheet feeding mechanism for accomplishing reverse buckle feeding of individual sheets from a stack.

20 Claims, 4 Drawing Figures

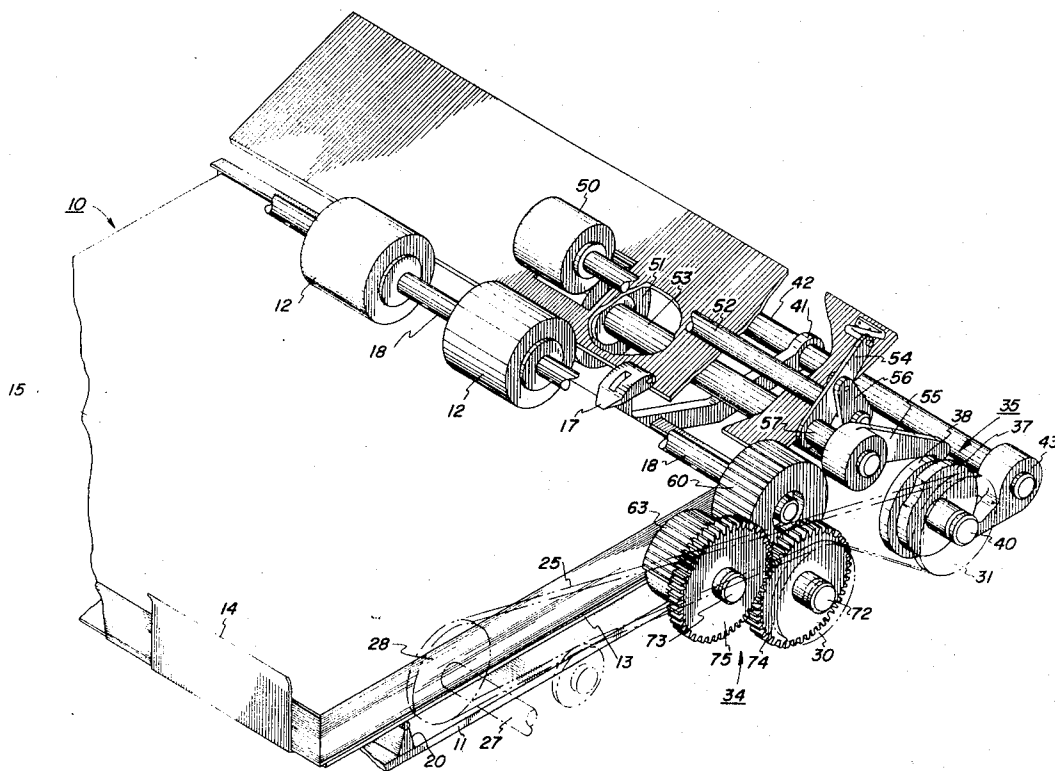


FIG. 1

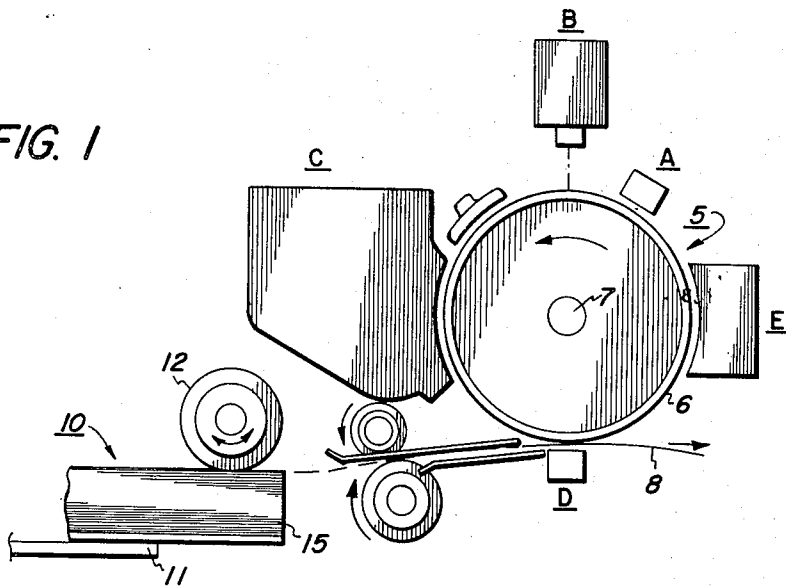


FIG. 3

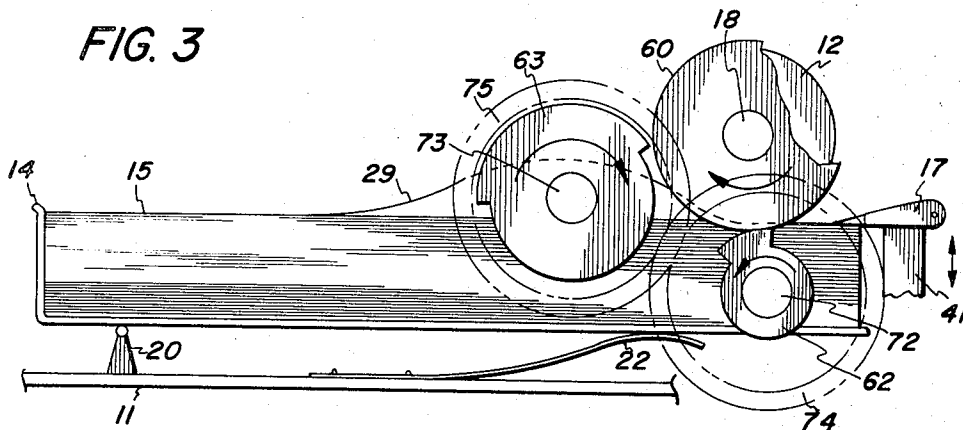
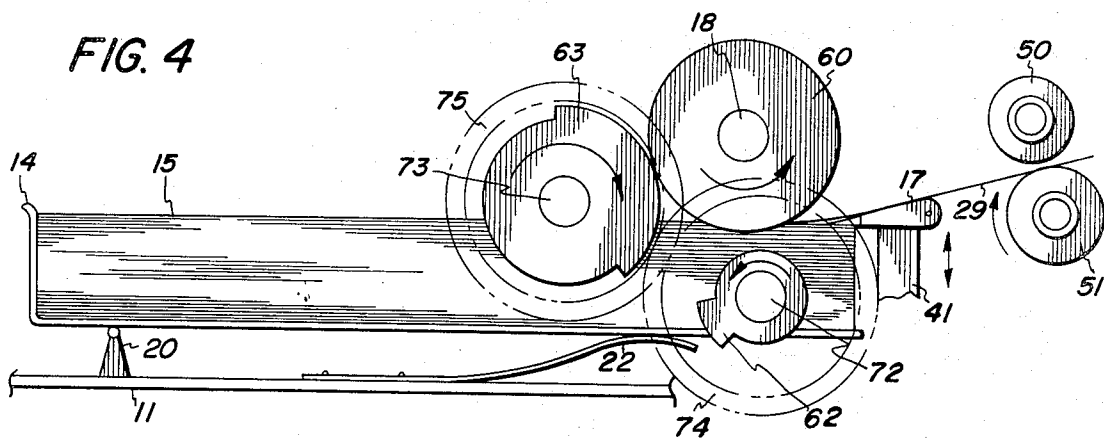
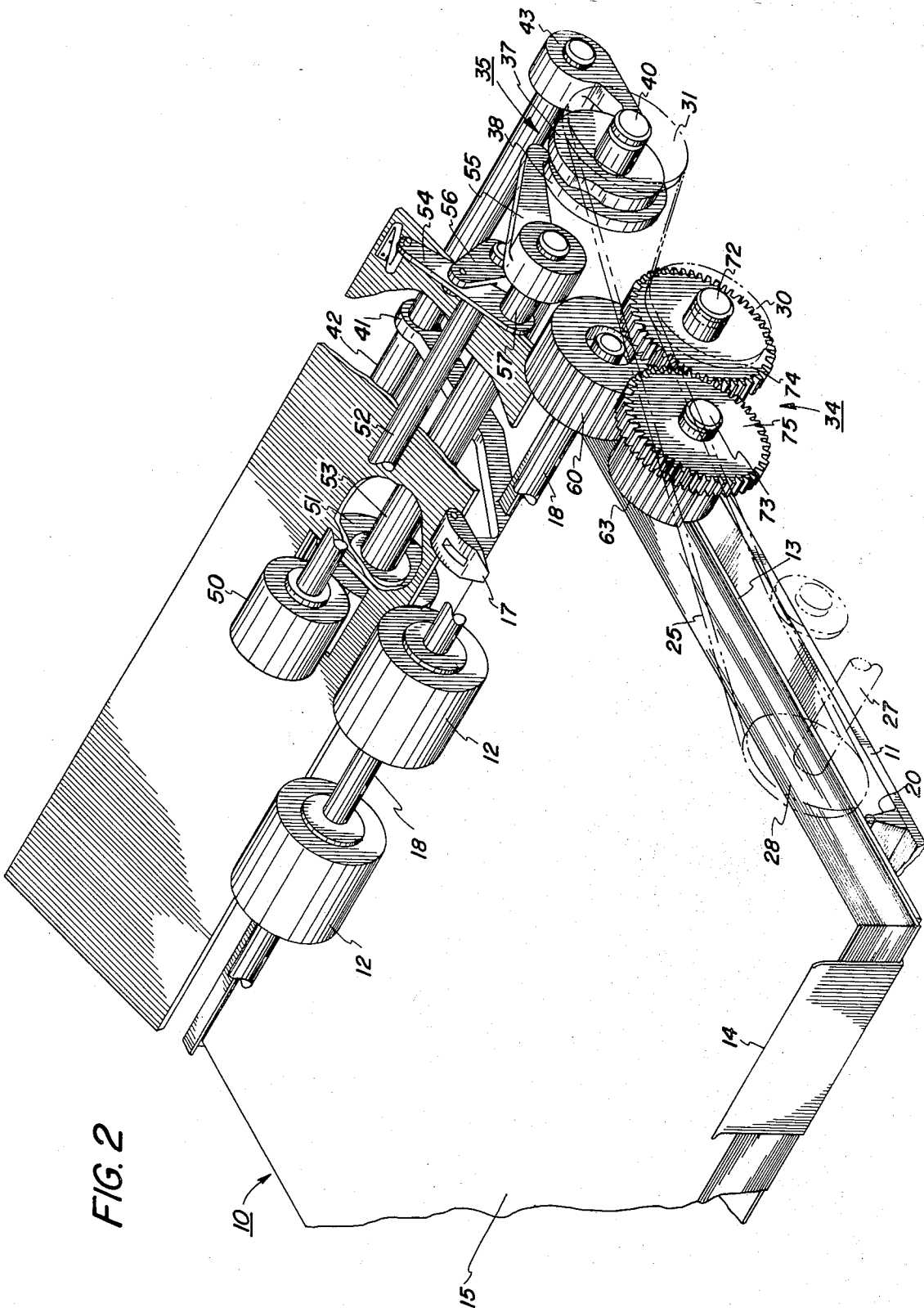


FIG. 4





SHEET FEEDER DRIVE MECHANISM

This invention relates generally to a drive mechanism and, in particular, to a drive mechanism for imparting an asynchronous multi-directional motion to a sheet feeding mechanism.

More specifically, this invention relates to a paper feeding device suitable for use in an automatic reproducing machine, as for example, a xerographic copier. In the xerographic copying art, a photosensitive plate is initially charged uniformly in the dark and then exposed to a light image of original input scene information to be reproduced. Under the influence of the light image, the charge on the plate is selectively dissipated in the light struck regions so as to record the original input scene information in the form of a latent electrostatic image. The plate is then developed by contacting the imaged areas with a toner material specifically developed for this purpose wherein the toner is electrically attracted into the imaged areas thereby rendering the latent image visible. Finally, a sheet of final support material is placed in overlying contact with the developed plate surface and the toner image transferred from the plate surface to the final support sheet. Generally, the sheets of support material are stored within the machine in a stack configuration and, upon demand, the sheets are individually separated and forwarded from the stack into the transfer station.

One manner of achieving separation and forwarding of the individual sheets is by a technique known as "reverse buckle" feeding. In this particular method, the rear margin of the stack is supported against the rear wall of the sheet support tray so that the sheets are free to move only in a forward direction. Feeding means are then brought into operative contact with the uppermost sheet in the stack and a motion imparted to the sheet to first drive the sheet rearwardly against the restraining force of the rear wall of the tray. As a consequence a longitudinal buckle is formed in the body of the sheet causing the sheet to be separated from the stack. Once separated, the direction of sheet motion is reversed and the sheet advanced through the opening in the tray and cleared therefrom prior to instituting a subsequent feeding cycle.

Although reverse buckle feeding, as exemplified by the sheet feeding mechanism, disclosed in the U.S. Pat. No. 3,645,615 to Spear, represents a reliable method of separating and forwarding individual sheets from a stack, it nevertheless has certain drawbacks which heretofore have limited its use in the copying art. Ordinarily, a reverse buckle feeder is driven by means of a pair of coacting gears which are programmed to impart the desired motion to sheets during both the buckling and forwarding phases of each feeding cycle. Mating gear pairs generally are provided with a certain amount of backlash to compensate for errors in the generation of teeth, material expansion and to accommodate lubricants, dirt or the like. Backlash therefore is a broad term generally used to define the difference between the thickness of a gear tooth and the width of the space in which it meshes.

As can be seen, backlash, when present, will allow one gear of a mating pair to be turned through some finite angle while the other gear remains stationary. Where the gears are adapted to drive in a single direction under uniform loading conditions, the effects of backlash are more or less minimized. However, where

the drive is forced to periodically change direction under varying loads, as in the case of a conventional reverse buckle feeder drive, the effects can be serious. It has been found, for example, when standard gears are used in the feeding apparatus disclosed in the previously noted Spear disclosure, severe torque spikes are generated which are ultimately broadcast throughout the machine. These forces can be of a magnitude sufficient to disturb the sensitive optics involved resulting in the production of degraded copy.

It is therefore an object of the present invention to improve apparatus for separating and forwarding individual sheets from a stack.

It is a further object of the present invention to provide a drive mechanism for a reverse buckle sheet feeding apparatus.

A still further object of this invention is to minimize the generation of unwanted forces in a copying machine during the processing of copy sheets.

A yet further object of the present invention is to provide a positive drive that is free of backlash.

These and other objects of the present invention are attained by means of a sheet feeding drive having an elastomeric direct contact element arranged to drive a sheet feeding mechanism and at least one motion imparting device having a profile working surface thereon adapted to move in friction drive contact with the elastomeric element whereby a predetermined motion is translated through the elastomeric element from the motion imparting device to the sheet feeding mechanism.

For a better understanding of the present invention as well as other objects and further features thereof, reference is had to the following detailed description of the invention to be read in connection with the accompanying drawings, wherein:

FIG. 1 is a schematic view illustrating an automatic xerographic machine embodying the present invention;

FIG. 2 is a perspective view of a paper feeding device embodying the drive mechanism of the present invention;

FIG. 3 is a partial end view showing the drive mechanism of the present invention imparting a rearward motion to the upper most sheet in a stack to form a separating buckle therein; and

FIG. 4 represents a partial end view of the drive mechanism of the present invention showing the drive mechanism imparting a sheet advancing motion to the separated sheet.

Referring now to the drawings, there is shown for the purposes of explanation an automatic xerographic reproducing machine incorporating the improved sheet feeding mechanism of the present invention. The copying machine illustrated in FIG. 1 employs an image recording drum-like member 5, the outer periphery of which is coated with a suitable photoconductive material 6 that is well known and used in the art for recording a latent electrostatic image of an original to be reproduced. Drum 5, which is suitably journaled for rotation within a machine frame by means of a shaft 7, rotates in the direction indicated to bring the image retaining surface thereon past a plurality of xerographic processing stations. Suitable drive means (not shown) is provided to power and coordinate the motion of the various cooperating machine components whereby a faithful reproduction of the original input scene infor-

mation is recorded upon a sheet of final support material such as paper or the like.

Since the practice of xerography is well known in the art, the various processing stations for producing a copy of an original are herein represented in FIG. 1 as blocks A-E. At station A, an electrostatic charge is placed uniformly over the photoconductive surface of the drum preparatory to imaging. The charged drum surface is then passed through an exposure station B for illuminating at least a portion of the charge surface with a light image of the original input scene information whereby the charge is selectively dissipated in the light exposed regions to record the original input scene in the form of a latent electrostatic image. Next, in the direction of drum rotation, the image bearing plate surface is transported through a developing station C wherein toner material is applied to the surface of the image bearing plate rendering the latent image visible. The developed image is then brought into contact with a sheet of final support material 8, such as paper or the like, within a transfer station D and the toner image transferred from the plate surface to the contacting side of the final support sheet. Finally, at cleaning station E, residual toner particles, remaining on the drum surface after the transfer operation, are removed from the drum in a manner well known in the art thus placing the photoconductive surface in a condition to be re-used in the xerographic recording process.

It is herein contemplated that the sheets of final support material processed in the automatic xerographic reproducing device will be stored in the machine within a removable paper cassette 10. It is further contemplated that the automatic reproducing machine will have the capability of accepting and processing copy sheets of varying lengths, the length of the copy sheet, of course, being dictated by the size of the original input scene information recorded on the photoconductor. To this end, the paper cassette is provided with an adjustable feature whereby sheets of varying lengths can be conveniently accommodated therein. In operation, the cassette is filled with a stack of paper of preselected size and the cassette inserted into the machine by sliding the cassette along a base plate which guides the cassette into operable relationship with a pair of feed rollers 12. When properly positioned in operable communication with the feed rollers, the top most sheet in the stack is separated and forwarded from the stack into the transfer station in a manner to be described in greater detail below.

Referring now more specifically to FIG. 2, there is illustrated a sheet feeding device for separating and forwarding individual sheets of final support material from a supply stack into the subsequent sheet handling and/or processing equipment. The sheets are stored in a stack configuration, generally referred to as 15, within the supply cassette 10. The stack is supported upon a generally horizontal platform 13 with the rear margin of the stack positioned in abutment against the rear wall retaining elements 14 of the supply tray. The front end of the supply tray, through which the sheets are forwarded, is provided with an opening with the front or leading edge of the stack being restrained in the tray by means of a pair of retaining tabs 17, one of which being clearly illustrated in FIG. 2.

Normally, the restraining tabs rest in overlying contact with the uppermost sheet in the stack and serve to hold the front margin of the stack in alignment during

the sheet separating and advancing process. The pair of sheet feed rollers 12 which are mounted above the supply tray upon a rotatable drive shaft 18 are arranged to operatively communicate in friction driving contact with the uppermost sheet of the stack. The feed roll members are made of a material, such as rubber or the like, having a high coefficient of friction to minimize slippage between the rollers and the sheet in process during the sheet feeding cycle.

The particular sheet separating and feeding operation herein employed is commonly referred to as reverse buckle feeding. This sheet feeding technique will be explained in further detail with specific reference to FIGS. 1 and 2. To accomplish this type of sheet feeding, the feed rollers are rotatably mounted in stationary position above the stack and the supply cassette rocked about a pivot 20 located near the rear margin of the tray causing the uppermost sheet in the stack to be moved into and out of operative contact with the rotatably mounted feed rollers. A spring member 22 is positioned below the supply tray and is arranged to act upon the bottom wall 13 thereof so as to continually bias the tray, and consequently the stacks supported therein, upwardly towards the fixedly positioned feed rollers.

The movement of the tray is coordinated with the movement of the feed rollers through the paper feed drive system which includes a timing belt 25 (FIG. 2) driven in the direction indicated by means of a power input shaft 27 and a drive pulley 28. The timing belt is tracked about pulleys 30 and 31 which serve to provide power to the sheet separating and forwarding drive mechanism 34 and the sheet registering and advancing drive mechanism 35, respectively.

Pulley 31 is co-axially aligned with a pair of contoured cams 37 and 38 upon a stub shaft 40 which is journaled for rotation in the main machine frame (not shown). Each front margin retaining tab 17 is connected via arm 41, rocker shaft 42 and by a cam follower 43 with the working surface of the control cam 37. The motion imparted to the tabs through the cooperating mechanism is programmed to move the paper cassette upwardly under the urging of spring 22 at the start of each feeding cycle whereby the uppermost sheet in the stack is positioned in friction contact with the feed rollers. For further information concerning this type of apparatus reference is had to a pending application Ser. No. 205,911 filed in the name of Punnett et al.

At the start of each sheet feeding cycle, the feed rollers are placed in contact with the uppermost sheet in the stack and the rollers are driven in the direction illustrated in FIG. 3 causing the uppermost sheet in the stack to be moved rearwardly against the restraining influence of the supply tray rear wall members 14. The top sheet 29 is moved back sufficiently to free the leading edge thereof from beneath the tab elements 17. As a consequence, a longitudinal buckle, as shown in FIG. 3, is formed in the trailing portion of the sheet thus separating the sheet from the remainder of the supply stack. Once separated, the direction of rotation of the feed rollers is reversed (FIG. 4) and the sheet then forwarded over the retaining tabs a sufficient distance to place the leading edge of the sheet between a pair of cooperating pinch rollers 50 and 51 positioned adjacent to the open end of the supply cassette. The bottom roller 51 of the pinch roller arrangement is continually

driven in the direction indicated by means of an input shaft 53 while the upper roll 50 is periodically moved in and out of contact with the lower roll to facilitate the forwarding of a separated sheet therebetween.

The action of the upper roll is regulated by means of the second control cam 38 affixed to shaft 40. The support shaft 52, upon which roller 50 is mounted, is secured at one end in a pivoted link 54 and the link, in turn, is pivoted in a second link 56 which is held in operative communication with cam follower 55 through a connecting shaft 57.

Initially, at the beginning of a sheet feeding cycle, cam 38 serves to hold the upper roller 50 in a raised position as illustrated in FIG. 4 thus allowing the leading edge of a sheet forwarded from the supply stack to pass freely between the two cooperating pinch rollers. As explained in greater detail in the previously mentioned Punnett et al disclosure, the leading edge of the sheet is driven between the pinch rollers into a registration gate (not shown) to properly align and register the sheet with the subsequent sheet processing station. When the sheet has reached the proper position beneath the pinch rollers, the cam follower 55 and the associated linkage mechanism imparts a motion to the shaft 52 causing the upper roller to move downwardly locking the sheet in friction driving contact between the two roller members. Simultaneously therewith, the first cam, that is, cam 37, translates a motion to the retaining tabs 17 causing the tabs to pull the tray downwardly away from feed rollers 12 freeing the sheet in process from the remainder of the stack. At this time, the sheet advancing function is taken over by the pinch rollers which advance the sheet into the station D (FIG. 1) and the developed image recorded on the drum placed on the copy sheet.

Ordinarily when a single pair of cooperating gear elements are relied upon to translate the entire motion sequence to the feed rollers, as for example the drive disclosed in the aforementioned Punnett et al disclosure, the backlash between the coacting gears causes unwanted torque spikes to be generated particularly at the time of motion change which occurs during the transition period between the reverse buckle phase and the forwarding phase of each feeding cycle. The drive apparatus of the present invention, because of its unique characteristics, minimizes the effect of backlash in the system and translates a smooth input to the feed rollers throughout all phases of the sheet feeding cycle and, in effect eliminates the generation of unwanted forces within the machine.

As illustrated in FIGS. 2-4, the drive system of the present invention involves a concentric elastomeric roller 60 arranged to cooperate with two motion imparting elements, a first reverse buckling element 62 and a second sheet forwarding element 63. The elastomeric roller is rigidly affixed to the outboard end of the feed roller drive shaft 18 as illustrated clearly in FIG. 2. The two motion imparting elements 62 and 63 are rotatably mounted upon stub shafts 72 and 73, respectively and the shafts fixed in the side wall of the machine frame. The stub shafts are positioned in relation to the feed roller drive shaft so that the working profiles of the motion imparting elements move in and out of driving contact with the outer periphery of the elastomeric roller as the elements are rotated in the directions indicated.

The two segmented motion imparting elements 62, 63 are fabricated of a metal material such as aluminum

or the like. The contacting peripheries of each of the motion imparting elements as well as the outer periphery of the elastomeric roller are provided with a textured or grooved working surface to enhance the driving characteristics between the contacting elements.

In practice, the elastomeric roll member and the segmented motion imparting drive elements are something more than just conventional friction drive elements in that they cooperate to provide a system in which slippage is minimized and backlash, for all practical purposes, is eliminated. To obtain this truly unique result, the resilient elastomeric roll is constructed of a polyurethane material having a hardness of between 20 and 80 durometers and provided with a series of uniformly spaced longitudinally extending grooves about the outer surface thereof. The grooves preferably are V-shaped in construction with the side walls meeting to form an included angle of approximately 90°. The circular pitch between grooves is sufficient to provide a top land of about 0.006 inches between each groove. The segmented working surface of each drive element is formed of a relatively non-deformable material. The working surface of the drive elements are also provided with longitudinally extending V-shaped grooves. These grooves, however, are otherwise quite dissimilar in construction to those formed in the elastomeric roll. Preferably, these grooves are shaped so that the side walls form an included angle of about 60°. The tooth spacing found on the urethane roll is dissimilar from that found on the drive elements with the circular tooth pitch on one of the coacting members being some non-integer multiple of the circular tooth pitch found on the other.

Although the profile created on each of the coacting members are tooth-like in appearance, they are nevertheless not gear-like in construction. The grooves are designed so that both the circular pitch and the tooth profile found on the urethane roll member differs from that on the segmented drive elements. As a result, during a paper feeding cycle, some of the teeth involved may tend to mesh with each other in a gear-like manner while other teeth on the driving element will be forced into deforming contact against the lands or other parts or the urethane roll surface. However, because of the unique construction involved, all the teeth on the drive elements will in some manner depress the urethane roller whether they contact at the peak or valleys and thus provide a positive non-slip driving action throughout every phase of the paper feeding cycle.

Affixed to the motion imparting elements 62 and 63 are a pair of cooperating (meshing) spur gears 74 and 75 through which the driving power from the main drive system is transmitted to the motion imparting elements. A drive pulley 30, which is part of the main drive system, is operatively connected to gear 74 and operates to cause the gear to continually drive in one direction, (counter clockwise as shown in FIG. 2), in predetermined timed relation with the other operating machine components. Gear 74, in turn, meshes with gear 75 and continually drives the coacting gear in the opposite direction.

The camming action of the pinch rollers 50 and 51 as well as the other machine functions, is coordinated with the motion of the feed rollers 12 through the timing belt and pulley arrangement whereby a sheet of final support material arrives at the transfer station in moving synchronization with the developed xero-

graphic image recorded on the photoconductive drum surface.

At the beginning of each paper feeding cycle, the smaller of the two segmented motion imparting elements, the reverse buckle elements 62, is rotated into pressure driving contact with the outer periphery of the elastomeric roller 60. As illustrated in FIG. 3, the reverse buckle element 62 imparts a prescribed motion to the feed rollers which causes the uppermost sheet in the stack to be moved rearwardly towards the back of the supply cassette. The rear margin of the sheet, however, is restrained by the rear wall of the cassette whereby a longitudinal buckle is formed along the body of the sheet thus separating the sheet from the remainder of the stack. The leading edge of the separated sheet is moved back sufficiently to effect the release of the sheet from beneath the front edge retaining tabs 17.

As the meshing spur gear elements 74 and 75 continue to drive in the direction indicated, the working surface of the reverse buckle elements 62 moves out of contact with the elastomeric roller 60 terminating the reverse buckle phase of the sheet feeding cycle. At this time, without reversing the direction of rotation of the spur gear elements, the second forward feeding element 63 is moved into pressure contact with the elastomeric roller causing a reversal in the direction of the sheet feeding rollers 12 and instituting the sheet forwarding phase of the sheet feeding cycle. As shown in FIG. 4, the sheet advancing phase of the sheet feeding cycle begins as element 63 drives the elastomeric element 60 in a counter clockwise direction causing the separated sheet to be advanced by the feed rollers over the top of the retaining tabs whereby the sheet is presented between the cooperating pinch rollers 50, 51.

As explained above, the control cam 38 causes the retaining tabs 17 to pull the remainder of the stack away from the feed rollers 12, thus freeing the separated and forwarded sheet. Simultaneously therewith, control cam 38 brings cooperating pinch rollers 50 and 51 into friction driving contact with the sheet in process driving the freed sheet into the sheet transfer station D, (FIG. 1). Sufficient dwell time is provided within the control cam system to allow the trailing edge of the sheet in process to be cleared from beneath speed rollers 12 before the next feeding cycle is commenced. As can be seen, because the unique characteristics of the present system, the spur gear elements which provide the drive to the paper feeder continually rotate in a single direction thereby minimizing the effect of backlash. Furthermore, it should be noted that the drive system herein disclosed is directly connected to the main drive system thereby eliminating the need for clutches or the like.

While this invention has been described with reference to the structure disclosed herein, it is not necessarily confined to the details as set forth and this application is intended to cover such modifications and changes as may come within the scope of the following claims.

I claim:

1. A drive mechanism including:

- a deformable cylindrical member having a series of uniformly spaced longitudinal grooves provided about the periphery thereof with the grooves being at a first circular pitch,
- a relatively non-deformable drive member having a working surface thereon arranged to move into and

out of pressure contact against the outer periphery of said cylindrical member, said working surface having a series of uniformly spaced grooves formed therein at a second circular pitch different from said first circular pitch so that some of the area between the grooves on said drive member act to deform the surface of said cylindrical member in pressure contact therewith and other areas between said grooves meshes with the grooves formed in said cylindrical member whereby a positive drive that is free of backlash is maintained between the two coacting members.

2. The drive system as described in claim 1 having a plurality of drive members being arranged so that the working surfaces thereon sequentially move into and out of pressure driving contact with said cylindrical member.

3. The apparatus of claim 1 wherein the grooves formed in the cylindrical member are V-shaped having an included angle of about 90° between the side walls thereof and the grooves formed in said drive member is V-shaped having an included angle of about 60° between the side walls thereof.

4. The apparatus of claim 1, wherein said cylindrical member is formed of a urethane material.

5. The drive mechanism of claim 1 wherein the areas between grooves on the drive member deforms the surface of the deformable member in both the peak and valley regions thereon when said drive member is moved in contact with the deformable member to insure a positive drive.

6. An apparatus for driving a sheet feeding mechanism comprising:

sheet feeding means for advancing individual sheets from a supply stack;

a resilient elastomeric roll member in operative communication with said sheet feeding means, whereby motion imparted to said roll member is translated to the individual sheet, said roll member having a series of spaced longitudinally extending grooves provided about the periphery thereof, said grooves having a first circular pitch;

at least one motion imparting element having a working surface thereon arranged to move in frictional driving contact against the periphery of said roll member, whereby a prescribed motion is translated from said at least one element to said roll member, said working surface having a series of spaced longitudinally extending grooves therein, said grooves in said working surface having a second circular pitch different from said first circular pitch.

7. An apparatus as in claim 6 wherein, said at least one element is relatively non-deformable.

8. An apparatus as in claim 6 wherein, the periphery of said roll member and the working surface of said at least one element are tooth-like, with the tooth profile on said roll member being different from the tooth profile on said at least one element.

9. An apparatus as in claim 6 wherein, said first tooth pitch is a non-interger multiple of said second tooth pitch.

10. An apparatus as in claim 6 including a plurality of motion imparting elements arranged so that the working surfaces thereon sequentially move into and out of frictional driving contact with said roll member.

11. An apparatus as in claim 10 wherein, first and second motion imparting elements are provided, said

first motion imparting element being arranged to move in a first direction and said second motion imparting element being arranged to move in an opposite direction.

12. An apparatus as in claim 11, wherein said sheet feeding means includes a supply tray for supporting said stack, a feed roll arranged to contact the uppermost sheet in said stack, said feed roll being supported by a shaft connected to said roll member, whereby said first motion imparting element causes said feed roller to advance the uppermost sheet rearwardly against the rear wall of said supply tray to form a separating buckle therein and said second motion imparting element causes said feed roll to reverse the direction in which said sheet is being advanced so as to forward said sheet from said supply tray.

13. An apparatus as in claim 12, wherein said feed roll and said roll member are coaxially supported upon said shaft.

14. An apparatus as in claim 13, wherein a gear is operatively connected to each of said first and second elements said gears being meshed together to coordinate the motion of said first and second elements.

15. An apparatus as in claim 10, wherein a gear is operatively connected to each of said elements and wherein said gears are meshed together to coordinate the motion of said elements.

16. An apparatus as in claim 14, wherein said elements are formed of a relatively non-deformable material.

17. An apparatus as in claim 16, wherein the periphery of said roll member and the working surfaces of said elements are tooth-like with the tooth profile on said roll member being different from the tooth profile on said elements.

18. An apparatus as in claim 17, wherein the grooves formed in the periphery of said roll member are V-shaped having an included angle of about 90° between the sidewalls thereof and the grooves formed in said elements are V-shaped having an included angle of about 60° between the sidewalls thereof.

19. An apparatus as in claim 18, wherein said roll member is formed of a urethane material.

20. An apparatus as in claim 19, wherein said elements are formed of aluminum.

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