MULTI-JAW TRANSVERSE SEALER

This invention relates to a packaging machine (10) having a carriage (52) drivable in a path (99) along a work region (32) and a sealing tool (70) movably mounted to the carriage (52) connected to a sealer actuator (192, 194) for moving the tool (70) with respect to the carriage (52) and performing a sealing operation on a workpiece (11). The carriage (52) can have multiple tools (70, 203, 1506) mounted to the carriage (52) which can be independently actuated to perform multiple operations on a workpiece (11). This invention also relates to a method of performing a packaging operation in which a tool (70) is driven along a path (99) with respect to a workpiece (11) and the tool (70) is aligned with respect to the workpiece (11) and the aligned tool is moved into operational association with the workpiece (11) for performing an operation on the workpiece (11).
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MULTI-JAW TRANSVERSE SEALER

Related Applications

This application claims the benefit of U.S. Provisional Applications Nos. 60/131,027, filed April 26, 1999; 60/144,483, filed July 17, 1999; and 60/185,019, 60/185,020, 60/185,065, each filed on February 25, 2000.

Field of Invention

This invention relates generally to packaging machines. More particularly, this invention is directed to carriages and methods for formation of packages of a product by applying a transverse seal to a package in a reliable repeatable fashion.

Background of Invention

Packaging machines are known which form a tube from a web of material, a portion of which is filled with a product, such as fluid or other pourable product, including dry products such as potato chips. Two portions along the tube are sealed transversely by sealing jaws to form a closed package. The tube is then severed through the sealed portions to separate the package from adjacent ones formed by the machine, which are then commonly formed into bricks.

European publication EP 0 887 273 teaches a packaging machine for continuously producing sealed packages of a pourable food product. A number of jaws are connected along chains on opposite sides of a tube to heat seal the tube. A cutting member is located beneath the jaws to cut the tube along the sealed bands.

European publication EP 0 887 264 discloses a packaging unit for producing aseptic sealed packages containing pourable food product from a tube of packaging material having first and second chain conveyors having a number of jaws and a number of counter-jaws to heat seal cross-sections of the tube, and the chain conveyors also have half shell elements for controlling the volume of the packages and which are connected to respective jaws and counter-jaws and cooperate with a relative cam for controlling the relative movement of the half shell elements to and from the supply path of the tube.
U.S. Patent No. RE. 33,467 issued to Steck et al. discloses a method and apparatus for sealing a polyfoil. A plurality of sealing jaws are mounted on endless carrying means which continually advance so that each sealing jaw can correspondingly contact an opposing pressure jaw to compress and seal the polyfoil by induction.

European publication EP 0 887 263 discloses a packaging unit for producing aseptic sealed packages containing pourable food form a tube of packaging material having jaws and counter-jaws attached to chain conveyors and guided along respective workpaths by pairs of cams having different profiles for controlling the interaction of the jaws.

**Brief Description of Figures**

Figure 1 is a schematic representation of one embodiment of a form, fill and seal packaging machine constructed according to the invention;

Figure 2 is a perspective view of a sealing subassembly constructed according to the invention;

Figure 3 is a side view thereof;

Figure 4 is a front view thereof;

Figure 5 is a perspective view of a sealing assembly incorporating the subassembly of Figure 2 and depicting the registration of a sealing jaw thereof with a sealing jaw of a further subassembly;

Figure 6 is a perspective view of one embodiment of a cam for use in deployment of a sealing jaw into engagement with a tube;

Figure 7 is a top view of the subassembly of Figure 2;

Figure 8 is a perspective view of a carriage constructed according to the invention;

Figure 8A is a perspective view of the carriage of Figure 8 in an engaged position;

Figures 9A is a perspective view of a first embodiment of a knife according to the present invention;

Figure 9B is a side view thereof;

Figure 9C is a detail view of the cutting edge thereof;

Figures 10A-10D are plan views of other embodiments of a knife constructed according to the invention;
Figure 11 is a top view of a set of carriages, depicting the registration of the sealing jaws thereof;

Figure 12 is a perspective view of another embodiment of a carriage constructed according to the invention;

Figure 13 is a schematic representation of a closed circuit track as employed in the present invention;

Figure 13A is a cross-sectional view of the track of Figure 13 taken along line A-A;

Figure 14 is a perspective view of another embodiment of a carriage of the present invention;

Figure 15 is a perspective view of a sealing subassembly with the carriage shown in Figure 14;

Figure 16 is a plan view of a carriage having an inertial lock;

Figure 17 is a perspective view of an alternative embodiment of a sealing subassembly;

Figure 18 is a perspective view of the carriage thereof;

Figure 19 is rear perspective view thereof;

Figure 19A is a top view of an alternative track follower of the carriage of Figure 18;

Figure 19B is a top view of an alternative track follower of the carriage of Figure 18;

Figure 19C is a side view thereof;

Figure 19D is a top view of an alternative track follower of the carriage of Figure 18;

Figure 20 is a front view of the subassembly of Figure 17;

Figure 21 is a cutaway plan view thereof;

Figure 22 is a cutaway perspective view thereof;

Figure 23 is a plan view of the subassembly of Figure 17;

Figure 24 is a perspective view of a brake system thereof; and

Figure 25 is a top view thereof.

**Summary of The Invention**

The present invention is directed to a packaging machine. In one embodiment, the packaging machine comprises a drivable carriage in a path having a sealing tool for performing a sealing operation and a sealer actuator connected to the sealing tool for moving
the sealing tool into association with a workpiece for performing a sealing operation on the
workpiece. The sealing tool can be disposed in various orientations along the path and an
actuator can move the sealing tool into association with the workpiece once the sealing tool is
in a predetermined orientation with respect to the workpiece. The packaging machine can
have an inertial lock to prevent the sealing tool from moving.

In another embodiment, the packaging machine has a sealing cam and the sealing
actuator can have a sealing cam follower connected with the sealing tool to follow the sealing
cam to move the sealing tool into association with the workpiece.

In yet another embodiment, the packaging machine can further comprise a cutter
movably mounted to the carriage and configured for performing a cutting operation on the
workpiece. The cutter may be connected to the sealing actuator for moving the cutter with
respect to the carriage into association with the workpiece for performing the cutting
operation or the cutter may be connected to a cutting actuator for this purpose. A cutting cam
to engage the cutting actuator to cam the cutter to perform the cutting operation can also be
part of the packaging machine.

In another embodiment the cutter is disposed at an angle with respect to a workpiece.
The angle can be any non-zero angle. The cutter can comprise a ceramic blade.

In another embodiment, the packaging machine can further comprise a volume control
tool movably mounted to the carriage and connected to a volume control actuator for moving
the volume control tool to engage the workpiece and control the volume thereof.

The present invention is also directed to a method of performing a packaging
operation on a workpiece. The method comprises the steps of: driving at least one tool with
respect to a workpiece; aligning the tool in a first orientation with respect the workpiece;
moving the aligned tool into association with the workpiece while maintaining said first
orientation; and performing a first operation on the workpiece with the tool. The driving of
the tool can include driving a carriage upon which the tool is mounted. Another step can
include retracting the aligned tool out of said association with the workpiece before moving
the tool out of first orientation; and moving the retracted tool out of first orientation.

In another embodiment, the method can include aligning a second tool in a second
orientation with respect to the workpiece; moving the aligned second tool into association
with the workpiece while maintaining the second orientation; and performing a second
operation on the workpiece with the second tool. The method can further include retracting
the aligned second tool from association with the workpiece; and moving the retracted second
tool out of said second orientation. The first tool can be a sealing tool and the first operation
comprises sealing the workpiece and the workpiece can be a web.

In another embodiment, a packaging machine comprises a first carriage having a first
5 tool movably mounted to the carriage for performing a sealing operation on a workpiece and
a track for guiding the carriage along a path and the carriage has a track follower associated
with the track for retaining the carriage with respect to the track in substantially all directions
normal to the path while permitting movement of first carriage along the path. The carriage
of this machine can include more than one tool and the path can be a closed circuit and the
track can be two parallel tracks. The track followers can be wheels and the wheels can be
10 arranged in a trapezoidal configuration and can have grooves to engage the tracks. The
wheels can be movably mounted to the carriage to allow for lateral movement with respect to
the carriage when the tracks are out of parallel. The wheels can be rigidly mounted to the
carriage and have a generally flat profile to allow for lateral movement with respect to the
tracks when the tracks are out of parallel.

In another embodiment, a packaging machine comprises a track with a carriage
15 mounted to the track for movement along the track and including a tool for operating on a
workpiece and a lubricant source is connected to the track for applying lubricant thereto at an
application location. A suction source can be connected to the track for removing excess
lubricant from the track at a suction location.

**Detailed Description of Invention**

Figure 1 shows a preferred embodiment of a production machine constructed
20 according to the present invention, which is preferably a form, fill and seal (FFS) packaging
machine of the type which may be employed in the packaging of food products, such as juices
or milk or other pourable solids or liquids, in individual sized, parallelepiped containers.
Alternative embodiments of the production machine, however, are for different processes,
such as for manufacturing or assembly, preferably with at least two tools operating on
portions of a workpiece. In the preferred packaging machine, the workpiece 11 includes a

30 web 12 formed into a tube 20.
The schematically represented FFS packaging machine 10 shown in Figure 1, includes a sealing assembly 40 and a web 12 of packaging material, which preferably includes at least one sealable surface 14 thereon, is fed forwardly over guide rolls 16 and 18 folded into a tube 20. As depicted, the flat web 12 of packaging material is fed forwardly in a workpiece direction 13 through the FFS machine, which is preferably the longitudinal direction. As the web moves through the machine, it is continuously folded into a tubular configuration, sealed along its longitudinal dimension to define a tube 20. The side edges 22, 24 may be overlain either with undersides against each other or in overlap with the undersides facing in the same direction. The longitudinally overlaid side edges 22, 24 of the web are sealed to complete the tube, such as by induction or heat sealing. Product, such as a fruit juice or milk is fed into the closed tube at a filling station 26 and the filled tube is fed forwardly to a transverse sealing station 28. At the transverse sealing station 28, the filled tube is squeezed such as at locations 42 and 44 to define a sealing region 46 transversely of the tube. The tube is thereupon sealed transversely of its length dimension, preferably at locations that are equi-distantly spaced apart along the length of the tube. Thereafter, the tube is severed into individual sealed packages 34 of product. Preferably the tube is severed within the bounds of each transverse seal.

The packaging material is preferably provided with layers of thermoplastic material on surface 14 of the web 12 which ultimately defines the interior wall of the formed tube 20. Thus when tube 20 is pressed inwardly thereof from its opposite sides, the inner wall of the tube 20 is collapsed against itself and provides contiguous portions of the thermoplastic inner wall of the tube 20 in position for sealing thereof. Preferably, an aluminum foil layer is disposed between the thermoplastic layers. Preferably, an induction sealing process is used to generate heat within the laminate packaging material. For instance, a high current resonant frequency is created, at which the sealing is performed. Alternating current produces a magnetic field intensity which, in turn, creates eddy currents within the aluminum foil layer in the packaging material. These eddy currents generate resistive heat which conducts thermally to the inner thermoplastic layer, raising it above its melting point. When two such opposing seal layers are pressed together in a sealing operation, a hermetic seal is formed.

The present invention is particularly suited to consistently effecting transverse seals at high production rates and rates of forward velocity of the packaging material through the
packaging machine 10, these seals having full integrity and being uniformly spaced apart from one another. In an alternative embodiment, however, the transverse seals are made at predetermined distances apart, longitudinally along the web, at distances that are not uniform but which can be consistently maintained.

Commonly, each of the packages is preferably filled with a consistent volume of product. In FFS packaging machines in particular, this consistency of volume is provided by making the individual packages of equal volume when sealed. In the preferred embodiment, as shown in Figure 1, a sensor 25 is mounted near the moving web 12 to detect registration marks on the web 12 as the web 12 moves past the sensor 25. Sensor 25 is preferably electronically connected to a controller 326. Controller 326 controls the speed and positioning of the carriages 52 and 53 as they move about the first and second sealing subassemblies 48 and 50, respectively.

Referring to Figures 2-8, a preferred embodiment of a sealing assembly is shown. The sealing assembly 40 preferably includes first and second sealing subassemblies 48 and 50, disposed on opposite sides of the filled tube 20. As can be seen in Figure 2, each subassembly includes at least one carriage 52, 53 that is mounted for cyclical movement along respective paths or circuits. The circuits preferably define closed loops, but may alternatively be open and different shapes. The circuits are preferably generally symmetrical, although various relative positions and shapes may alternatively be employed, including circuits that are non-parallel to each other. Preferably, first and second tracks 58, 60 define a closed oval circuit 30, along which a plurality of carriages travel in a path 99. Preferably path 99 is contiguous with and uniformly spaced from the moving tube 20 at the sealing station 28. Only one carriage per subassembly is depicted in Figures 1 and 2 for clarity, but each subassembly preferably includes a plurality of carriages mounted thereon. Each of the plurality of carriages of each of the subassemblies are preferably free to move to any position along their respective path at any point in time, independently of the movement or non-movement of every other of the plurality of carriages, although in other embodiments, groups or all of the carriages can be coupled for coupled movement along the path 99 such as by connecting some or all of the carriages with belts or chains. In one embodiment all carriages of the subassembly are connected by a chain and no independent movement is possible.
With specific reference to Figures 2-4, one embodiment of a sealing subassembly 48, for example, includes a frame 72. The depicted frame comprises first, second and third frame members 74, 76, 78, respectively, which are aligned parallel to one another but in spaced apart relationship to one another. In the embodiment shown, the frames are generally oval and planar, but other shapes and arrangements are suitable for use with the invention.

Spacers and interconnecting rods 80, 82, 84, 86 or the like provide for rigid anchoring of the three frame members relative to one another. Referring to Figures 2 and 4, first frame member 74 is disposed outermost of a first side of frame 72 and serves as the mounting location for a first track 58 which is disposed along the outer peripheral margin 94 of the inside face 96 of frame member 74. The second frame member 76 is disposed outmost of a second side of frame 72 and serves as the mounting location of a second track 60. Second track 60 preferably is substantially a mirror image of first track 58, and is mounted on the peripheral margin 97 of the inside face 98 of second frame member 76.

Referring to Figures 2-5 and 7, the third frame member 78 is disposed between, aligned with, and spaced apart from, the first and second frame members 74, 76. This third frame member serves as the mounting location for a plurality of electrically conductive coils 160 ("active elements") which are electrically insulated from one another and aligned in side-by-side relationship along the outer peripheral margin 162 of the third frame member 78. These aligned coils are generally congruent with the first and second tracks 58, 60 so that a carriage moving along the tracks follows a path which is congruent with the aligned coils 160. The coils are preferably encased within an epoxy or other encapsulating material in order to avoid unwanted exposure to the elements. The coils preferably serves as the active elements of a linear motor. These coils, when energized, serve to transport the carriages around the track.

Referring to Figure 5, each track includes rails or races 140, 142, respectively, defined along the opposite outer edges of the tracks 58, 60 within which the carriages of a respective subassembly are constrained to move concurrently with the forwardly moving tube 20. The first and second rails 140, 142 of each of the tracks 58, 60 are preferably spaced generally uniformly apart from one another along the entire length of their respective track. Each such rail is defined by a double chamfer 141 of the side edge of the track. In addition to the hereinabove described functions of the frame, it also serves as a means for mounting the
system on a superstructure of an existing manufacturing machine or to an independent
supporting structure, e.g., the floor, etc. Other configurations of a frame may be employed as
the application requires, without sacrifice of the functional nature of the frame, such as tracks
extending along open paths, or paths having different shapes. Alternatively a single track can
be used.

Preferably, there are at least two distinct types of carriages that perform different
operations on the web 12 and are disposed on opposite sides of the web 12. Although the
configuration and construction of the different types of carriages are substantially similar,
there are slight variations in design to accommodate the unique operation of each type of
carriage. For example, in the preferred embodiment, cutting carriage 52 has a knife 203 to
perform a cutting operation and sealing carriage 53 has a power interface to provide energy to
perform a sealing operation. Also, the elongated sealing jaw 71 of the sealing carriage 53 of
the second subassembly is provided with a centrally located slot that extends along the length
of the sealing jaw in position to receive within such slot the cutting edge of the knife after the
cutting edge has severed the tube disposed between the registered sealing jaws of the two
subassemblies. Like carriages are preferably arranged to travel on the same sealing
subassembly so that cutting carriage 52 and sealing carriage 53 are on opposite sides of the
moving web 12.

Referring to Figures 5 and 7-8, each carriage, 52 and 53, includes a base member or
carriage body 35 including legs 102, 128 attached at opposite ends of a cross member 100
that substantially spans the separation distance between the first and second tracks 58, 60.
Preferably the carriage body 35 remains in a predetermined orientation relative to the track as
it travels throughout the circuit 30. The carriage body 35 is preferably substantially
perpendicular to the length direction of the tracks 58 and 60. A first leg 102 depends from a
first end 103 of cross member 100 and in facing relationship to the first track 58. A second
leg 128 depends from a second end 105 of the carriage and in facing relationship to second
track 60. First and second legs 102, 128 are preferably planar but other shapes may be used.
Legs 102, 128 preferably support a set of four wheels each which engage and travel along
tracks 58, 60, but wheels can alternatively be attached directly to the carriage body 35. Each
wheel is preferably of a unitary construction and is provided with a shape preferably
conforming to the rails 140, 142, and shaped to stabilize and guide the carriages along the
tracks, preferably constraining lateral movement of the carriages with respect to the track. Wheels 106, 108, 118, 120, 132, 134, 136, and 138 of the preferred embodiment comprise lateral walls 107, as shown in Figure 8, extending adjacent the track to restrict lateral movement with respect thereto. Preferably, each wheel is provided with a slot or V-groove 143, in the lateral walls 107, in the outer circumference of the wheel and configured to receive therein one of the rails 140, 142. In other embodiments, the lateral walls are curved, but extend to a greater diameter than a portion of the wheel which rolls along the track. With the V-groove 143, the lateral walls 107 preferably extend radially beyond the point of contact between the wheel with the track. Other wheel embodiments have a single lateral wall, with at least one wheel having a lateral wall to prevent movement in one lateral direction, and the other wheel having a lateral wall on an opposite side of the track or tracks, to prevent movement in the opposite lateral direction. Alternatively, a set of wheels can be attached directly to the carriage body or can be mounted to a single leg extending from the body to the track.

Carriages 52, 53 include at least one tool configured for performing an operation, preferably for manufacturing or assembly, on the workpiece or moving web 12. Exemplary tools which can be used include sealers, cutters and volume controllers, however the invention is not limited thereto and can include tools capable of performing other operations on the workpiece. Preferably, a plurality of tools is mounted to the carriage.

Preferably, the tools are movably mounted to the carriage so that each tool is actutable towards and away the workpiece 11 or moving web 12 in a work region 32 at a predetermined location along the circuit 30 or path 99 and in a predetermined manner, independent from the carriage to which they are mounted. As best seen in Figure 3, preferably work region 32 is the linear portion of the oval circuit 30 adjacent the workpiece 11. Generally, as the carriage travels around the circuit 30 or path 99 and through work region 32, the carriage is oriented to align some or all of the tools with the workpiece 11 before the tool is moved with respect to the carriage and actuated to engage the workpiece and perform an operation thereupon. As will be explained further below, each tool is preferably mounted for reciprocal movement towards and away the moving web 12 and at a desired angle thereto, which can minimize rubbing, scraping, or wear on the workpiece and which enables greater precision. The tools preferably move towards and engage the
workpiece 11 at an angle normal to the workpiece direction 13. Also, each tool is preferably actutable at a predetermined location with the workpiece as the carriage travels around the circuit 30.

In the embodiment shown in the Figures 1-8, the tools of each carriage 52, 53 include a sealer, such as sealing jaw 70 and 71, respectively, which is designed to engage a side 42 of the moving web 12 or tube 20, apply pressure against the web 12, and form a seal transversely of the forwardly moving filled tube 20. As depicted in Figure 8, elongated sealing jaws 70, 71 are mounted having a width suitable to extend fully transversely of a packaging material being processed in the FFS machine 10.

Sealing jaws 70, 71 are mounted for reciprocatory movement towards and away the workpiece 11 and at an angle with respect to workpiece direction 13 to the moving web 12. Preferably, the sealing jaws are mounted for movement perpendicularly away from and toward the workpiece 11 and tracks 58, 60 and outermost face of the cross member 100 of the carriage, as shown by arrow 190 of Figure 8. Referring to Figure 8A, sealing jaw 70 is shown in an engaged position. Sealing jaw 70 engages tube 20 at a sealing angle 278. Preferably sealing angle 278 is about 90°.

Preferably, an actuator is mechanically coupled to the sealing jaws to move the sealing jaws with respect to the carriage. Referring to Figures 7 and 8, sealing jaws 70, 71 are movable preferably by rods 192, 194 which engage cams 280, 282 to actuate the movement, however other suitable actuators may be used, including electric, hydraulic, pneumatic cylinders or other actuators or motors. In this regard, preferably first and second rods 192 and 194 are slidable in openings 196 and 198 through the thickness of cross member 100 to reciprocally move sealing jaws 70, 71. Preferably ball bearings surround rods 192, 194 in openings 196, 198 to facilitate the sliding of the rods through the openings 196, 198, however bushings or any other suitable bearing may be used. Rod 192 is further secured in position relative to cross member 100 by mounting lugs 202 and 204 that project from the inside face 206 of a leg 210 that depends from the cross member 100. In like manner, rod 194 is secured in position relative to cross member 100 by mounting lugs 207, 208 that project from the face 214 of a leg 212 that depends from cross member 100.

Preferably, each of the rods 192, 194 is slidably received within its respective mounting lugs 202, 204 and 207, 208 so that the sealing jaws 70, 71 may be extended or
retracted away from or toward cross member 100. Cross member 100 is fixedly anchored to
legs 102, 128 and constrained by the wheels (106, 108, 118, 120, 132, 134, 136, and 138,
respectively) against lateral movement relative to tracks 58, 60. The inboard ends 216, 218 of
rods 192, 194 terminate in a respective yoke 220, 222 within the respective legs of which
there are mounted cam followers 224, 226. Rod 192 is further provided with an encircling
coil spring 228 having one of its ends 230 bearing against the yoke 220 and its opposite end
234 bearing against the inboard face 236 of the stop 202. By this spring, the rod is biased in a
direction away from the cross member 100 of the carriage and inward with respect to the
frame 72. The second rod 194 is mounted by like mounting lugs 207, 208 and springs 241
and 229 as is the first rod, the lugs and springs which mount the second rod being
substantially mirror images of their counterparts that mount the first rod. Thus, the first and
second rods serve to mount the opposite ends 250 and 252 of the sealing jaw for straight-line
reciprocatory movement of the sealing jaw 70, 71 relative to cross member 100 of the
carriage 52, 53. That is, the mounting provides for the opposite ends of the sealing jaw 70,
71 to move equal distances toward or away from the cross member 100 so that the outer face
254 of the sealing jaw 70, 71 engages a filled tube 20 preferably with uniform pressure across
the length of the face 254 of the sealing jaw 70, 71.

In the preferred embodiment, the sealing jaws 70, 71 are aligned and actuated, such
as by cams 280, 282, to engage the tube 20, however linear motors, pneumatic cylinders or
any other suitable actuator mechanism or motor can alternatively be used. To this end, within
the space between the first and third frame members 74, 78 and within the space between the
second and third frame members 76, 78, there are provided first and second cams 280, 282.
Each cam 280, 282 is preferably anchored in position between its respective frame members
76, 78 such as by standoff mountings 284, 286, and 288, 290, respectively, but alternatively
the cams can be mounted in any fashion suitable to allow the cam followers to contact them.

First cam 280 includes a camming surface 292 defined along its outer periphery and the cam
282 includes a camming surface 294 defined along its outer periphery. These camming
surfaces determine the timing and extent of the extension and retraction of the sealing jaws
70, 71 with respect to the carriages 52, 53, in a direction toward and away from moving tube
20 through the work region 30 of sealing station 28. In this embodiment, cam follower 224,
mounted on the inboard end of the rod 192, is adapted to engage camming surface 292 of first
cam 280, and cam follower 226 mounted on the inboard end of rod 194 is adapted to engage camming surface 294 of second cam 282. Thus, as each carriage is moved along the path defined by the tracks 58 and 60, cam followers 224, 226 follow the contour of the camming surface of their respective cams.

In reference to the camming actuating mechanism, Figure 6 shows a representative cam employed in the various embodiments of the invention. The contour of each cam includes at least one portion thereof which defines a projection 298, or elevated portion, from the periphery of the cam and which is located along the camming surface at predetermined locations thereof which correspond to the timing of the movement of a tool attached to a carriage during which it is desired that the tool be actuated, such as to engage the moving tube 20. Cam followers are preferably on the inboard ends of rods to encounter these projections on the camming surfaces of respective cams so that the tools associated therewith are actuated. For example, in the embodiment shown in Figures 1-8, the rods 192, 194, hence the guide bar 262 and the sealing jaws 70, 71 attached thereto, move in an extended direction, outwardly and away from the cross member 100, and toward tube 20 as the carriage moves through sealing station 28. This movement of the rods 192, 194 functions also to compress springs 228, 229 so that after the cam followers 224, 226 have moved past their respective cam projections, the tension in the springs 228, 229 serve to bias the guide bar 262 and the sealing jaw 70 in a distal direction toward the carriage and away from the tube. Because each of the rods 192, 194 is pinned to the outboard end of the guide bar 262, this outward movement of the rods 192, 194 compresses its encircling coil springs 228, 229. Upon the passage of the cam followers past their respective projections 298 on the camming surface of the cams 280, 282, the tension in the coiled springs 228, 229 returns rods 192, 194 to their most inwardly position relative to cross member 100 of the carriage 52, 53 and withdraws the sealing jaw 70, 71 from engagement with the tube.

Referring now to Figure 11, the carriages can also include a power delivery unit to deliver power to a tool mounted to the carriage. In the preferred embodiment, as can be seen in Figures 11-14, sealing carriage 53 has a power delivery interface unit that delivers the power required to seal the web 12 to sealing jaw 71. Referring to Figure 11, sealing jaw 71 of the sealing carriage 53 has a power interface block 350 attached to one end of the sealing jaw 71. The power interface block 350 of carriage 53 is mounted to cross-arm 100 by an L-
bracket 351 and is positioned to face the exterior of frame member 76 of sealing subassembly 50 as the carriage 53 travels around path 99. A power delivery unit 352 is supported by the frame member 76 adjacent the power interface block 350 to inductively transfer power to the power interface block 350 mounted on carriage 53. Electrical leads 353 extend from interface block 350 and connect to a mount block 354. A pair of plates 355 and a cap block 356 are attached to mount block 354, such as by screws 357 or any other suitable attachment means, to complete a circuit with sealing jaw 71. As described above, current travels to the sealing jaw which is then applied to the web 12 to create a seal.

The method of sealing the tube will now be discussed. To perform a transverse scaling of the tube, one sealing jaw 70 of the first subassembly 48 registers with a sealing jaw 71 of the second subassembly 50, which is mounted on a carriage located on the opposite side of the workpiece 11 or moving web 12, as shown in Figure 1, and provides a sealing energy. Tube 20 is disposed between sealing jaws 70, 71 for a finite period of time that is sufficient to effect the desired transverse seal. Sealing jaws 70 and 71 are moved toward each other and move into engagement with tube 20 as opposing carriages 52, 53 move forwardly along path 99, through a work region 32 of the sealing station 28 in a workpiece direction 13. Preferably the seal is created by induction as described above, however any other suitable sealing method can be used. For some time, the two sealing jaws 70, 71 are held in register with one another and are moved with tube 20 through the work region 32 preferably drawing the tube 20 at the same velocity as the velocity of the forwardly moving tube 20. During this interval of time, the web 12 continues to move forwardly through the FFS machine 10 and sealing station 28, and the sealing jaws 70, 71 of the first and second sealing subassemblies 48, 50 are registered and first move into engagement with the opposite sides of a portion of workpiece 11 or the filled tube 20, thence into pressure-applying relationship to the tube 20. The pressure applied to the filled tube 20 by the sealing jaws 70, 71 is maintained while energy is applied to that portion of the tube 20 which is captured between the sealing jaws so that the aluminum layer of the web 12 is energized and the thermoplastic layer which surrounds the aluminum layer has been heated to its fusion point. Preferably, pressure is still applied for a further time after such energy is removed so that the region cools to its solidification temperature and a seal 46 is thereby formed. Subsequently, the tube 20 is preferably severed at the sealing region 46 to create separate packaging portions 34, as seen in
Figure 1. Thereafter, the sealing jaws 70, 71 are moved away from and out of engagement with tube 20.

Preferably, the cam followers are in constant contact with the cam track. Various means such as compression springs, spring reels, inertial locks or any other means suitable for maintaining contact between the cam follower and the cam track. For example, coil springs 228, 229 (shown in Figure 7) are positioned between the yoke of the cam follower and the seal jaw carriage to bias the cam follower toward the cam track. In addition or in the alternative, as can be seen in Figure 15, a spring reel 1230 can be used between the seal jaw cross member 1100 and the knife holder 1200 to bias the knife holder away from the tube. Alternatively, the track can include inner and outer races, such as by having generally U-shaped cross-section, such that the cam followers can ride within the track, as discussed below with reference to Figure 21. The cam followers are preferably used in combination with a compressible spring, however other biasing means may also be used.

In an alternative embodiment, shown in Figure 16, an inertial lock 421 is mounted to the carriage and sensitive to centripetal motion of the carriage along the path and operable with the sealing tool to prevent centrifugal movement of the sealing tool past a predetermined position. For example, the inertial lock 421 can be employed to prevent the sealing jaw 70 from extending too far if its cam follower comes off the cam track. The inertial lock 421 comprises a hook 422 and a latch 420. Hook 422 extends from cross member 100 and is disposed adjacent a latch 420 that extends from knife carrier 200. Hook 422 is movable, preferably rotatably, to catch or engage the latch 420 to prevent the sealing jaw 70 from extending in an extended direction, past a predetermined position when the carriage 1052 to which the knife carrier 200 is mounted is driven around a curve in the track, where due to centripetal forces, the knife tends to extend from the carriage. Hook 422 has a hooked end 424 which engages latch 420 when hook 422 is in a locked position. A weight 423 is disposed at the opposite end of hook 422 and is preferably biased toward cross member 100 by a compression spring 425 so that hook 422 is biased toward an open position in which hooked end 424 is disengaged from latch 420. Preferably, hook 422 is moved from the open to the closed position by the acceleration caused by the motion of the carriage on the curve of the track, especially at the bottom of the track, where the force of gravity also acts to extend the knife carrier 200. Thus, in operation, the weight 423 at the end of hook 422 swings
outwardly under acceleration, and hooked end 424 swings to a lock position and engages latch 420 to prevent the sealing jaw from moving away from the carriage 1052. This arrangement and also alternative locking mechanisms can also be employed with other tools on the carriage, such as the sealing jaws. The hook 422 may also hook to different portions of the tool or tool carrier to arrest its movement away from the carriage.

In the preferred embodiment, the cutting carriage 52 (shown in Figures 7 and 8) includes a knife 203 which is designed to transversely cut through the tube 20. The knife 203 is mounted for reciprocal movement towards and away the workpiece 11 and at an angle with respect to the web 12 moving in a workpiece direction 13. Knife 203 is preferably only included in at least one of each pair or group of the carriages that are arranged to oppose each other and come together on opposite sides of the tube 20. Referring specifically to Figures 7-8A, cutting carriage 52, which is disposed opposite sealing carriage 53 in operation, has a knife 203 mounted to a knife carrier 200. Knife carrier 200 includes a central cross arm 201 to which a knife 203 is removably secured, such as by screws 205, 207. In a preferred embodiment, each end of central cross arm 201 defines a lateral extension 213, 215, each of which includes a leg 217, 219 which extends inwardly of the frame and terminating in a lateral lug 221, 223, respectively. Each lug 221, 223 is provided with a through opening 225, 227 that slidably receives therein respective rods 192, 194. A second coil spring 240 is provided in encircling relationship to the rod between the inboard face of the lug 204 and lateral lug 221 on leg 217. Thus, spring 240 biases knife carrier 200 in an inward direction inwardly and away from cross member 100, hence biasing knife 203 toward its retracted storage position as shown by the dashed lines of Figure 8. In this embodiment, the tube is severed transversely and within the bounds of the formed seal to divide the tube into individual filled and sealed packages 34.

Referring now to Figures 9A-9C, a first embodiment of the knife 203 comprises a generally planar blade. A substantially planar top surface 370 is spaced from a substantially planar bottom surface 372 to define the blade thickness T. Preferably, the blade has a generally uniform thickness T, however the thickness can be varied. Preferably, the blade thickness T is preferably between about 0.2 and 3 mm, more preferably between about 0.5 mm and about 1.5 mm, most preferably about 1 mm. The blade has a cutting edge 256 at one end and a mounting portion 374 which is preferably disposed at the opposite end to secure the
blade to an actuator. Mounting portion 374 preferably includes holes 375 for mounting screws therethrough, however other suitable mounting means may also be used.

Side edges 376 extend perpendicularly from the mounting edge to the cutting edge 256 and are preferably parallel to each other so that the blade has a rectangular shape. Alternatively, the blade may have any shape suitable for mounting the knife to an actuator device. For instance, as seen in Figure 8, the blade can have a back portion 255 for mounting to an actuator and a front portion 257 for performing a cutting operation and the back portion 255 can be narrower than the front portion 257.

The cutting edge 256 is shown straight, but may alternatively be serrated or have other shapes to improve cutting. For example, as described further below, the cutting edge can be arcuate, or can comprise a plurality of straight edges as well as many other geometries suitable for cutting. Preferably, the cutting edge 256 is beveled and includes at least one cutting surface that is angled with respect to the bottom surface 372. Referring to Figures 9A-9C, preferably knife 203 has a first cutting surface 259 and a second cutting surface 261. Cutting surfaces 259, 261 are preferably planar, however they can be serrated or have other non-planar geometries. First cutting surface 259 is positioned towards the tip of cutting edge 256 and disposed at an angle 377 with respect to the bottom surface 372. Second cutting surface 261 is positioned adjacent first cutting surface 259 and further away from the tip of cutting edge 256 and disposed at an angle 378 with respect to the bottom surface 372. Preferably angle 377 and angle 378 are acute angles and preferably angle 377 is greater than angle 378. Preferably angle 377 is between about 10° and about 20° and preferably angle 378 is between about 0° and about 10°.

The knife 203 is preferably made from a non-metallic material, such as a ceramic. Also preferably, the knife 203 is made from a non-conductive material. It is also preferred that the knife 203 be made from a material that has a small grain boundary size. Preferably, the grain boundary size is below that of stainless steel. More preferably, the grain boundary size is below about 1 micron on average, more preferably below about 0.6 microns on average, most preferably below about 0.5 microns on average. Preferably knife 203 is made from a ceramic material. One preferred material includes a zirconium oxide, such as zirconia, however other materials such as alumina and silicon carbide can also be used. Zirconia is advantageous because it is impervious to corrosion by most acids. In this regard, the preferred knife 203 is able to resist corrosion by acids typically found in foods, especially in
juices and milk, and is thus able to resist corrosion when it is used in an acidic environment,
such as when severing a tube filled with acidic liquids such as various fruit juices which
typically contain various organic acids, such as citric acid. Also, because the grain boundary
size is smaller than a typical stainless steel blade, fewer corrosive elements, such as the
aforementioned acidic liquids, enter within the grain boundary to corrode the blade. As a
result, the cutting edge 256 is able to remain sharp longer and therefore be used for a greater
amount of time and cycles.

Referring to Figure 8, knife 203 includes a cutting edge 256 which can be projected
from the outer face 254 of the sealing jaw 70 by relative movement with respect to the
carriage of the knife carrier 200. In this embodiment, the cutting edge 256 is straight and
cutting edge 256 is disposed at an angle with respect to the face 254 and with respect to the
portion of the workpiece 11 or tube 20 to be cut. Referring to Figure 8A, preferably, cutting
edge 256 is disposed at an angle 279 of incidence with respect to the tube 20 or to the front
face of the sealing jaw, which engages the tube, to reduce the cutting force required to sever
the workpiece 11. As a portion of the cutting edge 256 smaller than the entire portion that
faces the web 12 contacts the workpiece 11 at any one time to cut the web 12, the entire
workpiece 11 can be cut efficiently and at a lowered force compared to a non-angled blade
because the cut can be made gradually across the web. Preferably, the knife cutting edge 256
is non-parallel and any non-zero angle of incidence can be used, however the knife can have a
cutting edge that is parallel to the workpiece 11 or web 12. Preferably, angle 279 of the
cutting edge 256 is an acute angle. More preferably, the angle 279 is from about 0.25 to
about 20 degrees, and most preferably from about 0.5 to about 10 degrees. Most preferably
from about 1 to about 3 degrees. Alternatively, the cutting edge 256 may be other than
straight with a plurality of portions that are non-parallel to the outer face 254 of sealing jaw
70, and tangent to the workpiece 11 or tube 20. It has been found that in some cases a 50%
reduction in the force required to sever the web may be achieved by varying the angle of
incidence by as little as 1°.

Referring to Figures 10A-10D, alternative embodiments of knife 203 are shown
having non-straight cutting edges. In the embodiments of these figures, the geometrical
configuration of the cutting edge is preferably symmetrical with respect to the center of the
blade in a direction transverse to the workpiece 11. In this way, the knife may engage the
workpiece and exert a transversely symmetrically balanced cutting force upon the workpiece,
to reduce or eliminate the tendency to bias the workpiece in a transverse direction as a result of the cutting force.

Referring to Figure 10A, one embodiment of knife 203 includes a serrated cutting edge 379.

As shown in Figure 10B, another embodiment of knife 203 includes a cutting edge 380 defined by more than one straight edge. In this embodiment, straight edges 381 and 382 meet at a peak 386 at an angle 383. Preferably, angle 383 is obtuse. More preferably, angle 383 is between about 160° and 180°. This embodiment of knife 203 is shown in a packaging environment and disposed central to sealing jaw 70. Sealing jaw 70 is shown registered with sealing jaw 71 and engaging workpiece 11. In Figures 10B-10D, workpiece 11 comprises web 12 folded upon itself to define a three layered portion (shown centered with respect to the sealing jaw 70) corresponding to the longitudinally sealed edges 22, 24 in the overlapped position, as previously described. Sealing jaw 70 may seal transversely across the three layered portion, and knife 203 can sever the three layered portion. Preferably, this embodiment of knife 203 is disposed with respect to the outer jaw face 254 and workpiece 11 such that the angle of incidence 387 of straight edges 381, 382 with respect to the workpiece 11 is similar to angle 279, as discussed previously with respect to the embodiment of Figure 8.

Referring to Figures 10C and 10D, other embodiments of knife 203 having arcuate cutting edges are shown in a packaging environment similar to that of Figure 10B. The embodiment of Figure 10C includes a cutting edge 384 having an arcuate geometry and the radius of curvature is located towards the mounting portion 374 so that the cutting edge 384 is generally convex. Cutting edge 384 comprises an arc that spans the width of the blade W and is preferably centered with respect to the transverse direction. Cutting edge 384 extends laterally beyond the endpoints of cutting edge 384 at the midpoint 389 by a height H. Preferably the ratio of height H to knife width W is between about 7% to about 20%. Preferably the ratio of radius to knife width W is greater than about 1.5, more preferably the ratio is greater than about 2. Preferably, this embodiment of knife 203 is disposed with respect to the outer jaw face 254 and workpiece 11 such that the knife engages workpiece 11 with an angle of incidence 388 similar to angle 279 of the embodiment of Figure 8. Angle of incidence 388 is measured between a line tangent with cutting edge 384 at the midpoint 389 and the workpiece 11.
Referring to Figure 10D, another embodiment of the knife 203 is shown having an arcuate cutting edge 385 and the radius of curvature is located away from the knife 203 to define a generally concave cutting edge 385. Cutting edge 385 comprises an arc that spans the width of the blade W and is preferably centered with respect to the transverse direction. Cutting edge 385 is generally concave and extends laterally inward from the endpoints 390 of cutting edge 385 at the midpoint 391 by a height H. The ratios of height H to knife width W and radius to knife width W are preferably similar to the ratios of the embodiment of Figure 10C. Preferably, the knife is disposed such that the knife engages workpiece 11 with an angle of incidence 392 similar to angle 279 of the embodiment of Figure 8. Angle of incidence 392 is measured between a line tangent with cutting edge 385 at the endpoints 390 and the workpiece 11.

Preferably, knife 203 is disposed centrally with respect to the sealing jaw 70 and designed for severing a workpiece 11 that is engaged by the sealing jaw 70 and held between the sealing jaw 70 and sealing jaw 71. Knife 203 preferably is in the form of a planar blade having a first end 260 thereof anchored to the knife carrier 200, such as by screws 205, 207 as shown in Figure 8. Knife 203 is extendable outwardly from knife carrier 200 and slidably through a slot 258 in a guide bar 262 and a further slot 264 in sealing jaw 70 from a retracted to an extended-cutting position. Thus, upon movement of knife carrier 200 in an extended direction outwardly and away from carriage 52, knife 203 is caused to slide through slots 258, 264 and project its cutting edge 256 from outer face 254 of sealing jaw 70 to sever workpiece 11 or tube 20.

Referring again to Figure 2, activation of the knife 203 for severing a workpiece 11 or tube 20 held between registered sealing jaws 70, 71 is effected in the depicted embodiment by an actuator, such as cutting cams 270, 271 mounted to the respective outboard faces of the first and second frame members 74, 76 as shown in Figure 4 and can be disposed anywhere along the path 99 of circuit 30. Preferably, cams 270, 271 are outside of and angled over tracks 58, 60. Cams 270, 271 include ramps which define camming surfaces 274, 275 that are disposed within the path of travel of cam followers 272, 273 associated with knife 203. Preferably, cam followers 272, 273 are disposed on the opposite ends of cross arm 201, on lateral extensions 213, 215, respectively. As these cam followers move along their camming surfaces 274, 275, the springs 240, 241 are compressed and the cross arm 201 is caused to move toward the sealing jaw 70, 71 of the carriage and thereby to move the knife 203.
outwardly from the carriage and into severing engagement with tube 20. After cam followers 272, 273 have moved along the path 99 past their camming surfaces 274, 275, springs 240, 241 bias cross arm 100 and knife 203 in a retracted direction inwardly from the sealing jaw and withdraw cross arm 100 and knife 203 out of severing engagement with tube 20 and return to its storage position for a subsequent severing operation.

Referring now to Figures 14 and 15, another embodiment is shown with an alternative carriage 1052. In this embodiment, activation of knife 203 for severing tube 20 held between sealing jaws 70 and 71 is effected by driving carriage 1052 along path 99 to move the cam followers 1224, 1226 along sealing jaw cams 1280, 1282. Similar to the previously described embodiment, first and second cams 1280, 1282 are disposed along the path 99 and anchored in position between their respective frame members to actuate a tool attached to the carriage. Preferably, cams 1280, 1282 have similar camming surfaces which substantially define the timing and extent of movement of the sealing jaw 70 associated with the carriage 1052 in an extended and retracted direction toward and away from tube 20 moving through work region 30 in the sealing station 28.

As can be seen in Figure 15, cam 1280 includes a camming surface 1292 defined along its outer periphery, and the cam 1282 includes a camming surface 1294 defined along its outer periphery. Preferably cam 1282 has a camming surface 1294 similar to camming surface 1292 of cam 1280. The cam follower 1224 is mounted on the inboard end of rod 1192 is adapted to engage camming surface 1292 of first cam 1280, and the cam follower 1226 mounted on the inboard end of the rod 1194 is adapted to engage the camming surface 1294 of the second cam 1282. Thus, as carriage 1052 is moved along path 99 of circuit 30 defined by the tracks 58 and 60, the cam followers 1222, 1224 follow the contour of the camming surface of their respective cams. The contour of each cam includes at least one portion thereof which defines a projection 1298 from the periphery of the cam and which is located along the camming surface at the locations thereof which correspond to the timing of the movement of a carriage during which it is desired that the sealing jaw engage moving tube 20 and remain in engagement with moving tube 20 for the formation of a seal transversely thereof. In this regard, first and second rods 1192, 1194 are slidably mounted to knife carrier 1200 and sealing jaw 70 is slidably attached to knife carrier 1200 by rods 1152, 1154 and springs 1132, 1134 are situated between the sealing jaw 70 and knife carrier 1200 to bias the sealing jaw outwardly away from the knife carrier. Rods 1192, 1194 extend to a
sealing position as cam followers 1224, 1226 pass over a first projection on camming surface 1292. During operation, this movement of the rods extends knife carrier 1200 away from cross member 1100 of carriage 1052, hence as knife carrier 1200 moves towards moving tube 20, sealing jaw 70 engages web 12 and is registered with sealing jaw 71 which is attached to a similar carriage and heat is applied to seal tube 20.

In this embodiment, after tube 20 has been sealed, cam followers 1224, 1226 engage further projections on the end of camming surface 1292 to effect the severing of tube 20. In this regard, cams 1280, 1282 include a further projection 1300 at a location at the end of projection 1298. As the cam followers engage projection 1300, knife carrier 1200 moves further away from crossing member 1100, causing springs 1132, 1134 to compress, as the sealing jaw 70 is already engaged against tube 20, and the knife 203 moves through slot 258 and across tube 20 to sever the tube. Upon the passage of the cam followers past their respective projections 1298, 1300 on the camming surface of the cams 1280, 1282, tension in coiled springs 1228, 1229 retracts the rods to their most inwardly position relative to cross member 1100 of the carriage and withdraws the sealing jaw 70 from engagement with the tube 20.

Referring now to Figures 17-25, another embodiment of the present invention has a carriage 1500 mounted on tracks 1602, 1604 of sealing subassembly 1600. The subassembly has three frame members 1606, 1608, 1610. Tracks 1602, 1604 are shown mounted to the frame members 1608, 1610. The tracks are preferably mounted along the entire inside perimeter of frame members 1608, 1610 to complete a circuit 1630 in the same manner as described in previous embodiments. Carriage 1500 is shown mounted in the work region 1634 of the circuit adjacent a workpiece and set to engage the workpiece and perform an operation upon the workpiece.

As best seen in Figures 18 and 19, carriage 1500 of this embodiment preferably includes three tools mounted for reciprocal movement with respect to the carriage body, towards and away the workpiece, between extended and retracted positions. The carriage 1500, 1501 includes a sealing jaw 1502, a cutter such as knife 1504, and a volume controller 1506. Each tool is actuatable individually and independently, such as by a camming mechanism, linear motor, pneumatic cylinder or other suitable actuator or motor. Preferably, a camming mechanism is used having the tools connected to actuating rods 1508, 1512, 1516, which engage cams. Although a single rod can be provided, preferably at least two rods are
provided for moving each tool to reduce stiction and friction which can be caused by bending of the rods. Thus, the two rods per tool of this embodiment produce straight-line reciprocatory movement of the tools relative to the circuit. The rods are preferably arranged on three separate parallel spaced planes perpendicular to the carriage body or cross member 1532 so that the rods can move in a direction preferably normal to the workpiece when the carriage is in the operating region. Preferably, the rods have cam followers 1520, 1524, and 1528 attached to their distal ends which follow tool actuating cams. As can be seen in Figure 22, preferably three separate cams are used, sealing jaw cam 1534, volume control cam 1536, and knife cam 1538, with one cam drivingly connected to each tool. Sealing jaw 1502 and cutter 1504 function as previously described.

The volume controller tool 1506 is movable towards and away from the web 12 during operation, between extended retracted positions. Referring to Figure 18, the volume controller tool 1506 of this embodiment includes a volume controller plate 1580 pivotally mounted on a support member 1582 at one end and pivotally mounted to the sealing jaw 1502 at the opposite end. Volume controller plate 1580 is preferably U-shaped and has arms 1586, 1588 on opposing lateral sides so that the volume and shape of the portion of the web which is engaged by plate 1580 can be more precisely controlled. The support member 1582 is attached to an actuating mechanism to move the volume controller 1580 towards and away the workpiece or moving web. Preferably a cam actuating mechanism is used and includes rods 1512 and cam follower 1524 for following volume control cam 1536.

Referring now to Figure 23, the operation of the volume controller will now be discussed. In operation, volume controller plate 1580 is first in a disengaged position and aligned opposite an opposing disengaged volume controller provided on a carriage on the opposite side of the web. Once aligned, the opposing volume controller tools 1506 are actuated in a direction towards the tube 20. In this regard, when the support member 1582 is moved away from the carriage 1500 the volume controller plate 1580 is tilted into engagement with the tube 20. Preferably, the volume controller plate 1580 is pivoted into a position generally parallel with the tube 20. Arms 1586, 1588 are preferably aligned with opposing arms on the opposing volume controller to engage and generally surround and squeeze the tube around its circumference to control the volume of the portion of the tube 20 held therebetween. As the tube is squeezed between opposing volume control plates, the contents between the plates are forced in a direction away from between the volume
controller plates 1580. The spacing between the opposing volume controller plates 1580 is preferably predetermined, however the volume controller can engage the tube or squeeze the tube further as desired such as by adjusting the volume control cams, as explained below. When the volume controller is disengaged, the support member is moved back, towards carriage body 1532 and volume controller plate 1580 is tilted out of engagement from the tube.

5 Referring now to Figures 21 and 22, the preferred actuator cams are shown. Referring to Figure 21, the preferred sealing jaw cam 1534 and volume control cam 1536 are shown. Sealing jaw cam 1534 preferably comprises a track having a generally U-shaped cross-section, such that cam followers 1520 ride within the track. In Figure 22, the preferred knife actuator is shown. Preferably the actuator is an eccentric cam 1538 that engages cam followers 1526, 1528 associated disposed along the path of carriage 1500 with rods to extend and retract the knife 1504 from carriage 1500 in a direction towards and away the workpiece.

10 Preferably, the volume controller tool 1506 can be adjusted. Volume control cam 1536 is movable relative to frame member 1606 in a direction towards and away the workpiece to adjust the amount of engagement or squeezing that the volume controllers may exert on the workpiece. In this regard, it is sometimes desirable to be able to fine tune or manually adjust volume control cam 1536 when the FFS is in operation. As can be seen in Figure 17 and 20, a knob 1616 is disposed on the outside of frame member 1610 of sealing subassembly 1600 and connected by linkages to the volume control cam 1536 to allow manual movement of the volume control cam 1536.

15 Each carriage further preferably includes a brake to selectively halt movement of the carriages along the circuit. Referring to the embodiment of Figure 7, a bracket 182 is provided with a brake pad 180 and attached to the distal end 178 of leg 102. Brake pad 180 faces a brake plate 183 that is mounted on the inside face of frame member 74. Brake plate 183 is preferably mounted on a brake cylinder 184 that extends through the thickness of frame member 74 and in position to be engaged by a solenoid 188 or other device suitable for moving the brake plate into and out of engagement with the brake pad 180.

20 Referring to Figures 24 and 25, an alternative braking system is shown. A brake plate 1618 is attached to the interior of frame member 1610. Brake plate 1618 is configured and dimensioned to extend along the entire circuit or path along which the carriages travel. Preferably, brake plate 1618 is generally oval and extends along the periphery of frame
member 1610 and adjacent and spaced from track 1604. A plurality of springs 1620 are disposed between brake plate 1618 and the inside face of frame member 1610 to resiliently bias the brake plate inward toward the carriages mounted on tracks 1602, 1604 to engage brake pads 1622 or shoes which are mounted to the carriages. Brake cylinders 1624 are attached to brake plate 1618 and disposed on the outside of frame member 1610 to disengage brake plate 1618 by retracting it in a lateral direction away from the carriages to disengage the brake pads 1622 or shoes mounted on each of the carriages. Most preferably, the brake cylinders 1624 are under pressure the brake plate 1618 is disengaged, and when the brake cylinders 1624 are not pressurized, the brake plate 1618 is engaged. In this regard, when brake cylinders 1624 are without power, or deactivated, the brake plate 1618 is naturally biased inwards to engage the brake pads 1622 of the carriages and stop carriage movement around the circuit. Also, preferably, the brake system allows for the brake to be disengaged when the brake system is without power to allow for maintenance on the system or the like.

Referring to Figure 25, preferably the brake pad 1622 is mounted to the outside of carriage 1500 and a spring 1626 is disposed between the brake pad 1622 and the carriage 1500 to resiliently bias the brake pad away from the outside of the carriage. This serves to control the brake pressure more evenly on all brake pads 1622 and the system is more tolerant of a brake plate 1618 that is slightly non-planar or brake pads 1622 that are of varied thicknesses or at varied locations due to the stack-up of tolerances or the like. Also, the brake system is preferably configured to allow the brake plate to move swift enough to pause the carriages in a predetermined time while preventing damage to the carriages 1500, 1501, springs 1626 or tube 20.

Each carriage preferably includes wheels to engage tracks and facilitate the traveling of the carriage around the circuit. In the embodiment of Figures 7 and 8, wheels are rotatably mounted on wheel mounts on the outer faces of legs 102, 128. Outer face 104 of first leg 102 is provided with a first set of wheels 106 and 108, each of which is rotatably mounted on opposite ends 110, 112 of a first mounting plate 114. First mounting plate 114 is preferably centrally pivotally mounted, such as by a pivot pin 116, to the outer face 104 of leg 102 so that wheels 106 and 108 may swing about an arc having pivot pin 116 as its center. A second set of wheels 118, 120 are pivotally mounted on the face 104 of leg 102 and adjacent the first set of wheels by means of a second mounting plate 122. A second pivot pin 124 pivotally mounts second mounting plate 122 to the face of the first leg 102 adjacent, but separated
from, pivot pin 116 of first mounting plate 114. Thus, wheels 118, 120 of this second set may swing in an arc having second pivot pin 124 as its center. Further, the second, and opposite, end 105 of the carriage 52 includes a like planar leg 128 depending therefrom and in facing relationship to the track 58. As depicted in Figure 8, on the outer face 130 of this second leg 128 there are mounted third and fourth sets of wheels 132, 134 and 136, (fourth wheel not visible) respectively whose structure and mounting are preferably similar to the structure and mounting of the first and second sets of wheels. In this embodiment, one wheel on each wheel mount is mounted for movement along the innermost rail of a respective track and the other of the wheels on each wheel mount is mounted for movement along the outermost rail of a respective track. In this manner, the carriage is securely mounted on the tracks for movement along straight and curved portions. As shown in Figure 13, by means of the pivotally mounted sets of wheels of the preferred embodiment, as a carriage enters and passes through a curved segment of a track, each set of wheels on each of wheel mounting plates 114, 122 pivots about its respective pivot pin 116, 124 to accommodate the difference in the radius of curvature of the outer and inner rails 140, 142 so that the carriage remains in a predetermined orientation, preferably substantially perpendicular to the length dimension of the tracks 58, 60. This arrangement can maintain the carriages in a stable relation with the tracks 58, 60.

In the embodiment of Figure 18, wheels 145, 146, 147, 148 are attached to a wheel plate 144 that is facingly attached to the outside of first and second legs 102, 128. Wheel plate 144 has a first set of wheels 145, 147 located towards the outward end of the carriage and a second set of wheels 146, 148 located towards the inboard end of the carriage. Preferably the wheels are arranged in a generally trapezoidal configuration so that the carriages ride well on both straight and curved segments of the track. The wheels 145, 147 of the first set are spaced slightly closer together than the second set of wheels 146, 148 to facilitate turning as the carriage travels along a curved segment of track. Referring to Figure 13, the wheels are spaced from each other so that difference in the radius of curvature, $r_2$, of outermost rail 140 relative to the radius of curvature, $r_1$, of innermost rail 142, is accommodated so that the carriage remains in a predetermined orientation, preferably substantially perpendicular to the length dimension of the tracks 58, 60.

In the embodiment of Figures 17-25, preferably wheel plate 144 is attached to legs 102, 128 in a generally telescoping fashion to allow for greater track tolerance. Referring to
Figure 19A, wheel plate 144 may be mounted to legs 102, 128 by pins 151 arranged perpendicular to the outside of legs 102, 128 and can telescope in and out slightly in a direction towards and away the outside of the legs 102, 128 to accommodate tracks that are out of geometry or out of parallel or misalignment of the tracks or any other minor imperfections in the layout of the tracks. Pins 151 are preferably mounted in tight fitting bushings to allow only one degree of freedom, preferably in the direction lateral to the track. As a result, there is some play in the positioning of the carriage along the track, especially within that portion of the track wherein the linear segment transitions into a curved segment of the track. Also, the wheel plate 144 has a notched cutout 149, facing the outside of first and second legs 102, 128 and is able to telescope towards and away the outward end of the carriage as well. This telescoping feature allows the carriage to travel smoothly even if the rails of tracks 58, 60 are imperfectly spaced apart or are imperfectly parallel in the lateral direction. Spacing between track followers on opposite sides of the carriage can be varied to accommodate imperfection in the tracks that are less than parallel.

Referring to Figures 19B and 19C an alternative embodiment of the carriage wheels is shown. A group of wheels 155, preferably including four wheels, is attached to one side of the carriage. Wheels 155 have a flat profile so that the wheels can ride flatly along a track 156. Preferably track 156 also has a flat profile to match the shape of wheels 155. In operation, the wheels 155 follow track 156 along the path, but can move laterally with respect to track 156 to accommodate imperfections in a pair of tracks that are not generally parallel where the distance therebetween varies. Alternative shapes of the wheels 155 and track 156 can be used in other embodiments, such as a mildly curved profile instead of flat or grooved. Preferably, track 156 has races or rails 157 on the outer surface, and the outer surfaces 158 of the wheels 155 have corresponding shapes to rails 157. Alternatively, wheels 155 and track 156 can have different shapes. For example, wheels 155 can be flat, as shown in Figure 19B, and track 156 can be chamfered similar to tracks 58, 60, as shown in Figure 13A, and have rails similar to rails 140, 142. As such, the wheels 155 can ride flatly on the rails 140, 142, and can move laterally with respect to the rails 140, 142, while preventing separation of the carriage from the track in a radial direction with respect to the path, to keep the carriage following the path.

Referring to Figure 19D, an alternative embodiment of the carriage wheels 158 is shown. In this embodiment, preferably at least two wheels 158 are mounted to the wheel
plate 144. The circuit 30 preferably comprises at least two concentric tracks 159 and wheels 158 can be disposed therebetween to follow tracks 159 around the circuit 30. In this way, wheels 158 are preferably constrained from movement away from the track in a direction normal to the tracks 159. Also, this alternative can be used in conjunction with the previously described wheel embodiments.

Preferably the carriages are driven by a drive mechanism, such as a linear motor, however any other suitable driving mechanism can also be used. Where a linear motor is used, preferably a plurality of electrically conductive coils are provided along frame member 78 to magnetically interact and drive magnets 174 associated with the carriages. Preferably each coil includes an electromagnetic field and the permanent magnet 174 of a carriage associated with a coil is disposed within the sphere of influence of this associated coil.

Each of the magnets 174 is preferably rigidly connected to its respective carriage such that movement of the magnet produces corresponding movement of its carriage. As can be seen in Figure 7, Leg 164 is attached to the inside face 166 of cross member 100 of carriages 52, 53. An L-shaped bracket 168 having leg 170 depends inwardly from leg 164. An elongated magnet 174 is secured on surface 172 of leg 170 which faces frame 78 and the electric coils. Magnet 174 is disposed contiguous to, but spaced from outer face 176 of frame 78. As thus mounted, magnet 174 is in position to be within the sphere of influence of the electromagnetic field of one or a subset of the coils when the coils are enabled and supplied with electrical energy suitable to develop an electromagnetic field thereabout.

A controller 326 is operatively associated with the drive mechanism to control the movement and location of the carriages as they travel around the circuit. Preferably each carriage is provided with a position sensor which communicates with the controller the position of the carriage along the circuit. For example, a preferred position sensor device can be seen in the embodiment depicted in Figure 7. Carriage 52 includes a mounting bracket 310 which is anchored at one of its ends 312 to the cross member 100 and extends in cantilevered fashion to terminate in a yoke 314 having legs 318, 320 beyond the outermost side 316 of the second frame member 76. As can be seen in Figure 5, yoke 314 extends outward from knife cam 271 as carriage 52 travels along path 99. As shown in Figure 7, leg 320 of yoke 314 is adjacent the outer rim 322 of mounting plate 324 which is mounted to, and spaced apart from and parallel to, the outer face of frame member 76. The outer rim 322 of plate 324 serves to mount a printed circuit board 323, for example, which is oval in shape and
lies congruently with track 60 which is mounted on the inner face of second frame member 76. The inner face of the leg 318 of the yoke 314 carries one or more magnets 342 whose locations on the inner face of the leg are specific for a given carriage. The printed circuit board 323 includes a plurality of sensors (not shown) which interact with the magnets 342 disposed on the inner face of the leg of the yoke and communicate with the controller for control purposes, such as positioning and can be part of a hall effect sensing system or a magneto restrictive sensing system.

As can be seen in Figure 17, a contact absorbing member may be attached to each carriage 1500 to prevent damage to the carriages should they contact each other during operation. Preferably, a spring 1550 surrounding a shaft 1551 is mounted on the carriage body 1532. In this way, at least a portion of the contact force can be absorbed between adjacent carriages when adjacent carriages come into contact. Alternatively or additionally, a resilient rubber material can be mounted to the carriage body 1532 to define a bumper to absorb contact between adjacent carriages.

Preferably tracks 58, 60 are self lubricating. Referring to Figure 13, a preferred lubricating system is shown. In this system, track 58 has weep holes 1540 disposed on opposite rails 140, 142 through which a lubricant, preferably oil, is transferred from a lubricant source 432 to the track rails 140, 142 to provide lubrication of the track and allow the carriages to travel more smoothly around the circuit 30. The weep holes 1540 are preferably connected by a channel 1541 through which the lubricant is flowed. The weep holes are preferably disposed towards the top of the track to allow gravitational forces to assist the circulation of the lubricant around the track. A pump 430 is fluidly associated with weep holes 1540 to pump the lubricant from lubricant source 432 and through channel 1541 to the exterior of track 58.

A vacuum system may be used in combination with the lubrication to remove any lubricant that accumulates on the track. Referring to Figure 13, a vacuum pump 434 is shown connected with vacuum holes 1542. Vacuum holes 1542 are shown as being disposed at the bottom of track 58, however they may be disposed at any location along track 58. Vacuum holes 1542 are also disposed on opposing rails 140, 142. Also, the carriages are preferably provided with oil wiping brushes 1546 to facilitate the circulation of the lubricant around the track and to prevent lubricant accumulation. Preferably brushes 1546 are located between the wheels and ride in contact with the tracks. Brushes 1546 are preferably made of a felt
material although any suitable material capable of absorbing and transferring the lubricant can be used.

The following applications are filed on even date herewith and the contents of each application is incorporated herein by reference thereto: U.S. Application No. _________ to Jacobs et al., entitled "Packaging Machine"; U.S. Application No. _________ to Jacobs et al., entitled "Machine with Independently Movable Tools"; U.S. Application No. _________ to Hoffman et al., entitled "Induction Sealing Jaw"; U.S. Application No. _________ to Ortiz et al., entitled "Packaging Machine"; and U.S. Application No. _________ to Ortiz et al., entitled "Variable Motion System and Method".

Whereas the present invention has been described in specific terms, it is to be recognized that various equivalent embodiments may be employed. For example, the movable members of the present system may be mounted for movement along the track by sliding interconnections between the movable member and the track, or the movable member could be levitated magnetically with respect to the track. Accordingly, it is intended that the invention be limited only by the claims appended hereto.
Claims

What is claimed is:

1. A packaging machine, comprising:
   a carriage drivable in a path along a work region;
   a sealing tool movably mounted to the carriage and configured for performing a
   sealing operation on a workpiece disposed in the work region; and
   a sealer actuator connected to the sealing tool and operable in the work region for
   moving the sealing tool with respect to the carriage into operational association with the
   workpiece for performing the sealing operation.

2. The packaging machine of claim 1, wherein:
   the actuator is configured for moving the sealing tool into said operational association
   once the sealing tool is in a predetermined orientation with respect to the workpiece; and
   the sealing tool is disposable in another orientation with respect to the workpiece.

3. The packaging machine of claim 1, wherein the sealing tool is movable along
   the path such that in a first portion thereof the sealing tool is disposed in said predetermined
   orientation, and in another portion of the path, the sealing tool is disposed in said another
   orientation.

4. A packaging machine of claim 1, further comprising a sealing cam,
   wherein the sealing actuator comprises a sealing cam follower connected with the
   sealing tool, the sealing cam being configured and disposed with respect to the path to cam
   the sealing cam follower to move the sealing tool into said operational association.

5. The packaging machine of claim 4, further comprising an inertial lock
   mounted to the carriage and sensitive to centripetal motion of the carriage along the path and
   operable with the sealing tool to prevent centrifugal movement of the sealing tool past a
   predetermined position.
6. The packaging machine of claim 1, further comprising a cutter movably mounted to the carriage and configured for performing a cutting operation on the workpiece.

7. The packaging machine of claim 6, wherein the cutter is connected to the sealing actuator and operable in the work region for moving the cutter with respect to the carriage into operational association with the workpiece for performing said cutting operation.

8. The packaging machine of claim 6, further comprising a cutting actuator connected to the cutter and operable for moving the cutter with respect to the carriage into operational association with the workpiece for performing said cutting operation, wherein the cutting and sealing actuators are movable independently.

9. The packaging machine of claim 8, further comprising a cutting cam, wherein the cutting actuator comprises a cutting cam follower connected with the cutter, the cutting cam being configured and disposed with respect to the path to cam the cutting cam follower to move the sealing tool to perform said cutting operation.

10. The packaging machine of claim 1, further comprising:
    a volume control tool movably mounted to the carriage and configured for engaging the workpiece to control the volume thereof; and
    a volume control actuator connected to the volume control tool and operable for moving the volume control tool with respect to the carriage to engage the workpiece.

11. A packaging machine, comprising:
    a cutter having a cutting edge configured for performing a cutting operation on a workpiece;
    a feeder for moving a workpiece adjacent the cutter; and
    a cutter actuator operatively associated with the cutter for driving the cutter into the workpiece with the cutting edge disposed at a workpiece angle thereto.
12. The packaging machine of claim 11, further comprising a workpiece holder having a face configured for engaging and orienting the workpiece, wherein the cutting edge is disposed at a face angle to said face.

13. The packaging machine of claim 12, wherein the face angle is a non-zero angle.

14. The packaging machine of claim 12, wherein the face angle is between about 0.25 to 6 degrees.

15. The packaging machine of claim 11, wherein the cutter comprises a blade comprising a ceramic.

16. The packaging machine of claim 11, wherein the cutter comprises a blade and the blade is substantially impervious to corrosion by acids found in fruit juices or milk.

17. A method of performing a packaging operation on a workpiece comprising the steps of:
   
   driving at least one first tool and a workpiece such that the first tool is moved along a path with respect to a workpiece
   
   aligning the first tool in a first orientation with respect the workpiece;
   
   moving the aligned first tool into operational association with the workpiece while maintaining said first orientation; and
   
   performing a first operation on the workpiece with the first tool;
   
   retracting the aligned first tool out of said operational association with the workpiece before moving the first tool out of said first orientation; and
   
   moving the first tool out of said first orientation.

18. The method of claim 17, wherein the driving of the at least one first tool and the workpiece comprises driving a carriage upon which the first tool is mounted.
19. The method of claim 18, wherein the step of driving the at least one first tool and the workpiece comprises:
   aligning the carriage in a predetermined carriage orientation with the workpiece; and
   maintaining the carriage in said carriage orientation while the first tool is in said first orientation.

20. The method of claim 17, further comprising:
   aligning a second tool in a second orientation with respect to the workpiece;
   moving the aligned second tool into operational association with the workpiece while
   maintaining the second orientation; and
   performing a second operation on the workpiece with the second tool.

21. The method of claim 20, further comprising:
   retracting the aligned second tool from said operational association with the
   workpiece; and
   moving the retracted second tool out of said second orientation.

22. The method of claim 17, wherein:
   the first tool comprises a sealing tool; and
   the performing of the first operation comprises sealing the workpiece, wherein the
   workpiece comprises a web.

23. The method of claim 17, wherein:
   the second tool comprises a cutting tool; and
   the performing of the second operation comprises cutting the workpiece, wherein the
   workpiece comprises a web.

24. A packaging machine comprising:
   at least one sealing tool for performing a sealing operation on a workpiece; and
   at least one tool carrier connected to the sealing tool and configured for moving the
   sealing tool along a path and into operational association with the workpiece.
25. The packaging machine of claim 24, further comprising an actuator operatively connected to the tool carrier for aligning the tool in a predetermined orientation with the workpiece before moving the tool into operational association with the workpiece.

26. A packaging machine, comprising:
   a first carriage;
   a first tool movably mounted to the carriage and configured for performing a first sealing operation on a workpiece in a work region;
   a first track configured for guiding the first carriage along a first path; and
   wherein the first carriage comprises a first track follower associated with the first track for retaining the first carriage with respect to the first track in substantially all directions normal to the first path while permitting movement of the first carriage therealong.

27. The packaging machine of claim 26, further comprising:
   a second tool driven along a second path disposed relative to the first path and to the work region such that the first and second tools in operational association for performing the sealing operation.

28. The packaging machine of claim 27, wherein the first tool comprises a first sealing jaw and the second tool comprises a second sealing jaw, the sealing jaws disposed on opposite sides of and engaged with the workpiece when in said operational association.

29. The packaging machine carrier of claim 26, wherein the first track comprises first and second parallel tracks and the first track follower comprises first and second followers portions engaged respectively with each parallel track.

30. The packaging machine of claim 29, wherein the first track comprises first and second generally parallel tracks and first and second wheels are movably mounted to the first carriage to allow the first and second wheels to move laterally with respect to the carriage when the first and second tracks are out of parallel to accommodate a change in distance between tracks.
31. The packaging machine of claim 26, wherein the path comprises a closed circuit and wherein the first track follower comprises at least one wheel rollably engaging the first track.

32. The packaging machine of claim 31, wherein the at least one wheel comprises first and second wheels disposed on opposite sides of the first track for preventing separation of the first carriage from the track in said directions normal thereto.

33. The packaging machine of claim 31, wherein the at least one wheel comprises first, second, third, and fourth wheels positioned in a generally trapezoidal configuration on the first carriage, the first and second wheels disposed on opposite sides of the first track from the third and fourth wheels, for preventing separation of the first carriage from the track in said directions normal thereto.

34. The packaging machine of claim 31, wherein the first track comprises first and second rails disposed on opposite sides of the first track rollably engaged with the first and second wheels, respectively.

35. The packaging machine of claim 34, wherein each wheel comprises a lateral wall extending adjacent the track to restrict lateral movement with respect thereto.

36. The packaging machine of claim 26, wherein the first track comprises first and second generally parallel tracks and first and second wheels are rigidly mounted to the first carriage and have a flat profile to allow the first and second wheels to move laterally with respect to the track when the first and second tracks are out of parallel to accommodate a change in distance between tracks.

37. A packaging machine of claim 26, further comprising a lubricant source connected to the track for applying lubricant thereto at an application location.

38. The machine of claim 37, wherein a suction source is connected to the track for removing excess lubricant from the track at a suction location.
Fig. 10C

Fig. 10D