VIBRATORY CONVEYOR

This is a continuation of application Ser. No. 09/003,998 filed Jan. 8, 1998.

BACKGROUND OF THE INVENTION

The present invention relates to an excited frame vibratory conveying apparatus for conveying objects thereon.

Carmichael, U.S. Pat. No. 4,313,535, incorporated by reference herein, discloses an excited frame vibratory conveyor that includes an elongated conveying member mounted by beam springs on an excited frame. The excited frame has a balanced vibratory drive for vibrating the excited frame along a line of force that passes through the center of masses of the conveying member and the excited frame. The balanced vibratory drive includes a pair of counter-rotating masses that provide a resultant vibratory force. The basic objective of such a system is to maintain the vibration amplitude of the excited frame at zero while the conveying bed or member is vibrated near its natural frequency of maximum amplitude. The generally recognized advantages of such a system, over conventional direct vibratory conveyors where the vibratory drive is connected directly to the conveying member, is that under some conditions it is possible to transfer less vibration into the floor or ceiling supports and to provide a conveyor that is considerably less massive than the direct drive systems. Carmichael also teaches that the stroke of the conveying member may be controlled by changing the rpm of the vibratory drive. Consequently, it is possible to adjust the stroke of the conveying member by changing the speed of rotation of the vibratory drive.

Unfortunately, the conveyor system taught by Carmichael experiences significant transient vibrational motion of the excited frame and conveying member during start up and shut down of the conveyor system. It is during these periods of transition that significant vibrational forces are transferred into the floor or ceiling supports which may result in catastrophic failure, such as the conveyor system becoming dislodged from its supports. During normal operation product is added to one end of the conveying member at the same rate as it is being discharged from the other end of the conveying member. However, it has been observed that when excess product is added to the conveyor system taught by Carmichael, the system will experience catastrophic failure, such as transferring significant vibrational forces into the floor or ceiling supports, bouncing the excited frame on its supports, and failure of the conveyor system to convey products. In order to prevent such a potentially catastrophic failure, the conveyor system is normally designed to operate at a point less than its maximum efficiency in the event that excess product is added to the conveying member. Carmichael also teaches the use of such an operating point by including only one-third of the weight of the anticipated particulate material in the calculations to determine the loaded center of mass of the elongated conveying member. Unfortunately, operating the conveyor system at such an operating point is less efficient than operating the conveyor system at its resonant frequency.

Frolich et al., U.S. Pat. No. 5,127,512, disclose an electromagnetically driven vibrating conveyor system that operates with a constant excitation frequency. The conveyor system is a dual-mass system, namely, the mass of an electromagnetic drive and the mass of the conveyor itself to which the drive is directly connected thereto. The electromagnetic drive regulates the amplitude of the vibration

during operation at different loading conditions. Unfortunately, such a dual-mass system transfers substantial vibrational forces into the floor or ceiling supports and tends to be more massive in comparison to the excited frame system taught by Carmichael. Further, the electromagnetic drive is typically more expensive and complicated than the traditional counter-rotating mass drive, as taught by Carmichael. Bertrand, U.S. Pat. No. 4,088,223, and Fishman et al., U.S. Pat. No. 5,213,200, also disclose direct drive vibratory conveyors.

What is desired, therefore, is an excited frame vibratory conveyor that eliminates the transients occurring during start-up and shutdown, and also operates at maximum efficiency.

SUMMARY OF THE INVENTION

The present invention overcomes the aforementioned limitations of the prior art by providing a conveying system including a frame supporting a conveying member suitable to move products thereon. A drive, which is preferably an electromagnetic drive having a mass that vibrates back and forth along a substantially straight path, is connected to the frame and is operated in a fashion to provide several advantages therefrom.

In a first aspect of the invention, the drive is capable of maintaining the frame substantially stationary while the conveying member is at least one of brought from a stationary state to a generally resonant state suitable to move the products thereon and brought from the generally resonant state suitable to move the products thereon to the stationary state. As such the excited frame experiences no substantial transient vibrational motions during the start up and shut down of the conveyor system. This prevents significant vibrational forces from being transferred into the floor or ceiling supports thereby preventing catastrophic failure.

In another aspect of the invention, the drive also preferably provides a vibratory force to the frame that never matches the natural frequency of the frame while the conveying member is brought from a stationary state to a generally resonant state suitable to move the products thereon. The drive maintains the frame substantially stationary while the conveying member is moving the products thereon. In this manner the transients of the excited frame are reduced during start up and shut down.

In another aspect of the invention, the electromagnetic drive, which preferably has a mass that vibrates back and forth along a substantially straight path, provides a force to the frame in such a manner that the conveying member moves products thereon while the frame maintains substantially stationary. Also the electromagnetic drive may produce a force in a direction which provides both horizontal displacement and vertical displacement to the conveying member while maintaining the frame substantially stationary with the conveying member moving the products thereon. The use of the electromagnetic drive provides superior flexibility for the operation of the excited frame vibratory conveyor than obtainable with a dual counter rotating mass drive taught by Carmichael.

In another aspect of the invention, the electromagnetic drive provides a force to the frame where the force has a variable frequency and the force has a variable amplitude at each of the frequencies. Also the force may have a frequency and an amplitude that are variable independently of one another. In either case the drive maintains the frame substantially stationary while the conveying member is moving the products thereon. This further provides control over the