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Overload Disengaging Pusher Dog for Monorail Carrier

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Abstract

This disclosure describes a power and free monorail carrier system featuring a pusher dog designed to disengage under controlled overload conditions. The arrangement prevents damage to the carrier or the power chain drive system when a carrier becomes jammed or obstructed. It details the mechanism for disengagement, the method for detecting a disengaged carrier, and the procedures for recovery and re-engagement. The system also addresses accumulation behavior and maintains functionality on inclined sections, offering a protective measure against system overloads in material handling applications.

1. Technical Field

[0001] The present technical disclosure relates to overhead conveyor systems, specifically power and free monorail arrangements utilized for material transport in industrial environments. More particularly, it concerns mechanisms for preventing damage to carriers and the power chain drive system when a carrier encounters an obstruction or jam.

2. Technical Context

[0002] Power and free conveyor systems are commonly employed for their ability to transport items asynchronously, allowing carriers to accumulate, diverge, and converge along a track network. In these systems, a continuous power chain (10) equipped with pusher dogs (12) travels within a power track (14), propelling carriers (20) that run on a separate free track (16). The carriers are typically equipped with an engagement mechanism, such as an engagement pin (26), which interacts with the pusher dogs (12). A significant challenge in such systems is managing situations where a carrier (20) becomes jammed or obstructed. Without a protective mechanism, a stalled carrier can cause the power chain (10) to stall, leading to system downtime, or exert excessive force on the carrier's structure, resulting in damage to the carrier (20), the engagement pin (26), or the pusher dog (12). Current solutions often involve shear pins that require manual replacement or complex electromechanical clutches that add significant cost and complexity. The present arrangement aims to provide a controlled, reversible disengagement under overload conditions, coupled with detection and recovery capabilities, to mitigate these issues.

3. System Overview

[0003] The disclosed system comprises a power and free monorail conveyor wherein the carrier's (20) propulsion mechanism incorporates a controlled overload disengagement feature. A pusher chain (10), driven by a drive unit (18), traverses a power track (14) and carries a series of pusher dogs (12). Each carrier (20) features a carrier trolley (22) running on a free track (16) and an engagement mechanism, typically an engagement pin (26) or a similar follower. This engagement pin (26) is designed to interact with the pusher dog (12) for propulsion. The critical innovation is that the pusher dog (12) itself, or its connection to the pusher chain (10), is equipped with an overload mechanism (34) that allows it to disengage from the engagement pin (26) when a predetermined force threshold is exceeded. Upon disengagement, the carrier (20) ceases to be propelled by the power chain (10). A detection sensor (30) monitors the state of carriers (20) and the pusher dogs (12) to identify disengaged carriers. A system controller (38) processes these signals and can initiate a recovery sequence using a recovery mechanism (32). The system is designed to allow accumulation of carriers (20) behind a stalled unit and supports operation on inclines. FIG. 1 illustrates the engagement mechanism, while FIG. 2 provides a block diagram of the overall system.

4. Components

[0004] The system consists of several key components working in conjunction:

[0005]

- **Pusher Chain (10):** A continuous loop chain, typically a rivetless type, propelled by a drive unit (18). It serves as the primary motive force for the carriers (20).
- **Pusher Dog (12):** An attachment to the pusher chain (10), designed to physically engage with and propel the carrier (20). In this system, the pusher dog (12) or its mounting incorporates an overload disengagement mechanism. This mechanism often involves a spring-loaded pivot or a detent system.
- **Power Track (14):** The structural rail system that guides and supports the pusher chain (10).
- **Free Track (16):** The structural rail system that guides and supports the carrier trolleys (22). It typically runs parallel to, and often below, the power track (14).
- **Drive Unit (18):** An electric motor and gearbox assembly that provides power to move the pusher chain (10) at a controlled speed.
- **Carrier (20):** The primary unit for transporting goods. Each carrier includes a carrier frame (36), carrier trolleys (22), and an engagement mechanism.
- **Carrier Trolley (22):** Wheel assemblies mounted to the carrier frame (36) that ride on the free track (16), allowing the carrier to move freely.
- **Engagement Pin (26):** A fixed or pivotable projection on the carrier (20) designed to be contacted and pushed by the pusher dog (12). This pin is typically robustly attached to the carrier frame (36).
- **Overload Mechanism (34):** This is integrated into the pusher dog (12) or its mounting. It is configured to yield or pivot when an axial pushing force on the pusher dog (12) exceeds a design threshold.* **Overload Mechanism (34):** This is integrated into the pusher dog (12) or its mounting. It is configured to yield or pivot when an axial pushing force on the pusher dog (12) exceeds a design threshold. This mechanism typically employs a heavy-duty spring (such as a compression or torsion spring) or a cam-and-roller arrangement that allows the pusher dog (12) to temporarily retract or swing away from the engagement path of the engagement pin (26). The disengagement force is determined by the spring constant and pre-load, or the cam profile.
- **Accumulation Buffer (28):** A spring-loaded or damped bumper typically located at the front and/or rear of the carrier (20) frame (36). This buffer absorbs impact energy during carrier accumulation, protecting the carriers from damage when they come into contact. FIG. 3 illustrates carriers in an accumulated state.

- **Detection Sensor (30):** A proximity sensor, photo-electric sensor, or mechanical limit switch placed at strategic points along the free track (16). These sensors detect the presence or absence of a carrier (20) or specifically monitor the position of a disengaged pusher dog (12). For example, a sensor could detect if a pusher dog (12) is in its normal engaged position or in its disengaged, retracted state.
- **Recovery Mechanism (32):** A mechanical device, such as a ramp or a wedge, installed along the free track (16). Its purpose is to guide a disengaged pusher dog (12) back into its engaged position, or to lift/lower a carrier's engagement pin (26) to facilitate re-engagement. FIG. 3 also shows a recovery ramp.
- **System Controller (38):** A programmable logic controller (PLC) or similar industrial control system that receives input from the detection sensors (30), controls the drive unit (18), and manages the overall logic for carrier movement, accumulation, and recovery.

5. Operation

[0006] The operation of the system involves several phases:

[0007] **Start-up:** Upon system activation, the drive unit (18) begins propelling the pusher chain (10) at a controlled speed. Pusher dogs (12) are in their normally engaged position. Carriers (20) are loaded onto the free track (16). As a pusher dog (12) approaches a carrier (20), it engages the carrier's engagement pin (26), and the carrier begins to move.

[0008] **Steady Running:** During normal operation, the pusher dog (12) continuously propels the carrier (20) along the free track (16). The force exerted by the pusher dog (12) on the engagement pin (26) remains below the predetermined disengagement threshold of the overload mechanism (34). Carriers (20) maintain a nominal spacing, either being driven by individual pusher dogs (12) or accumulating against a preceding carrier if an accumulation zone is active.

[0009] **Fault or Interruption (Disengagement):** If a carrier (20) encounters an obstruction or becomes jammed on the free track (16), the resistance to its motion increases significantly. As the pusher chain (10) continues to move, the force exerted by the pusher dog (12) on the jammed carrier's engagement pin (26) rises. When this force exceeds the design threshold of the overload mechanism (34), the pusher dog (12) disengages. This might involve the dog pivoting downwards, retracting into the chain link, or a cam releasing the engagement. The disengaged carrier (20) then remains stationary, while the pusher chain (10) and its subsequent pusher dogs (12) continue to move past it without further force application. The disengagement force can be designed within a range of approximately 200 N to 1000 N, depending on carrier weight and potential obstruction scenarios.

[0010] **Detection and Accumulation:** Immediately following disengagement, the detection sensor (30) located upstream or downstream of the disengagement point registers the event. This could be a sensor detecting the absence of a carrier (20) at a specific pusher dog (12) position, or a sensor directly monitoring the state (engaged/disengaged) of the pusher dog (12) itself. The system controller (38) receives this signal. If subsequent carriers (20) approach the stalled carrier, their pusher dogs (12) will continue to propel them until they make contact with the rear of the stalled carrier (20) or the preceding accumulated carrier. The accumulation buffers (28) on the carriers absorb the impact, and the subsequent pusher dogs (12) then disengage as their respective carriers (20) cease motion, leading to a train of accumulated carriers (20) behind the initial obstruction. The power chain (10) continues to run, with pusher dogs (12) cycling past the accumulated carriers.

[0011] **Recovery:** Recovery from a disengaged state can occur in several ways.

[0012]

- **Manual Intervention:** An operator clears the obstruction. Once the path is clear, the accumulated carriers (20) are either manually nudged or the system controller (38) initiates a slow advance of the power chain (10) or specific recovery mechanisms.
- **Automated Re-engagement:** As the power chain (10) moves, a disengaged pusher dog (12) eventually reaches a recovery mechanism (32), such as an upward sloping ramp. This ramp mechanically forces the pusher dog (12) back into its engaged position. As the re-engaged pusher dog (12) then comes into contact with the engagement pin (26) of the now-unobstructed carrier (20), the carrier resumes motion. For carriers that were accumulated, re-engagement can happen sequentially as each carrier is freed from the accumulation. The system controller (38) can be configured to pause or reduce the speed of the power chain (10) in the affected zone to facilitate this re-engagement.

[0013] **Incline Sections:** On inclined sections, the disengagement mechanism functions similarly. The normal pushing force will include a component due to gravity. The overload mechanism (34) is designed with a threshold sufficient to handle the normal gravitational load plus the maximum design pushing force before disengagement. If a carrier (20) jams on an incline, the pusher dog (12) will disengage as before, preventing rollback or excessive stress on the carrier (20) or chain (10). If the carrier (20) is on an upward incline and becomes disengaged, it may tend to roll back if not held by an anti-rollback device (not shown). For downward inclines, a disengaged carrier (20) may accelerate if not restrained, necessitating specific detection and braking mechanisms in critical areas.

6. Example Embodiments

[0014] **Embodiment 1** In this configuration, the pusher dog (12) itself is pivotably mounted to the pusher chain (10) via a hinge. A heavy-duty compression spring (34) holds the pusher dog (12) in its upright, engaged position. When an overload force is applied to the front face of the pusher dog (12) by the engagement pin (26), the dog pivots downwards against the spring (34) tension, allowing the engagement pin (26) to pass over it. Once the engagement pin (26) has passed, the spring (34) returns the pusher dog (12) to its upright position. The detection sensor (30) in this embodiment is a photo-electric sensor positioned to detect the absence of the pusher dog (12) in its upright position as it passes a specific point on the power track (14). Recovery is automatic as the dog resets itself.

[0015] **Embodiment 2** This embodiment features a fixed pusher dog (12) on the pusher chain (10), but the carrier's (20) engagement pin (26) is the component with the overload mechanism. The engagement pin (26) is mounted on a sliding block within the carrier frame (36), constrained by a shear pin or a spring-loaded detent (34). Upon overload, the engagement pin (26) retracts or slides back into the carrier frame (36), allowing the fixed pusher dog (12) to pass. Detection of a disengaged carrier involves a proximity sensor (30) that monitors the extended position of the engagement pin (26). If the pin is retracted, the carrier is considered disengaged. Recovery requires a mechanical ramp (32) that interacts with the retracted pin (26) to push it back into its extended, engaged position. If a shear pin is used, manual replacement is required, or a self-resetting spring-loaded detent can be implemented.

[0016] **Embodiment 3** This configuration utilizes a cam-and-follower mechanism for the pusher dog (12) disengagement. The pusher dog (12) has a cam profile on its underside. It is held in an engaged position by a follower mechanism biased by a spring (34). When an overload occurs, the engagement pin (26) exerts force, causing the cam profile on the pusher dog (12) to ride over its follower, momentarily retracting the dog. The recovery mechanism (32) is integrated into the power track (14) structure, comprising a passive ramp that guides the cam profile back into its engaged position after passing the obstruction. Detection is achieved by a magnetic sensor (30) that detects the presence of a magnet embedded in the tip of the pusher dog (12) only when it is in the fully engaged position.

7. Alternative Configurations

[0017]

- **Carrier Mounted Disengagement:** Instead of the pusher dog (12) disengaging, the carrier's (20) engagement pin (26) or a similar engagement feature could be designed to retract or pivot under overload, as demonstrated in Embodiment 2.
- **Segmented Pusher Dog:** The pusher dog (12) could be constructed with multiple segments, where a leading segment disengages while a trailing segment remains rigid to absorb lighter forces or indicate partial jams.
- **Pneumatic or Hydraulic Disengagement:** Instead of purely mechanical springs, pneumatic or hydraulic cylinders could be used to bias the pusher dog (12) into position, allowing for adjustable disengagement force and remote reset capabilities.
- **Distributed Detection:** Multiple detection sensors (30) could be distributed along the free track (16) to provide more precise location data for disengaged carriers (20), improving recovery efficiency.
- **Automated Obstruction Clearance:** In conjunction with detection, small robotic manipulators or diverter gates could be activated by the system controller (38) to attempt to clear minor obstructions, reducing the need for human intervention.

8. Parameter Variations

Parameter	Realistic Range	Effect of Variation
Disengagement Force	200 N to 1000 N	Lower values protect carriers at lower loads but increase nuisance disengagements. Higher values allow heavier loads but risk damage.
Pusher Chain Speed	5 m/min to 60 m/min	Affects throughput. Higher speeds require faster detection and recovery, and potentially higher impact forces during accumulation.
Carrier Weight Capacity	10 kg to 5000 kg	Influences required disengagement force and structural integrity of carrier and track system.
Accumulation Buffer Stiffness	500 N/mm to 5000 N/mm	Stiffer buffers transmit more force during accumulation. Softer buffers absorb more energy but allow greater compression.
Recovery Ramp Angle	5 degrees to 30 degrees	Steeper angles provide faster re-engagement but may increase impact on the dog. Shallower angles provide smoother re-engagement.
Detection Sensor Spacing	1 m to 10 m	Closer spacing provides more accurate location but increases cost. Wider spacing reduces cost but delays fault identification.
Pusher Dog Pitch	400 mm to 2000 mm	

Parameter	Realistic Range	Effect of Variation
		Influences carrier density and potential for accumulation. Shorter pitch increases density, longer pitch allows more individual movement.

9. Additional Implementations

[0019] The controlled overload disengagement mechanism described can be adapted for various other material handling systems. For instance, it can be integrated into floor-mounted or inverted power and free systems where the carriers are pushed from below. The principles of disengagement, detection, and recovery are transferable. In systems requiring precise positioning, the disengagement mechanism can be combined with indexing features, where carriers are precisely located at workstations, and an overload at the station triggers disengagement rather than a system stall. For applications involving hazardous materials or environments, the automated recovery features become even more critical, minimizing human exposure. Furthermore, the detection system can be enhanced with predictive analytics, where patterns of disengagement or near-disengagement are used to identify potential maintenance issues on the track (16) or carriers (20) before a full jam occurs. The use of wireless sensors on carriers (20) to report their status directly to the system controller (38) can provide more comprehensive fault detection and recovery capabilities, especially in complex track layouts with multiple merge and diverge points.

10. Figures

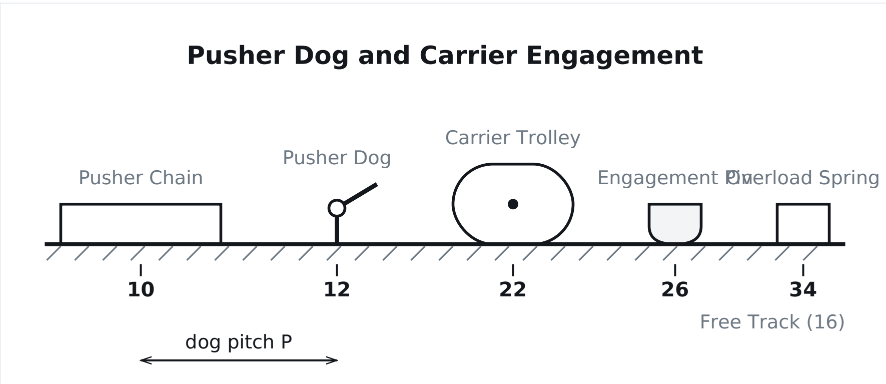

FIG. 1 An elevation view illustrating the engagement between the pusher dog and the carrier's engagement pin. PNG

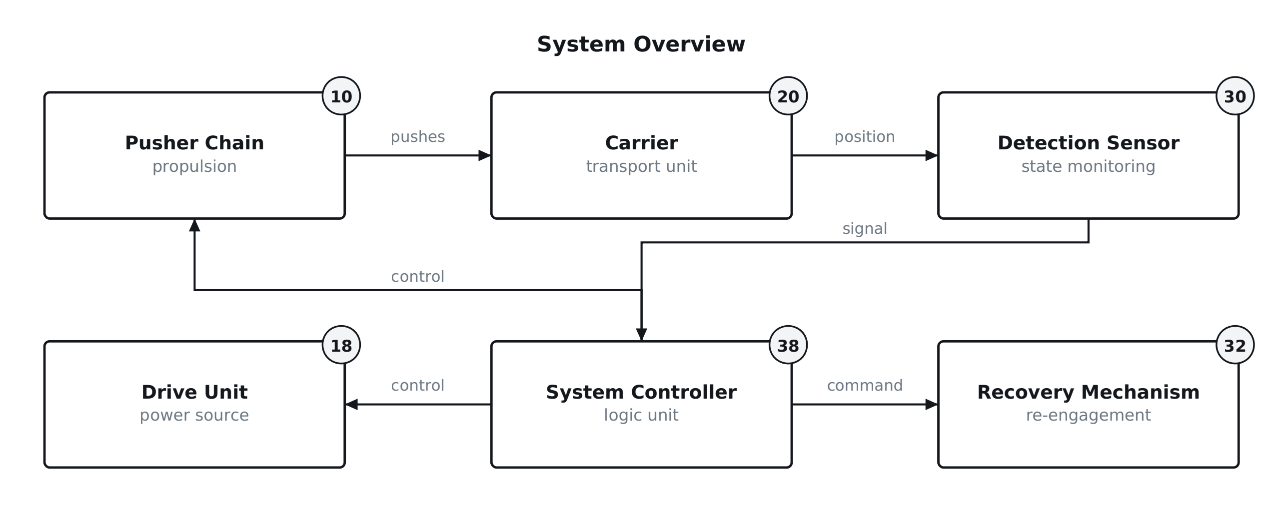

FIG. 2 A block diagram showing the primary components and information flow within the system. PNG

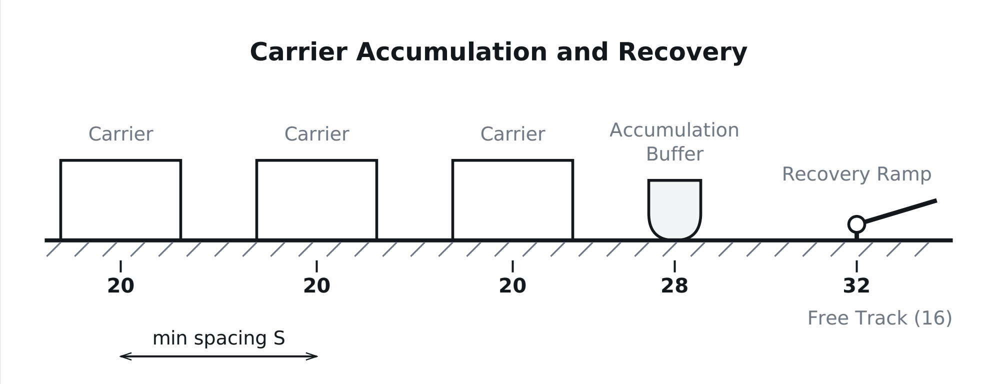

FIG. 3 An elevation view illustrating multiple carriers in an accumulated state and a recovery ramp. PNG

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