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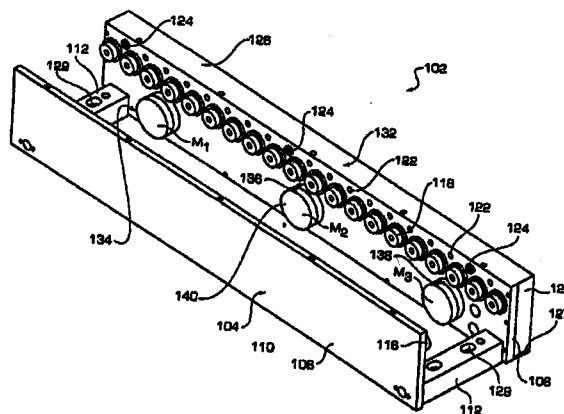
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(54) Title: MATERIAL TRANSFER SYSTEM



(57) Abstract: A conveyor system (102) that is particularly suited for clean room usage and which can operate on a pre-determined and readily adjustable drive roller (118) gear slippage basis (206, 207, 236, 238, 240) so as to readily accommodate different pallet load requirements. Adjustment is carried out by way of a simple adjustment in the slip (5) setting of the drive gears (206, 207). An adjustable load clutch (238, 240, 234) for varying the slip point of drive gears (206, 207) supported by drive roller (118) support assemblies which each have a drive roller support shaft (212) on which is mounted the drive roller (118), the drive roller gear (206, 207), a friction control device (238) and a compression adjustment device (240, 246), with the compression adjustment device being adjustable so as to alter a slip (5) setting of the friction control device. The compression adjustment device (240, 246) is a threaded nut (242) received on a threaded, free end of a drive roller (118) support shaft (212) and adjustable to vary the compression level between a gear sleeve (236) in contact with a fixed bearing portion receiving the driver roller shaft, (212) a friction control washer (241) in contact with the gear, a slip/wear ring (238) in contact with the friction control washer (241) that abut the compression nut (238).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MATERIAL TRANSFER SYSTEM

FIELD OF THE INVENTION

The present invention is directed at a material transfer system particularly suited for use in a clean room environment.

BACKGROUND OF THE INVENTION

There exists in the prior art roller-chain type conveyor systems employing an endless chain carrying a plurality of idler rollers arranged at regular intervals. Objects to be conveyed are mounted on the idler rollers and carried along therewith. Since idler rollers are involved, it is possible to stop an object at a desired station by applying a resistance to movement. However, in such a system the chain and rollers are continuously driven under the stopped object. This leads to significant vibration so as to limit the range of usage of such systems. In addition, due to the vibration and a variety of other factors, a significant amount of particulate matter is generated rendering such systems not well suited for clean room environments.

In an effort to avoid some of the difficulty associated with roller chain conveyor systems, there has been proposed a roller type conveyor system which drives the object by the rotating torque of a plurality of stationary driven rollers installed along the conveying path and driven by way of a pulley based drive system. An example of such a system can be seen in U.S. Pat. No. 4,844,231 ("the '231 patent") which describes a motor driven driving mechanism featuring a power train including a plurality of pulleys with each pulley cooperating with a respective one of the rollers. The driving pulleys have an extended flange which receives the hub of the rollers. The frictional relationship between the two surfaces allows for a normal rotation mode and slippage upon the occurrence of roller rotation resistance.

While lessening the vibration problems associated with the above-described roller-chain type conveyor systems, this type of system suffers from a variety of drawbacks. For example, the high number of pulley assemblies involved introduces a loss of energy along the transmission line. Also, systems such as that described in the '231 patent suffer from the problem of inconsistent slip torque conditions. Also, the arrangement of the '231 patent can lead to relatively long down times upon attempts to restart after component breakage. The prior art such as that described above is also

relatively inflexible and accordingly not easily subject to change to accommodate, for example, different load and stoppage requirements. As one example, the manner of varying the slip relationship between the roller and the pulley extension in the '231 patent is limited to forming different length grooves on the contact interface between the roller and the pulley extension, which is representative of a non-adjustable device once the groove is formed.

U.S. Patent No. 5,485,911 illustrates a cantilevered-shaft type roller conveyor in which each roller unit includes a sleeve like roller member supported directly on and surrounding a cantilevered shaft extending from a side frame and having a fixed internal bevel drive gear as part of its drive member. Each roller is driven by a mating bevel gear secured to a rotatable, common drive shaft. The drive member is switchable in position to achieve either a mechanical element intermeshing driving of the roll or a friction connection driving of the roll. While again avoiding some of the drawbacks noted above with respect to chain-roller conveyor subsystems, the arrangement of U.S. Patent No. 5,485,911 introduces other drawbacks such as extensive down time upon component breakdown or wear replacement, involving the resetting in position of the heavy common drive shaft and the introduction of different, and not readily compensatable, slippage levels. In addition, the arrangement of U.S. Patent No. 5,485,911 introduces the potential for misalignment upon, for example, temperature expansion or longitudinal bowing of the drive shaft. In addition, any shaft vibration is also carried along the shaft's length so as to induce vibration effects in all rollers in contact with the shaft.

U.S. Patent No. 5,971,137 illustrates another conveyor system which features cantilevered rollers driven by a driving belt. In U.S. Patent No. 5,971,137, the driving belt is a toothed belt traveling along a guideway provided by an internal wall support. A spring washer clutch is also described. This patent has drawbacks such as difficulty in accessing drive components upon belt binding or belt breakage and a not readily adjustable torque setting means for its rollers, with either case introducing the possibilities of extended downtimes while replacements and adjustments are made. U.S. Patent No. 5,558,205 introduces another toothed belt/drive cantilevered roller system in a conveyor, which suffers from similar drawbacks as presented for U.S. Patent No. 5,971,137.

U.S. Patent No. 3,374,877 illustrates another conveyor system which features a series of gear-driven live rollers which are adaptable to sectional construction. The

system consists of a material transfer support structure wherein a plurality of object drive rollers are arranged along it. A plurality of drive roller support assemblies that support respective object drive rollers and are supported by said material transfer support structure wherein said drive roller support assemblies comprise a drive roller support shaft. The said shaft having an axially interior end supporting respective object drive rollers. An object drive roller drive train comprising a downstream roller drive transmission system which drives the object drive rollers supported on said drive roller support assemblies, said downstream roller drive transmission system including roller drive gears supported on respective shafts. This patent has drawbacks such as shaft vibration that is carried along the shaft length which induce vibration effects in all rollers in contact with the shaft.

SUMMARY OF THE INVENTION

The present invention is directed at avoiding or lessening the above noted drawbacks associated with the prior art. The present invention features a material transfer system in the form of a conveyor roller system that is particularly well suited for use in a clean room environment. The invention represents a highly flexible and durable system having a positive energy drive transmission from the initial power source (eg., motor) to all conveyance rollers in the transmission line such that slippage is avoided in the drive system during object conveyance.

In a preferred embodiment, a plurality of gears, including downstream roller driving and intermediate idler gears, are arranged in direct series and in driving communication with each other. The gears work together to provide conveyance roller rotation with respect to drive rollers that preferably are cantilever drive rollers that work in conjunction with idler rollers on the opposite side of a support structure.

The conveyor system features an adjustable load clutch which allows for drive train transmission slippage at predetermined points in a roller drive system upon the occurrence of a predetermined level of roller resistance. Accordingly, the drive system can operate continuously while supported objects are held in place or otherwise resisted from free movement. In addition, the slip occurrence start point at each of the slip locations associated with the multiple rollers is easily adjusted to a desired setting. The arrangement of the present invention allows for establishing, both on overall basis and on an individual roller basis, a preset slip settings that is readily set to suit various usages and torque adjustment requirements, without a need for

disassembling components in the roller drive system. In this way, a predetermined slip away setting is set forth within the driving gear train such that when a stationary carrier queue occurs slippage initiates. In this way roller wear and tear is also minimized.

Also, through use of, for example, high tensile strength, low water absorption, self lubricating injected plastic gears, as the sole source of torque energy transfer along a transmission line parallel with the direction of elongation of the conveyor, there is achieved high efficiency energy transfer with components that are not high in particle emission and which are highly impact resistant so as to avoid downtimes. The preferred self lubricating (low friction) injected plastic gears, are wear resistance while also providing a low vibration, smooth energy transfer means. The gear drive train system extending along the length of the conveyor works in conjunction with the other components of the present invention to provide a low vibration-object conveyance with low particle emission levels and preferably also anti-static qualities. These qualities are achieved, in part, through the use of high strength plastic rollers (e.g., carbon fiber reinforced acetate) having anti-static qualities together with high friction, vibration absorbing roller rings supported by the rollers for direct contact with a pallet or conveyed object. For example, a soft polyurethane roller ring provides for a low vibration, smooth conveyance while the high friction quality of the anti-vibration ring of, for example, polyurethane, ensures a positive transfer drive with respect to the conveyed pallet/object. Thus, under the present invention, there is achieved smooth, low vibration conveyance with a minimal of particle development, allowing, for instance, a class 10 clean room certification without the need for a vacuum system.

In addition, the drive train arrangement of the present invention is preferably externally positioned with respect to a conveyor side wall so as to further reduce particulate material within the immediate conveyance area and provide for ready operator access. This reduction in particulate material can further be enhanced by one or more vacuum lines arranged along the support structure and designed to pull particles from the clearance area immediately adjacent the rollers. However, the arrangement of the present invention is designed to provide a low particle

emission level (e.g., class 10 clean room) without the need for the added expense and complications involved with a vacuum system. The drive train components are also well suited for use with products sensitive to electrical charges through use of rollers with anti-static properties that are in electrical discharge communication with roller supporting shafts (e.g., idler rollers preferably threaded directly into the side frame) and the side wall supporting those shafts.

Additional advantages found in the present invention includes the low maintenance requirements and low costs associated with the present invention's low individual component replacement costs and relatively steady performance, particularly with the benefit of its positive energy transfer system. Also with the drive train system of the present invention, the replacement of a drive train component that has broken or requires servicing can be done rapidly without altering other components in the drive transmission line and, if it is a gear or other roller support assembly, it can be readily and accurately set to a predetermined slip setting commensurate with other drive train components. The present invention is also well suited for use in conjunction with a continuous conveyor system, particularly one with individual conveyor segment sensors and control software for product/status determination and for orchestrating product/pallet movement within individual conveyor segments and also with respect to segment to segment movement as well as with respect to a multi-unit conveyor system.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 illustrates a perspective view of a preferred embodiment of material transfer assembly of the present invention.

Figure 2 illustrates a top plan view of that which is shown in Figure 1.

Figure 3A illustrates a top plan view taken along cut-away line III-III in Figure 1.

Figure 3B illustrates gear type "A" shown in Figure 3A.

Figure 3C illustrates gear type "B" shown in Figure 3A.

Figure 4 is a side elevational view of that which is shown in Figure 1, but with the protective drive system cover removed, and a portion cutaway for draftsman convenience.

Figure 5 is an end elevational view of that which is shown in Figure 1, with an added specialized pallet as the supported load and with the side end of the drive train assembly cover removed.

Figure 6 is a more detailed perspective view of the area designated "6" by dashed line in Figure 4.

Figure 7 is a more detailed view of the area "7" designated by dashed lines in Figure 4.

Figure 8A illustrates a motor mount of the present invention in conjunction with the upstream drive system.

Figure 8B illustrates the motor mount casing.

Figure 9A is an illustration of a roller drive assembly.

Figure 9B shows a cross-sectional view of a spur gear.

Figures 10A, B, C and D represent a top plan, end elevational, side elevational, and bottom view of the main frame of the material transfer assembly shown in Figure 1.

Figures 11A, B and C represent a top plan, end elevational, side elevational view and bottom view of the idler frame of the material transfer assembly shown in Figure 1.

Figure 12A is an illustration of a preferred upstream drive system assembly of the present invention.

Figure 12B is an end elevational of the upper driven pulley shown in Figure 12A.

Figure 12C is an end elevational view of the lower drive pulley shown in Figure 12A.

Figure 12D is an enlarged view of a section of the timing belt in Figure 12A.

Figure 13A is a cut-away view of the pulley driven shaft assembly of the present invention.

Figure 13B represents a cross sectional view taken along section line A-A in Figure 13A.

Figure 13C represents an exploded view of the driven pulley and driven shaft with fixed spur gear combination of the present invention.

Figure 14 shows a top plan view of an idler gear assembly to be supported by the main frame.

Figure 15A shows a view of a drive roller support assembly.

Figure 15B shows the roller drive shaft of Figure 15A alone.

Figure 16 shows a drive roller used in the assembly of Figure 15A in object support mode.

Figure 17 shows a side view of an idler roller support assembly.

Figure 18 shows an idler roller main body used in the assembly of Figure 17.

Figure 19 shows a schematic depiction of a material transfer conveyor system comprised of a plurality of interconnected and intercommunicating material transfer assemblies.

Figures 20A, B and C show a top plan view, end elevational view and side elevational view of an adjustable support stand with attached material transfer assembly.

DETAILED DESCRIPTION

Figure 1 provides a perspective view of a preferred embodiment of a material transfer assembly of the present invention. As shown in Figure 1, material transfer assembly 102 comprises support assembly 104 which includes idler frame 106 shown vertically arranged and parallel with main frame 108 so as to leave clearance space 110 therebetween. Extending between main frame 108 and idler frame 106 are a plurality of side conveyor mounts 112 which, as best shown in Figures 1, 2 and 3, are used for interconnecting and securing in position idler and main frames 106, 108 (e.g., a threaded fastener with dowel pin combination). Side mounts 112 are positioned, respectively, at the opposite, bottom ends of frames 106 and 108 so as to help maximize clearance space 110. Side mounts 112 also provide means for facilitating the interconnecting or abutment or close positioning of several material transfer assemblies 102 to form a material transfer conveyor system (such as a series of material transfer assemblies to form a multi transfer assembly conveyor system or one or more material transfer assemblies with a cross over conveyor segment or some other conveyor accessory assembly).

Figures 20A to 20C illustrate a preferred means for mounting material transfer assembly 102 which features support stand 332 having interconnected support bars including four vertical

support posts 334 with threaded bottom reception ends 336 receiving adjustment feet 338 with the threaded extension of each foot received within a respective receptor end 336 of a vertical support post. Support stand 332 further includes a lower set of four support bars 340 interconnected with each of the vertical support posts 334 and a corresponding upper set of support bars 342 provided so as to be commensurate in level with the upper ends of vertical support posts 342. The support bars 342 in the upper set which extend at the ends of the support stand 332 are provided with threaded reception holes (not shown) through which extend appropriate fasteners. As shown in Figure 5, fastener F can be used in the mounting of the material transfer assembly following passage through corresponding fastener holes 129 in side mounts 112. To accommodate for a range of potential tilt orientations in material transfer assembly. Figure 5 also shows swivel connection Sw (e.g., 0-15°C) is provided either at the interface between transfer assembly 102 and support stand 332 and/or by way of a swivel foot such as Sw for the support stand 338.

By manipulation of adjustment of swivel connection Sw the conveyor travel plane can be adjusted to the desired setting whether or not there exists deviations in the underlying support from a horizontal plane. The desired setting is typically one wherein the material transfer assembly is horizontally oriented to provide for smooth transfer assembly to mutual transfer assembly conveyance, although tilted plane conveyance (e.g., 0-15° from the horizontal) is also made possible by the adjustable support structure.

The material transfer assembly 102 is preferably used as a conveyor segment of a larger conveyor system, although it can also represent a self contained conveyor system depending on the desired usage. Figure 20A illustrates an example of a series of material transfer assemblies with corresponding underlying supports 332 in position to provide conveyor system 100, with the second material transfer assembly 102 being in end-to-end contact and at a common level with material transfer assembly 102. The material transfer assembly 102 in Figure 1 thus represents a preferred conveyor system segment (or self-contained conveyor system) well suited for industry usage such as in a conveyor system wherein shock and vibration is of great concern

and/or electrical sensitive devices are involved and/or a clean room requiring a high clean level product is involved. Examples of conveyor systems involving one or more of the above concerns includes, for example, hard disk assembly lines, semiconductor die manufacturing lines, disk media manufacturing; magnetic head manufacturing lines, medical manufacturing lines and optical lens coat process lines, etc.

Figure 2 (and partially Figure 1) further illustrates a series of equally spaced cantilever idler rollers 116 each preferably having an axis of rotation along a common, horizontal plane. In material transfer assembly 102 there is an illustrated example of having twenty idler rollers 116. The number of idler rollers (and the number of driving rollers described below) can, however, be adjusted both in number and size to suit the intended use for the material transfer system of the present invention.

Idler rollers 116 are shown positioned within clearance space 110 and thus internal and below the upper edge of idler frame 106. Figures 1 and 2 further illustrates an equal number of driving rollers 118 which are shown arranged so as to share a common axis of rotation with regard to a respective idler roller counterpart positioned across clearance space 110. As the roller axis for mutual driving/idler roller sets are coincident, and the contact surface of the idler rollers falls on a common horizontal plane, a pallet 120 (or actual product) to be conveyed such as that represented in Figure 5 is maintained horizontally oriented during its travel. The use of sloped flange-like exterior roller walls (described below) are helpful in maintaining proper pallet position during travel, although the low vibration arrangement of the present invention makes this much less of a problem than in the prior art. Also, in view of the preferred cantilever relationship of the driving rollers and idler rollers and the providing of power only to the former (as explained below), the conveyed product 120 is maintained in proper side to side orientation by the influence of the guiding and supporting surfaces of respective, opposed idler roller and driving roller sets.

Figures 1, 7 and 10C illustrate sensor reception holes 122 which are spaced along the longitudinal length of main frame 108 (e.g., a series of 40 mm spaced apart holes aligned

midway between adjacent roller pairs) and are sufficient in number to provide one sensor for every series of rollers driven by a common driving source. As explained below, there are three driving sources in the Figure 1 embodiment. Accordingly, three sensors 124 suitably mounted within three respective receptor holes 122 are provided as best shown in Figures 1 and 5. The central axis of the receptor hole 122 is designed such that the inserted sensor 124 is properly aligned for determining the presence or not of an object traveling on the idler and driving rollers 116, 118. A preferred sensor is an induction sensor which includes a pair of threaded nuts along an external threaded induction sensor main body such that the sensor can be inserted in position and held by way of the pair of nuts compressing against opposite side surfaces of main frame 108. Other suitable sensors such as optical, acoustic, infrared, etc. can also be relied upon depending on the nature of the conveyance arrangement and objects being transported. Depending on the relative relationship between the rollers, product being conveyed, and sensor mount location, the sensors can be received in tilted holes (e.g., tilted vertically up or down and/or side to side). Figure 5 shows a sensor aligned with a side edge of a pallet for presence/non-presence determination.

Figures 1, 5 and 9A further illustrate drive system cover 126 which is designed (in conjunction with slotted bottom plate 127 secured to and extending out from the bottom of main frame 108 and abutting end plates 130) to fully enclose all drive system components positioned externally of main frame 108. In a preferred embodiment, drive system cover 126 includes cover section 128 extending out from a preferred securement location with respect to the upper edge of main frame 108, down vertically and parallel with main frame 108 and then into a sealing relationship with regard to the slot formed in bottom plate 127. Thus, in a preferred embodiment cover section 128 has an L-shaped cross-section and its side ends are covered with side end cover plates 130 best shown in Figure 1, and which cover side plates 130 are secured by way of easily removed bolts or the like to main frame 108 and preferably also to cover section 126.

Idler frame 106 is covered over with cover strip 129 (Figure 1 being free of cover strip 129 while Fig. 5 shows the cover strips in position) which is J-shaped to avoid sharp edging, and

is formed of an easily cleanable material and is fastened along the upper edge of frame 106 in a manner which avoids any particulate accumulation pockets. Cover strip 129 also provides a protective barrier with respect to side frame to prevent damage to the idler frame when, for example, there is frequent loading and unloading of pallets.

Figures 1-9 illustrate one embodiment of a preferred roller drive system 132 of the present invention. In the embodiment shown in Figure 4, drive system 132 comprises three drive train systems 134, 136 and 138 with each drive train connected with a subset of driving rollers (e.g., 7 drive rollers for system 134, 6 for system 136 and 7 for 138) to achieve the required roller drive for the material transfer assembly involved. As will become clearer below, the present invention's design makes it well suited for varying the number of driven rollers per segment and also, while the drive system 132 is shown to comprise three drive subsystems 134, 136 and 138, a lesser (e.g., 1 drive system only for a material transfer assembly 102) or greater number of drive subsystems are also considered part of the present invention. Due to preferred motor torque motor characteristics and energy loss through an extended number of driven rollers, however, the number of driven rollers per drive subsystems is preferably limited to the range of 1-8 rollers. Therefore, a 20 roller material transfer assembly preferably has three separate driving sources or motors M1, M2, M3 each coupled with an upstream drive transmission assembly (preferably in a vertical drive transmission orientation) and a downstream transmission assembly extending along the length of the side frame wall and to the exterior side of that supporting side wall frame. In a preferred embodiment, the downstream drive transmission, which is in driving communication with the drive rollers, derives its rotation entirely from gears mounted on idler and drive roller shafts supported by the side of main frame 108 in cantilever fashion. An example of this arrangement can be seen in Figure 1 and Figure 4. From the standpoint of smooth operation and good rotation characteristics the arrangement shown in Figures 1 and 4 is preferred, although the arrangement of the present invention allows for ready production of a large variety of different material transfer assembly configurations.

As shown in Figures 3A to 7, each drive train system 134, 136 and 138 comprises a drive

source 140 such as motor (a preferred motor being, for example, a Hurst Motor AC 24V e/h: SP-3716 sold by Hurst Manufacturing of Princeton Indiana, USA) an upstream drive transmission assembly 142 (which is preferably a combination pulley-timing belt assembly) and a downstream drive transmission assembly 144 in driving communication with a roller shaft of the object driving rollers and extending along a line parallel with the direction of elongation of the side frames and hence also parallel to the direction of object conveyance. The downstream drive transmission assembly is preferably a gear train system such as a continuous series of meshing gears of the same type (e.g., common gear module M as described below) in driving communication from the upstream drive transmission assembly to all of the driven rollers powered thereby including left and right continuous gears extending out from the downstream driving component of the upstream drive transmission assembly.

To avoid added vibrational influences due to a not securely fixed motor/support relationship and to provide a compact self contained material transfer system, each motor 140 is received within a respective motor mount hole 146 as best shown in Figure 10C so as to extend partially into the clearance space. Motor mount hole 146 is sized to accept the motor preferably in a sliding relationship but is made large enough to accept the upper tolerance range of the motor casing. To help in facilitating a secure attachment of each motor 140 to main frame 108, yoke assembly 150 is utilized and is best shown in Figures 6 and 8A and 8B. Yoke 150 is positioned on the external side of main frame 108 as shown in Figures 4 and 5. As shown in Figures 6 and 8A, B yoke 150 includes external or peripheral yoke section 152 and internal yoke section 154. Section 152 represents an external peripheral section designed to have its interior surface edge (153 - Fig. 8B) abut against the exterior main frame 108 when secured in location. Section 154 is a more internal section and of lesser thickness so as to define a member receptor cavity 160 and further includes through hole 162 designed to receive the motor's shaft. Each of Yoke sections 152 and 154 includes sets of threaded holes (156, 158) with the holes 158 in the more central section 154 being arranged for either direct bolt securement with the front face, main wing extensions of the motor, or a set of motor housing compression blocks (not shown) or

a cage like arrangement (not shown) representing different means for securement of the driving source in a fixed position with respect to the side frame. Holes 156 provide for main frame securement.

As best shown in Figures 6 and 8A, the drive shaft 166 of motor 140 extends through shaft reception hole 162. External to plate 154, the motor drive shaft 166 is attached to motor pulley 170 by way of, for example, a threaded locking member (not shown) received within a threaded hole formed in motor pulley 170 as shown in Figure 12B.

With reference to Figures 4-6, 7, 8A, 12A-D, 13A-C, a more detailed description of upstream drive transmission assembly 142 is provided. Motor pulley 170 includes two pulley flanges 171 and 173, to opposite sides of belt reception recess 175 which is defined by a series of drive teeth 177. The driving teeth 177 of pulley 170 are in driving engagement with timing belt 174 (see Fig. 12D) having teeth running along its inner surface for no slip positive energy transmission between the teeth of motor pulley 170 and the teeth of timing belt 174. Timing belt 174 also is in driving engagement with driven pulley 176. Driven pulley also features pulley flanges 171' and 173'; belt receptor recess 175' and 177'. While a variety of motor-upstream drive transmissions combinations are possible under the present invention, this illustrated positive drive relationship (i.e., maintaining fixed velocity ratios between driving and driven shafts) is beneficial from the standpoint that a preferred embodiment of the entire roller drive transmission features a no slippage power energy transmission from the drive source 140 to all drive rollers 118 (with the below described adjustable clutch providing the means for achieving pre-set drive roller gear shaft slippage upon a certain roller resistance level being reached). In addition, because of its location, the upstream driving system avoids problems such as in the prior art with difficult access upon belt binding or breakage.

As an example of one suitable motor and upstream drive transmission assembly relationship, motor 140 is an AC electric motor which maintains a settable constant rotation rate of, for example, 300 rpm. Motor 140 drives motor pulley 170 which preferably has 15 teeth and an effective pitch radius of 2.5 mm corresponding to the pitch line of the mating timing belt 174.

The timing belt 174 has teeth designed to conform to the teeth characteristics of motor pulley 170 and thus interlinks, in positive drive transmission fashion, motor pulley 170 with driven pulley 176. Figure 12D provides an enlarged view of a section of timing belt 174 having characteristics C1, C2, C3, C4 and C5. Timing belt 174 is preferably a T2.5 timing belt in accordance with DIN 7721 with the preferred values of C1 to C5 being 2.0mm, 0.6mm, 0.7mm, 1.0mm and 40° for a polyurethane belt (with or without anti-static properties) with internal steel tension strands.

Under a preferred relationship, driven pulley 176 has 30 teeth which teeth have the same characteristics as those of the timing belt 174 and motor pulley 170. In this way, there is provided a 1:2 step down ratio between pulley 170 and pulley 176. A step down of 1:2 is such that the conveyor transporting speed is reduced with respect to the step down ratio. By varying the step down ratio, by, for example, manipulation of the characteristics of the two timing pulleys and associated belt, a desired gear speed can be achieved. As shown in Figure 12B, driven pulley 176 preferably also has a threaded hole 178' for receipt of a locking screw similar to the corresponding threaded hole 178 for motor pulley 170. This arrangement assures a no slip, positive energy transmission relationship while allowing for rapid system adjustment such as different pulley/timing belt combinations for changing the gear ratios between the motor pulley and driven pulley, the spur gear 202 sharing a common shaft with driven pulley 176, and ultimately the drive rollers in contact with the objects being conveyed.

As shown in Figure 13 A, B and C, driven pulley 176 is supported in cantilever fashion from main frame 108 by way of driven shaft 180 having an enlarged head 182, an intermediate cylindrical portion 184 and an outer generally cylindrical extension 186 having opposing flat surface cut outs. The integral enlarged head 182 on shaft 180 is placed in abutment with the interior surface of the interior bearing and acts, with the locked in position pulley 176, to hold the entire driven pulley assembly 181 in position. First bearing ring 192 (e.g., a cage bearing or low friction sleeve) is received within an interior side bearing reception cavity 190 formed in frame 108 and receives an inner segment of cylindrical shaft 180. A corresponding second bearing ring

194 (preferably a flanged bearing ring as shown) is received within a second reception cavity 196 provided on the external side of main frame 108. Divider extension 198 extends radially inwardly so as to differentiate the two bearing cavities.

Cylindrical portion 184 of shaft 180 thus rotates internally with respect to either a low friction inner surface of a fixed set of low friction material bearing rings 192, 194 or, more preferably with respect to a moving internal race portion of a two part, caged roller bearing arrangement featuring an outer fixed bearing race. The flange portion 200 of second bearing 194 is provided on the external side of main frame 108 and internal to spur gear 202. Spur gear 202 has a cylindrical extension 188 and gear segment 189 with gear segment 189 preferably positioned closest to the exterior surface of the main frame and extension 188 in contact with pulley 176. Also, between the interior side of spur gear 188 and flange 200 is preferably provided spacer sleeve 187 which is formed of a relatively low friction material that avoids particulate material built up with respect to its sliding relationship with the fixed bearing race and its low compression setting on the pulley shaft.

As shown by Figures 13A-C, the arrangement of the present invention allows for rapid removal and reinsertion of the driven pulley assembly and/or motor pulley assembly. If it is desired that a different step down ratio be implemented (which step down range is subject to the required conveyor transferring speed) or upon a desire to service a component part of the driven pulley assembly shown in Figure 13A, an operator need only release fastener 178', slide the driven pulley 176 off from the two faced shaft extension, and then slide spur gear 188 off the flat faced shaft extension, followed by the reinsertion of a replacement set. As shown in Figures 3B, 13B, spur gear 202 is provided with a central key slot that is designed to have the same general configuration and an axial friction slide relationship with respect to the opposing flat faced extension section 186 of shaft 180. The interior receptor hole of pulley 176 is designed in similar fashion to provide rapid insertion and removal and a positive drive interrelationship. Spur gear 202 can thus be simply slid on and the shaft and axially locked in place (in a positive drive transmission state) by way of the threaded fastener extended through the pulley hole 178'

and locked in place on the flat faced extension section 186 with the common shaft support. In this way, the motor pulley step down speed of rotation is provided to spur gear 202 (and with common step down gear spur gear characteristics to the rollers as well).

Gear 202 is preferably formed from a high tensile strength, low friction or self lubricating material. The preferred material for spur gear 202 is a low coefficient injectable plastic material with a coefficient of friction preferably at or lower than that of acetal. While providing wear factors approaching traditional PTFE lubricated composites so as to greatly reduce stick/slip occurrences. Also, the material preferably has an injection shrink rate and flow rate the same or similar to acetal or nylon. Additionally, the preferred material has mechanical properties similar to acetal, and a high impact resistance similar to or greater than acetal as well as a water absorption preferably equal to or better than that of acetal and lower than material such as nylon.

A preferred material that satisfies the criteria described above includes LUBRILOY™ composite material which is a moldable injection material available from LNP Engineering Plastics Inc. located in the United States. Other suitable material are, for example, acetal, nylon, Celeon® material of Hoechst and Delrin® material of DuPont.

In a preferred embodiment gear 202 is sized the same and has similar characteristics as the general depiction of spur gear shown in Figure 9A (both material and size characteristics) with minor differences such as the shaft reception cavity configuration and, preferably also in the axial length of spur gear flange extension as can be seen from a comparison of Figure 3B and 3C).

In a preferred embodiment, the spur gear 202 generally has the following features (all length dimensions in mms) with the referenced measurement letters being illustrated in the spur gear shown in Figure 9B (although Figure 9A is directed at a type B spur gear shown in figure 3C as opposed to the driven pulley mount spur gear 202 represented by gear A in Figure 3B) :

	Module (m)	# of Teeth	PH7	d	D	H	L	l_1	l_2
A	.8	20-32	5-8	19-26	20-28	12.5	14	7-9	3
B	.8	25	6	20	21.6	12.5	14	9	3
C1	.8	25	8	20	21.6	12.5	10	5	2.5
C2	.8	25	6/4.5	20	21.6	12.5	7	2	1.0 (or more)

with module $m = \frac{\text{Diameter (mm)}}{\text{No. of teeth}} = \frac{d}{z}$

While various other spur gear dimensions are contemplated, the above range represents in row (A) above a preferred range while B represents an even more preferred range with reference to an uncustomized spur gear embodiment. While the C set represents a particularly well suited customized set of gears which are represented by Figures 3A and 3B with the gear C1 shown in Figure 3A and C2 represents the gear shown in Figure 3B. Accordingly "4.5" represents the remaining thickness after the face cutouts are formed.

These gear dimensions have shown to work well in association with the above described motor and upstream drive transmission assembly 142, although other gear size and teeth characteristics are contemplated under the present invention. Also, with the ability to easily remove pulley 176 from shaft 180 upon loosening the locking fastener screw receive in threaded hole 178' (or some other associated or independent shaft fastener) replacement of spur gear 202 supported in the driven shaft assembly 181 can easily be accomplished.

As shown in Figures 3A, 4 and 6, gear 202 is in direct torque transmission contact with respect to gear 206 (to the left in the Figure 6 view) and gear 208 (to the right in Figure 6) which

gears 206, 208 form part of the positive energy transmission drive train system 136 of Figure 4 extending parallel with the direction of conveyance and preferably perpendicular to the drive roller rotation axis. As also shown in Figures 4 and 7, a similar gear relationship exists for the other positive energy transmission drive train systems 136 and 138. Thus, the discussion to follow is equally applicable to those drive transmission sub-systems (except perhaps in the ultimate number of driving rollers). Gears 206 and 208 also preferably have the same size and characteristics as gear 202 as can be seen from a comparison of figures 3B and 3C.

Gears 206 and 208 are each supported by cantilever roller support assembly 210 best shown in Figures 9A and the expanded view shown in Figure 15A, B. As shown in Figures 15A, 15B, drive roller 118 is secured to roller shaft 212 having first end 214 positioned internally with respect to main frame 108 and preferably includes a threaded aperture 216 for receiving threaded fastener 218 which is shaped so as to fix roller 118 to shaft 212. Roller shaft 212 further includes flange section 220 partially received within a corresponding recess 215 formed in the external side of the main body of roller 118. That is, the inside diameter of roller 118 is slid over first end 214 and a C-sunk screw is threaded into threaded aperture 216 so as to compress flange 220 against the portion of drive roller 118 defining the flange reception recess 215. Flange 222 of internal bearing 226 is flush with the internal side of main frame 108 and faces the shaft flange section 214. Main frame 108 includes roller shaft assembly holes 224 which are best seen in Figure 10 and are equal in number to the number of rollers extending into the clearance space (e.g., 20 as shown in Fig. 10). Roller shaft holes 224 are sized to receive bearing means such as one or more bearing rings as in the illustrated cage bearing set represented by reference numbers 226, 228 in Figure 15A. These bearings are preferably arranged so as to have a fixed outer diameter part (race) and a moveable interior part (race). As with the internal side, a second bearing 228 has a flange section 230 placed in an abutting relationship with respect to the external side wall of main frame 108 and has an outer diameter greater than that of the external side of shaft hole 224. Cylindrical section 232 of roller shaft 212 extends axially outward of flange 220 and passes through bearings 226 and 228 in a slide fit relationship, which bearings are

preferably similar to those described above with respect to driven shaft 180. Preferably the flange and outer race of the bearing 228 represent an integral unit with the outer race having a transition fit to the frame and the flange acting as an axially stop. Thus, only the inner race rotates in a preferred embodiment of the invention.

Also positioned on cylindrical section 232 of roller shaft 212 is adjustable load clutch assembly 234 which in a preferred embodiment features sleeve 236, which is preferably a bronze sleeve designed to have a sliding friction relationship with respect to cylindrical section 232 of shaft 212 (and thus is easily slid on and off the same by hand). Sleeve 236 is preferably in a force fit relationship with respect to the interior diameter of spur gear 206 and thus provides a degree of protection to the preferably self lubricating plastic spur gear. Sleeve 236 also preferably extends only a short distance axially out from the encompassing spur gear body (e.g., 1 to 5mm and preferably only about 2mm) and toward the fixed outer race of the bearing. In this way, the possibility of particle emission is reduced significantly when the drive shaft is stopped due to an external force. Upon stoppage of shaft 212, gear 206 with its fixed internal insert will continue to rotate during conveyor operation. The axial load involved between the slightly outward extending sleeve and the fixed portion of the bearing due to the below described adjustable clutch 234 is relatively low. This factor, in conjunction with the choice of good wear properties on the contacting material (e.g., a sintered bronze for a 2mm thick annular sleeve 236) provides for an advantageous, low particle emission clutch assembly. While it is preferable to have the sleeve in abutting relationship with a stationary race component of the fixed in position bearing, other relationships are also possible such as a longer length sleeve in a fixed fit relationship with respect to the inner race of the bearing so as to rotate together with the inner race while in a slide relationship with the shaft when the latter is held in position. Sleeve 236 can also extend into the hole 224 such as in a situation wherein the sleeve itself functions as an axially fixed but rotatable bearing member or bearing member component (e.g., a movable inner race), or can be received within a reception area of a bearing. From the standpoint of providing a low cost system with low particle emission levels, an arrangement wherein the sleeve interior

end slides on a fixed surface such as the bearing is preferred.

Working axially outward there is shown main friction control device 238, and compression adjustment device 240. In the preferred embodiment shown in Figure 15A, main friction control device 238 is supported by cylindrical section 232 of shaft 212. In a preferred embodiment, main friction control device 238 comprises a washer 239 and a slip ring 241 with washer 239 formed of a moderate friction level material that is generally non-abrading and well suited for establishing a pre-determined friction level upon being set to a predetermined compression level. That is, main friction control device 238 is preferably in the form of a washer formed of an intermediate friction coefficient level such as a relatively soft material such as provided by a relatively soft plastic, polyurethane washer with sufficient integrity to avoid abrading and particle dissipation.

The radial thickness of washer 238 is preferably set to be at or greater than that of sleeve 236 so as to provide sufficient friction contact against the surface of the major diameter, external surface 243 of spur gear 206 against which washer 239 is compressed in a non-slippage or high friction state. The exterior end of sleeve 236 is preferably flush or set in from the plane defined by the external surface 243 of spur gear so as not to interfere with the friction contact between surface 243 and washer 239 to achieve the axial stoppage of spur gear 206. Slip ring 241 receives shaft 212 through its internal hole and has an interior side in contact with the exterior side of washer 239. Washer 239 is formed of a material that results in a lower frictional coefficient level between it and slip ring 241 as compared to the other surface contact interface between sleeve 236 and surface 243 of spur gear 206 upon being set in the desired adjustable compression state.

Roller shaft 212 further includes at its external end threaded section 242. Threadably mounted on threaded shelf section 242 is compression adjustment device 240 which is preferably in the form of a threaded hex nut which is well suited for a predetermined compression level torque wrench adjustment (e.g., a torque setting wrench suited for the preferred torque range of 40 to 80 g/cm) to achieve the desired degree of compression between the nut 240 and friction

control device 238. Once nut 240 is adjusted to its desired torque setting it is locked in place by way of a locking nut 246 so as to maintain the desired compression state for friction control device 238.

In operation (following the desired torque setting), the shaft 212 and fixed drive roller 118 rotate as a unit together with the spur gear and all other shaft supported or contacting components (all except for the fixed outer race of the bearings 226 and 228). This is the conveyor transport state wherein the drive roller does not face any significant resistance to rotation. Upon an object or pallet being stopped, the high frictional relationship between the pallet and drive roller (roller stoppage being enhanced by a soft polyurethane high friction/cushion ring as described in greater detail below), results in stoppage of shaft rotation. Stoppage of shaft rotation also leads to a stoppage of nut 240 rotation due to the threaded connection. Also the frictional resistance relationship between the interior side of nut 240 and the exterior side of ring 241 is greater than the frictional resistance between ring 241 and washer 239. The frictional resistance between the interior side of washer 239 and surface 243 of spur gear 206 is also greater than that between washer 239 and ring 241. Also, the frictional relationship between sleeve 236 and the contact surface of the fixed portion of bearing 228, is less than that involved between washer 239 and surface 243 (and also less than the surface interface between nut 240 and wear ring 241) such that slippage in the gear and fixed sleeve is initiated along slip planes S1 and S2 in a preferred embodiment. Accordingly, upon stoppage or high frictional resistance being placed on roller 118, the spur gear (and attached bushing sleeve 236 and washer 239) are free to slip with respect to fixed support shaft 212. This slippage is controlled by setting nut 240 to a predetermined torque setting through use of a conventional torque wrench or spanner, and nut 246 is threaded on to the threaded end of shaft 212 to lock nut 240 and the torque setting in place. The slip relationship described above also provides a system that is very low in particle generation and the internal bronze bushing also helps prolong the life of the spur gear while its material and positioning also avoids particle emission problems.

Therefore, adjustable clutch assembly 234 is useful in establishing consistent

drive/slip relationships between the driver shaft 180 and spacer 204 upon roller resistance due, for example, a stopped (e.g., backed up) pallet with respect to the preferred continuous driven drive mode system of the present invention (e.g., a continuous driven drive system used in conjunction with a preferred free flow type conveyor system with sensed pallet position and software to achieve desired pallet spacing relationships). The adjustable friction clutch gear assembly 234 enables roller gears to slip when under torque resistance pressure, thus eliminating particle generation to a clean room while also helping to avoid premature failure of the flanged drive roller 118. Adjustable clutch assembly 234 also prevents accidental jamming of the flange drive roller 118.

Figure 16 illustrates drive roller 118 by itself. Drive roller 118 features a shaft flange extension reception cavity 248 followed by shaft first end reception cavity 250 and truncated conical cavity 252 for receipt of a correspondingly shaped fastener head insert. Roller 118 further comprises larger ring section 254 which has face 256 spaced just inwardly of the inward wall surface of main frame 108 when the roller is mounted for operation. Larger ring extension 254 preferably has converging section 258 defining a sloping wall surface to help facilitate proper positioning of pallet 120. Roller 118 is preferably formed of an anti-static material such as a carbon reinforced plastic material. A suitable plastic material is a carbon fiber reinforced acetal material having sufficient carbon fiber material to provide an anti-static quality having the following electrical parameters:

Surf Resis (10E) Dr. T on Chip D 257	10E OHMS/SQ	2.0 to 6.0
Volume Resis (10E)	10E OHM-CM	2.0 to 6.0

A preferred material for rollers 118 is a STAT-KON (KC series) 10% carbon fiber reinforced acetal material available from LNP Engineering Plastics, Asia Pte Ltd. of San Centre Singapore.

Roller 118 further comprises ring recess 260 which is bordered on its internal most side

by smaller ring section 262. Received within recess 260 is friction roller ring 264, which, as shown in Figure 16, is intended for supporting contact of the lower surface of pallet 120. With most of the support assembly 104 being formed of strong material resistant to flexing the main area of concern with respect to vibration is in the area between the rollers and pallet. In a preferred embodiment, the material transfer system 102 provides for steady and gentle pallet/product transfer movements. Friction ring insert 264 helps in the providing of steady, low vibration relationship and is preferably dimensioned and positioned as the sole contact with the under surface of pallet 120 (at least for most pallet loads). The low vibration characteristics of the friction ring insert is based at least partly on the ring being formed of a material with better cushioning and shock damping properties than the main body of roller 118 so as to function as a good shock cushion element with respect to the carrier or pallet.

As shown in Figures 3A, 4 and 6, each of gears 206 and 208 in the three drive train systems 134, 136 and 138 is in contact with a respective one of idler gears 266, 268 positioned downstream with respect to torque transmission. Figure 3A provides a cross-sectional cut away view with a central region removed for draftsman convenience. Figure 6 illustrates a suitable intermediate drive train system 136 similar to that used in drive train systems 134 and 138. Idler gears 266 and 268 are preferably the same as gears 206 and 208 so as to maintain a consistent roller drive speed along the roller drive system while also allowing for rapid replacement without complications as to which size component is required. Moreover, the arrangement of the present invention, such as the aforementioned roller shaft assembly allows for improved mean time between failure as compared to other prior art systems in that a broken gear can be readily removed simply by removing the nut 240, plastic washer 238 and slip sleeve 236. For example, a three minute period is considered to represent the time period required by an average technician to change an old gear with a new gear.

With a module specification of, for example, of 0.8 and 25 teeth for spur gears 206, 266, etc., the pitch diameter for intermeshing gears is 20mm such that the rollers are set at 40mm intervals. As shown there is preferably three independently driven drive transmission gears with

the diametrical pitch of the gears being the same amongst the individual sets and for all gears in the three sets. Accordingly, there is a great deal of flexibility in designing the material transfer assembly lengths as different lengths can be achieved merely by adding one or more gears within one or more of the individual gear drive series of the sub-drive systems.

Figure 14 illustrates cantilevered idle gear support assembly 270. As shown in Figure 10 and Figure 14, main frame 108 includes idler shaft threaded holes 272 having a central axis along the same horizontal plane "HP" as the central axis of the roller shaft holes 224 and driver shaft reception cavity 196. As also shown by Figure 14, idle gear support assembly 270 comprises idler gear shaft 274 having first end 276 which includes threaded stub 278 received within an idler shaft threaded reception hole 272 and enlarged flange ring 280 which abuts the external wall of frame 108 and stabilizes shaft 274 from vibration and movements.

Idler gear shaft 274 further includes main cylindrical section 282 on which is rotatably supported sleeve 284 which is in a rotation support relationship with respect to cylindrical section 282 to provide for ease in rotation and torque transmission from an upstream roller driver to a downstream roller driver as explained in greater detail below. The gear 266 and internal sleeve 284 are frictionally joined together also in a non-slip manner for proper torque transmission. The sleeve (e.g., a bronze bushing as above) is sufficient to function as the bearing surface or a caged bearing can be provided between the rotating gear and the stationary shaft. Also, the gear is preferably held axially in place through use of a large headed bolt 279 received within a threaded recess formed in the idler shaft. Upon need of replacement a new spur gear 266 in support assembly 270 can be easily slid off and a new one put in place following removal of axial locking bolt 279. The idler shaft assembly 270 provides a self contained, but easily removed and replaced device which allows for proper positioning of the idler gear such as gear 266 along a common vertical plane with respect to the other aligned gears including shaft driven gear 202 and driving roller gears such as gears 206.

As best shown by Figures 4, 6 and 7 in each of drive train systems 134, 136, 138 there is included a large pulley driven spur gear 202 meshed with at least one other roller driver spur gear

(e.g. 206), and more preferably at least a pair of roller driver spur gears with or without an externally positioned idler gear (e.g., gear 266), and even more preferably a main frame supported gear set comprising at least one pair of roller driver spur gears and at least one intermediate spur gear with each arranged to opposite sides of an intermediate large pulley driven spur gear such as gear 202. One embodiment of a main frame supported gear set has all of the gears arranged so as to have a rotation axis on a common horizontal plane. That is, as can be seen in Figure 3A, B and C there is positioned a large pulley driven spur gear denoted "A" in Figure 3A and shown in Figure 3B and a series of same type spur gears with B representing roller driver spur gears and B' representing the idler gears spaced between either two roller driver spur gears or a roller drive gear and the driven pulley gear (providing an opposite roller rotation direction). As each gear from the pulley driven shaft gear downstream (preferably in opposite left and right directions out from one of the central driver shaft gears 202) is of the same design, the idler gears pass on a common rotation rate and torque level while also providing for a common rotation direction for each of rollers 118. In this way, pallet 120 is subject to a smooth consistent rate ride along the transfer system. The size of the common gear discussed above and the cantilever shaft frame locations are set so that the desired roller spacing is achieved along the length of the inner surface of main frame 108. For example, Figure 10C illustrates a central axis to center axis distance "S" for the roller shaft receptor holes which in a preferred embodiment is about 20 to 60 mm with 40 mm being preferred which works well with a typical gear pitch diameter D (Figs. 16 and 18) of 20mm for both the idler gears and the drive roller gears. This same spacing "S" is provided between the central axis of the idler gear reception holes 308 as shown in Figure 11C. Again, as with the other preferred dimensions set out above, these values are merely representative of some preferred values that have shown to be well suited for many intended uses of the present invention, but the present invention is applicable to a wide variety of size, spacing and other parameter values, some of which are driven to some extent by the desired usage of the highly versatile present invention.

As further shown in Figure 4, the drive train systems 134, 136 and 138 are also arranged

to provide a consistent spacing for all rollers supported by the main frame. Thus, the use of multiple sub drive systems also allows for increased versatility with respect to providing modified conveyor segment lengths with many of the same basic components. Thus, for example, in the twenty drive roller embodiment illustrated in Figure 4, outer drive train systems 134 and 138 each feature a central driver shaft gear with four driven rollers (with intermediate idler gears) extending longitudinally internally and a three drive roller set (with intermediate idler gears) extending longitudinally outward. Intermediate drive train system 136 features three drive rollers to opposite sides of the driver shaft gear (with intermediate idler gears). This arrangement is well suited for a material transfer assembly length of about 800mm featuring twenty driver rolls on the main frame 108 which is a well suited size for material transfer systems. The present invention is highly versatile in that through extension of the number of driving rollers downstream for a driver gear (preferably a central driver gear with multiple drive rollers to each side or a different number on each side or all on a common side) there can be achieved a wide variety of lengths with respect to that one driving source. Also, through coordination of the relative power source, roller drive rotation speed requirements, material transfer load characteristics and desired longitudinal conveyor length, a gear arrangement can be established which is well suited for that material transfer assembly. In this regard, reference is made to Figure 20A which illustrates a longer length material conveyor system 100 wherein the roller spacing is maintained constant along the length of each material transfer assembly 102 and across a respective gap between the two material transfer systems 102 and 102'.

Each roller 118 has an idle roller 116 counterpart supported in cantilever fashion on the opposing idler frame 106. Figure 17 illustrates a preferred idle roller support assembly 300 featuring idle roller shaft 302. Idle roller shaft 302 has an enlarged head 304 which is of a diameter suitable for securing the idle roller 116 on shaft 302. Also shaft 302 has threaded end 306 that is threaded into thread holes 308 (Figures 11B and 17) formed on the interior side of idle frame 106. Enlarged head 304 has a flat surface 310 facing bearing 312 which is spaced from second, more exterior bearing 314. Figure 18 shows the main body of idle roller free of the

shaft and bearings of Figure 17. As shown, roller 116 has a shaft reception passageway 318 which features interior and exterior bearing reception cavities 320 and 322 and small central or intermediate passageway section defined by stepped shoulder 323. Preferably the bearings are cage bearings with the enlarged head compressing against the fixed segment of that bearing and the idle roller main body rotating together with the external non-fixed component of the sleeve bearing 312.

Idle roller 116 preferably, with the optional exception of not having a polyurethane high friction ring, has a common exterior main body design and material composition as driving rollers 118. As can be seen by a comparison of Figure 18 with Figure 16 there also exists different internal shaft passageway configurations.

Figure 19 provides an illustration of conveyor system 100 comprised of a plurality of material transfer assemblies 102', 102'', 102''' arranged along a common longitudinal axis. This is just one of a many possible conveyor arrangements available under the present invention, with additional conventional accessories such as stops and cross over conveyor system components (not shown) being also readily included in the overall conveyor system. Conveyor system 100 in Figure 19 is preferably equipped with conveyor interface system 328 which preferably includes a central processor which interfaces with segments 102', 102'' and 102''' individually and as a common group. These segments also have their own drive unit and drive gear train systems and their own sub-central control systems such as programmable control software systems logic controllers which are interfaced with the main processor and/or each other. For example, a base Yokogawa Programmable logic controller (i.e., a PLC base provided by Yokogawa of Japan) set up to conform to the other components of the invention features with which it is interfacing.

As shown by the conveyor system representation shown in Figure 19, pallets travel along 102''' to the intermediate conveyor segment is 102'' whereupon a certain action is performed with the assistance of control signals from the central processor 330. Examples include, for example, one of the above mentioned uses of the present invention such as an optical lens coat process requiring a clean environment.

Processor 330 also coordinates with the product line control sub-systems via, for example, a "Smema" semi interface program standard which involves a series of communications between up and down streams of pallets to help monitor and control position and movement of conveyed objects within the system. Processor 330 and/or one or more sub processors individualized with respect to the conveyor segments involved are also used in conjunction with other conventional conveyor components such as soft stopping devices, a two lane transfer unit, or a pallet lift and relocater assembly (none shown) Processor 330 can also function in the capacity as a tool host controller for processing techniques associated with the conveyed pallet, for which specialized pallets such as that shown in Figure 5 are utilized. Another example of controlling pallet movement within a conveyor system is found in US Pat. No. 6,047,812 to Thorn et al. which is incorporated herein.

Thus, under the present invention several sections of an overall conveyor system can be orchestrated to provide "singulated" pallet movement (non-contact buffering) by providing an input signal upon a pallet reaching an end segment of the conveyor system to an upstream conveyor segment zone. In this way, a start signal can be sent to initiate and turn off the appropriate conveyor sections to feed a pallet forward based on the status designation downstream provided by the input signal. A programmable logic controller (e.g., a customized controller board insert supported on the support frame structure on the same side as the drive rollers) provides the appropriate logic framework for carrying out such an operation.

A preferred program logic control board features a control board in communication with the drive source(s) that preferably includes a capacitor based system for motor starts generated by an input from the board. Also, the board preferably features in association with the capacitor based system for motor starts electronic circuitry for removal of electromagnetic field build up which usually occurs during a conveyor system start or direction change. For example, when a motor turns on, a current surge (high voltage) will occur to initiate the motor. The circuitry of the present invention help keep the surge at a certain level (e.g., an 18 mV peak). This feature helps prevent damage to EMF sensitive products such as those systems featuring a hard drive

disk actuator.

The present invention thus provides a material transfer system which avoids many of the problems in the prior art by providing an entirely positive drive transmission system for the motor shaft to the most downstream drive roller within a common drive system or sub-system. The arrangement of the present invention is also highly durable and even when servicing or repair is required the downtime is minimized. Also, the material transfer system provides a highly consistent and easily adjustable system by providing an easily adjusted and precision set torque adjusted slip clutch for each of the roller drive gears in the driving system with the adjustment being made in relation to the load received by the drive rollers (e.g., the average pallet weight). The advantage of having a clutch system with respect to the transfer weight involved (pallet plus any objects supported thereon) is that it will typically reduce the frictional contact between the roller and the pallet. For example, upon a pallet brought to a completed stop such as through use of a sensor and motor stop signal, the clutch of the present invention will absorb momentum induced by the pallet due to the earlier transfer state thereof. As an immediate stop is not possible, a conventional roller will cause wear and tear between roller and pallet and the inducement of particle emission to the environment which is avoided with the clutch system of the present invention whose design also avoids clutch generated particle emissions to a clean room environment or the like. Thus, with the arrangement of the present invention there is provided a low particulate and low vibration system with the low particle emission of the system rendering it well suited for clean room usage (e.g. the general arrangement of the present invention provides for a class 10 certification Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, Germany).

WHAT IS CLAIMED:

1. A conveyer system (102), comprising:

A material transfer support structure (104);

A plurality of object drive rollers (118) arranged along said material transfer support structures (104);

a plurality of drive roller support assemblies that support respective object drive rollers (118) and are supported by said material transfer support structure (104), and wherein said drive roller support assemblies comprise a drive roller (118) support shaft (212), said shaft (212) having an axially interior end supporting respective object drive rollers (118), said drive roller support assembly further comprising a friction control device (238) and a compression adjustment device (240, 246) which are supported by said shaft (212);

and said friction control device (238) includes a friction control washer (241) and a slip ring (238), said washer (241) being in contact at one end with said driver gear and at an opposite end with said slip ring (238), and said slip ring (238) being axially internal to said compression adjustment device (240, 246);

and said compression adjustment device (240, 246) being positioned axially external along said shaft (212) with respect to each of said drive roller (118), drive roller gear (206, 207) and friction control device (238), and said drive roller gear (206, 207) being positioned axially between said drive roller (118) and said compression adjustment device (240, 246), and said compression adjustment device (240, 246) being adjustable so as to alter a slip (5) setting of said friction control device (238);

an object drive roller drive train comprising a downstream roller drive transmission system (144) which drives the object drive rollers (118) supported on said drive roller support assemblies, said downstream roller drive transmission system (144) including roller drive gears (206, 207) supported on respective shafts.

2. The conveyor system (102) as recited in claim 1 wherein said object roller drive train comprises a downstream roller drive transmission system (144)

comprising a plurality of intermeshing gears including at least a pair of drive roller gears (206, 207) supported on respective drive roller support assemblies and one or more intermediate gears in driving communication with at least one of said drive roller gears (206, 207).

3. The conveyor system (102) as recited in claim 1 wherein said compression adjustment device (240, 246) includes a compression adjustment nut (242), and said shaft (212) includes a threaded end on which is mounted said compression adjustment nut (242) for varying a compression level on said friction control device (238).
4. The conveyor system (102) as recited in claim 1 wherein said friction control device (238) of said drive roller support assembly further comprises a shaft sleeve (236) which is fixed to the drive roller gear (206, 207) and extends axially out from one end of the drive roller gear (206, 207), and wherein said friction control device (238) further comprises a bearing that is supported by the material transfer support structure (104) and surrounds the drive roller (118) shaft (212), and said shaft sleeve extends axially out from said roller drive gear (206, 207) and into contact with said bearing.
5. The conveyor system (102) as recited in claim 1 wherein said material transfer structure (104) includes a side wall to opposite sides of which extends said shaft (212) such that said object drive rollers (118) are on an interior side of said side wall, and said spur gear (206), compression adjustment device (240, 246) and friction control device (238) are to an opposite, external side of said frame (108).
6. The conveyor system (102) as recited in claim 5 wherein said compression adjustment device (240, 246) further comprises a locking nut (242) with said locking nut (242) being positioned at an axially external free end of said shaft (212) and being in contact with said locking nut (242).
7. A method of adjusting an adjustable load clutch (238, 240, 234) of a conveyor system (102) according to claim 1 comprising adjusting a position of an

adjustable compression member (240, 246) so as to further compress or lessen compression with respect to a slip roller drive gear, which slip roller drive gear includes a fixed interior sleeve having an interior end facing an exterior surface of a conveyor frame structure, a friction control device (238) having an internal end in contact with an external side of said slip roller drive gear and an external end in contact with an internal side of said adjustable compression member (240, 246) which is received on an external end of a shaft (212) which also supports said slip roller drive gear, the interior sleeve and said friction control device (238).