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Adams et al.

[11] **3,916,598**

[45] **Nov. 4, 1975**

[54] **SYNCHRONIZED TUBE FORMING AND FILLING MACHINE FOR FORMING CHUB PACKAGES**

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[52] **U.S. Cl.** .... **53/55;** 53/59 R; 53/64; 53/180

[51] **Int. Cl.^{2}** **B65B 57/00;** B65B 9/12

[58] **Field of Search** .... 53/28, 55, 59, 64, 75, 53/77, 180 M, 182 M

[56] **References Cited**

UNITED STATES PATENTS

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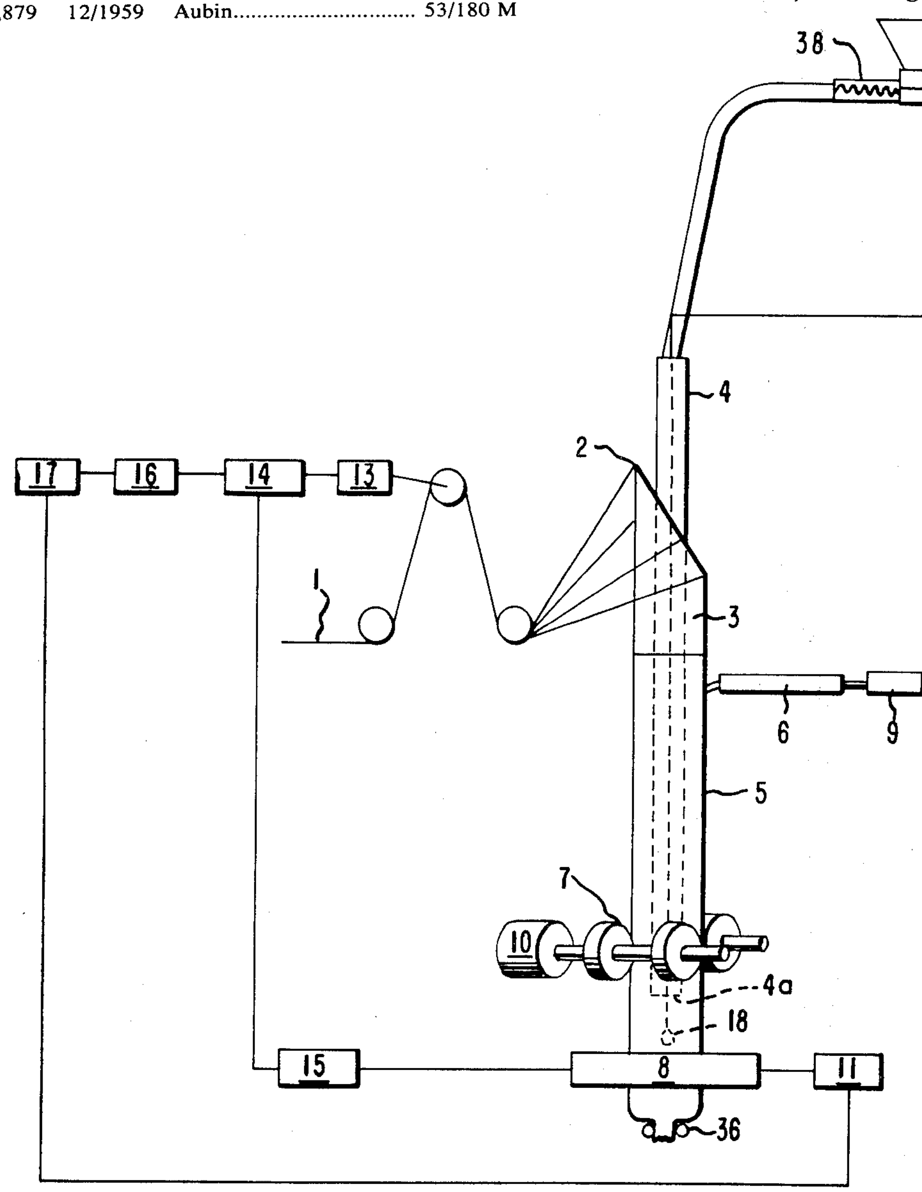
Primary Examiner—Robert L. Spruill

[57] **ABSTRACT**

Chub packaging machine wherein the drive motors for the tube-advancing means, the constricting-closure unit, and the product feed pump, and drive motor for an extruder sealing unit, or the air temperature of a hot-air sealing unit, operate cooperatively whereby all drive speeds change proportionately as the tube-advancement rate, or sealing air temperature, is changed. The constricting-closure unit and product feed pump drive motors operate also independently for more precise adjustment, preferably through automatic feedback control loops.

7 Claims, 3 Drawing Figures



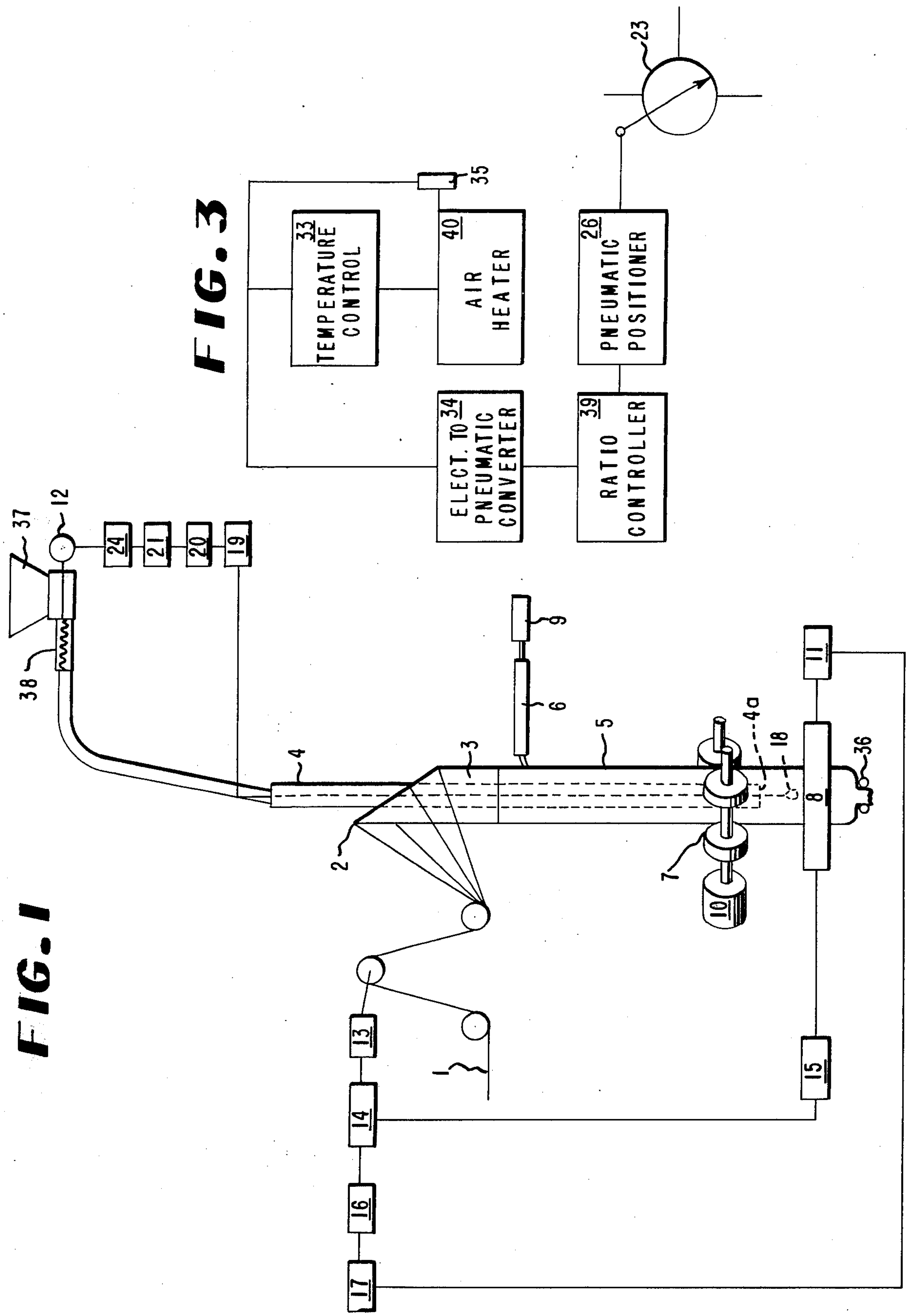
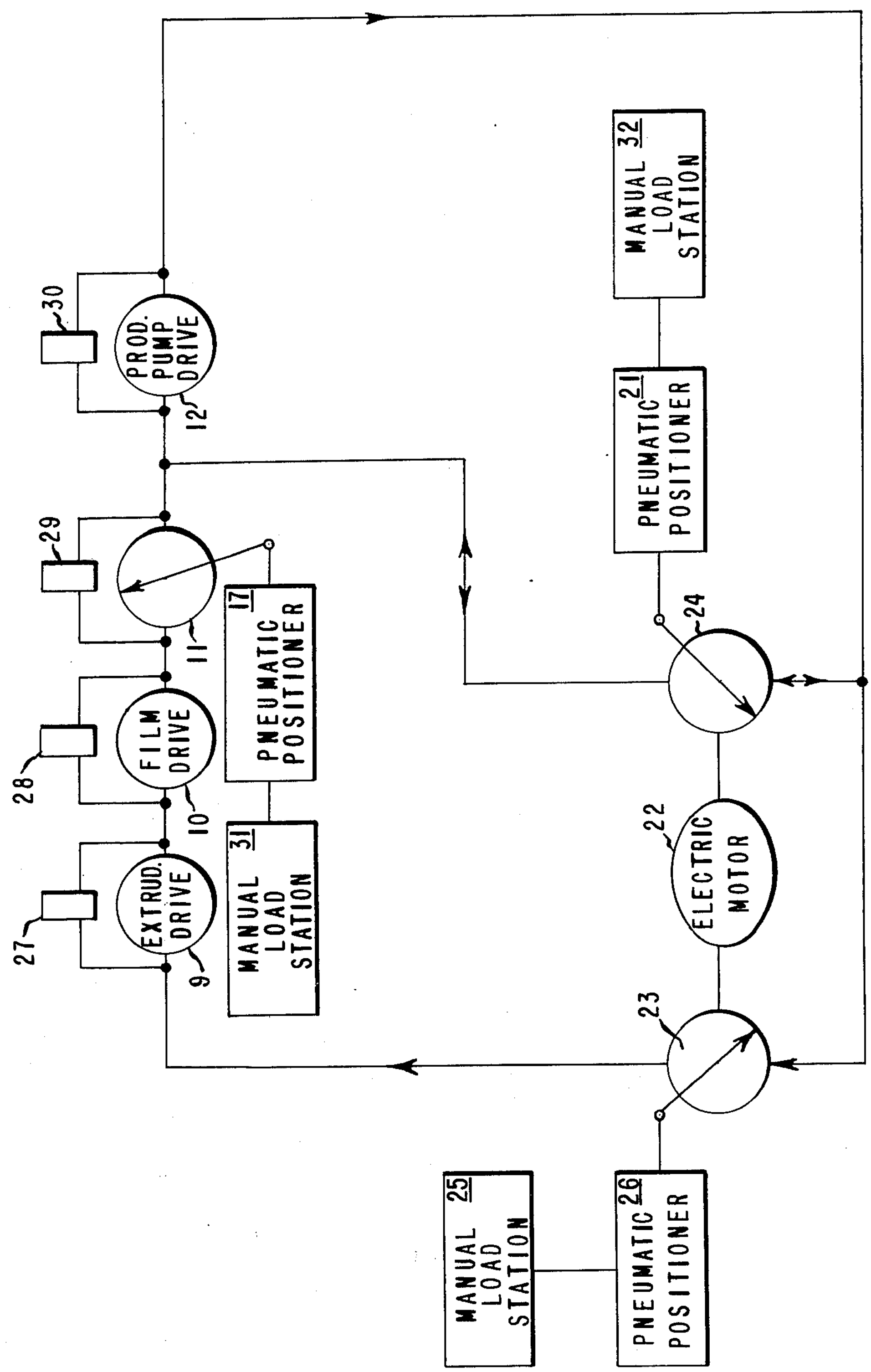

TEMPERATURE CONTROL 33
AIR HEATER 40
PNEUMATIC POSITIONER 26
ELECT. TO PNEUMATIC CONVERTER 34
RATIO CONTROLLER 39

FIG. 1

FIG. 3

FIG. 2



30
PROD. PUMP DRIVE
12
29
11
28
FILM DRIVE
10
27
EXTRUD. DRIVE
9
PNEUMATIC POSITIONER
17
MANUAL LOAD STATION
31
MANUAL LOAD STATION
32
PNEUMATIC POSITIONER
21
24
ELECTRIC MOTOR
22
23
MANUAL LOAD STATION
25
PNEUMATIC POSITIONER
26

SYNCHRONIZED TUBE FORMING AND FILLING MACHINE FOR FORMING CHUB PACKAGES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an improved packaging machine of the type which forms a web of pliable film material into a tube, feeds material to be packaged into the tube, and constricts and seals the filled tube at intervals to divide the same into a series of individual packages.

2. Description of the Prior Art

Tubular film packages or cartridges mechanically closed at each end, e.g., with a metal closure band, referred to herein as "chub" packages, have long been known in the food-packaging art. More recently, water gel explosives have become available in the form of chub packages.

A machine which is capable of producing chub packages on a continuous basis is described in U.S. Pat. No. 2,831,302. The production of compartmented chub packages in an apparatus which forms and longitudinally seals a convoluted tube and fills the resulting compartments is described in U.S. Pat. No. 3,795,081. Form/fill machines for making chub packages include (referring to the drawings of U.S. Pat. No. 2,831,302) tube-feeding means, e.g., cooperating feed rollers 45 for continuously advancing the tube 44 formed; sealing means 35 for forming a longitudinal seam in the tube; a constricting-closure unit 71 reciprocable in the direction of axial movement of the tube for constricting the tube at spaced intervals and applying a pair of successive encircling closure means to each constricted area; and a feed pump 49 for feeding the material to be packaged into the tube through a hollow mandrel 31. Tube 44 is formed from a web of film 20 which moves upwardly and over a curved forming plate 30 and down around the mandrel 31.

In the operation of the above-described machine, the rate of advancement of the tube, the rate of seam production, the reciprocating rate of the constricting-closure unit, and the rate at which material is fed into the tube determine the package length, weight, and tightness or stiffness, and seam integrity. Seam integrity requires that the proper relationship be maintained between the tube-advancement rate and the seam-producing rate, e.g., rate of extrusion of a hot-melt adhesive bead or level of air temperature delivered by a hot-air sealer. The ratio between the tube-advancement rate and the reciprocating rate of the constricting-closure unit determines the package length, and the ratio between the tube-advancement rate and the feed rate of the material into the tube affects the package weight or tightness.

At the present state of the art, the machine normally is set into operation by selecting a tube-advancement rate, an air sealing temperature which gives a satisfactory seal at the selected tube-advancement rate, and a constricting-closure unit reciprocating rate which gives the desired package length. While the tube is being advanced, side-sealed, and end-closed, the product feed pump is started and its delivery rate adjusted to produce the desired package tightness. Relatively low advancement rates are desirable at this stage to avoid considerable waste production during the start-up adjustment period. Once the initial adjustments have been made and it is desired to increase the operating

speed of the machine, the changes in the variables have to be made gradually to avoid error, i.e., to assure that the tubing is properly sealed when it reaches the end of the mandrel, and that the packages formed are long enough and packed tightly enough. A gradually effected change in parameters results in the generation of considerable waste. Operating with the improper conditions during the adjustment period can result in waste as well as in problems associated with the escape of the product into the machine.

At high operating speeds, e.g., at a tube-advancement rate greater than about 60 feet per minute, it becomes difficult, and sometimes impossible, for a machine attendant to cope with the adjustments necessitated by a change in operating speed, such adjustments being additional to those regularly required, even with fixed-speed operation, in the reciprocating rate of the constricting-closure unit and the material feed rate in order to refine the control of package length and tightness, respectively.

SUMMARY OF THE INVENTION

This invention provides an improvement in a machine for continuously forming a series of packages in which a hollow mandrel is provided through which material to be packaged is adapted to be moved, and in which mechanism is provided for forming a web of pliable film material into a tube around the mandrel, advancing the tube along the mandrel to a position beyond the end of the same for receiving the material to be packaged, and constricting and sealing the filled tube at intervals to divide into a series of individual packages, said machine including (a) tube-feeding means, e.g., feed rollers, for advancing said tube, (b) sealing means, e.g., a hot air jet sealer or a hot-melt adhesive extruder, for forming a longitudinal seam in said tube, (c) a constricting-closure unit reciprocable in the direction of axial movement of said tube for constricting the tube at spaced intervals and applying a pair of successive encircling closure means to each constricted area, and (d) a feed pump for feeding material to be packaged into said tube through the hollow mandrel.

The improvement of the invention comprises, in said machine,

1. means for cooperatively controlling elements (a), (b), (c), and (d), specified above, so that the advancement rate of the tube, the reciprocating rate of the constricting-closure unit, the rate at which material is fed into the tube, and the rate at which the seam is produced are maintained in a selected proportion as the advancement rate of the tube is changed;

2. means for independently adjusting the reciprocating rate of the constricting-closure unit to control the length of the individual packages, preferably an automatic feedback control loop containing means for monitoring the ratio of the advancement rate of the tube to the reciprocating rate of the constricting-closure unit and for controlling the speed of a drive motor for the constricting-closure unit; and

3. means for independently adjusting the rate at which material is fed into said tube to control the tightness of the individual packages, preferably an automatic feedback control loop containing means for monitoring package pressure and for controlling the speed of a drive motor for the feed pump.

On the basis of simplicity of design and operation, it is preferred that the means for cooperatively controlling the tube feeding means, sealing means, constricting-closure unit, and product feed pump be an hydraulic circuit comprising a variable-delivery hydraulic pump connected in series with, and adapted to deliver fluid under pressure to, series-connected hydraulic drive motors for the tube feeding means, constricting-closure unit, and product feed pump, and also for an extruder of hot-melt-adhesive when the seam in the tube is made with a strip or bead of such adhesive. The speed of the hydraulic pump can be set manually to give a desired tube-advancement speed, or it can be controlled by temperature, e.g., the temperature of air in a hot air jet sealer.

When the machine embodies hydraulic drives and an extruder for sealing, fixed-volume hydraulic motors are used to drive the tube feeding means and extruder, a variable-volume hydraulic motor to drive the constricting-closure unit, and either a fixed- or variable-volume hydraulic motor to drive the product feed pump. If a fixed-volume motor is used in the latter case, the product feed rate can be varied independently of the speeds of the other motors by means of a second variable-delivery hydraulic pump connected in parallel with the feed pump drive motor. The latter embodiment is preferred as it allows tight packages to be made over a wider range of package diameters.

BRIEF DESCRIPTION OF THE DRAWING

The design and operation of various embodiments of the packaging machine of the invention will be described with reference to the attached drawing in which

FIG. 1 is a schematic representation of a machine showing the location of the power elements therein, together with automatic package length and package pressure feedback control loops;

FIG. 2 is a block diagram of an hydraulic power and control circuit for a machine having an extruded bead sealing means and manually operated means for independently adjusting the constricting-closure unit reciprocation rate and product feed rate; and

FIG. 3 is a block diagram of a portion of a control circuit which can be used in the circuit shown in FIG. 2 when the sealing means is a hot-air sealer.

DETAILED DESCRIPTION OF THE INVENTION

Referring first to FIG. 1, a continuous web 1 of pliable film material, e.g., polyethylene, moves continuously from a supply roll (not shown), passing alternately in an upward, downward and upward direction around a series of idler guide bars or rollers and over the upper curved edge 2 of a cylindrical tube-forming member 3 and down around a hollow mandrel 4. Forming member 3 is cut and shaped to form a collar around mandrel 4, the upper edge being shaped or cut away to cause web 1 to reverse its direction and to guide the edges of web 1 downwardly and into overlapping tube-forming relation around mandrel 4. The film, as it advances over and into forming member 3, is formed into tube 5, which is longitudinally sealed along its overlapping edges by a linear bead of hot thermoplastic material, e.g., polyethylene, produced in extruder 6, which is driven by motor 9.

At a location between forming member 3 and the discharge end 4*a* of mandrel 4, tube 5 is engaged at diametrically opposed sides by tube-feeding means, in this case two cooperating pairs of feed roller 7, driven by motor 10. Each pair of rollers engages tube 5 for the continuous advancement thereof toward a tube-constricting and -closure unit 8 (e.g., 71 in the drawings of

U.S. Pat. No. 2,831,302, the disclosure of which is incorporated herein by reference). Constricting-closure unit 8, driven by motor 11, is reciprocable in the direction of axial movement of tube 5 for constricting the tube at spaced intervals and applying a pair of successive encircling closure means to each constricted area. The resulting individual packages are separated by cutting between the pair of encircling closure means. Closure means 36 remains after the separation.

The material to be packaged is pumped into mandrel 4 from hopper 37 by feed pump 38, which is driven by motor 12.

A preferred hydraulic power circuitry for the above-described machine is shown in FIG. 2. The primary source of power for the machine is a double-ended electric motor 22, which drives variable-delivery hydraulic pumps 23 and 24 from shafts at each of its ends. The speed of pump 23 is controlled manually at manual load station 25, via pneumatic positioner 26. Pump 23 supplies oil under pressure to series-connected hydraulic motors 9, 10, 11, and 12, which drive extruder 6, feed rollers 7, constricting-closure unit 8, and feed pump 38, respectively. Extruder drive motor 9 and film drive motor (i.e., motor that drives feed rollers 7) 10 are fixed-volume motors, and thus operate at a speed dependent solely on the amount of oil delivered to them from pump 23. The ratio of the speeds of motors 9 and 10 is fixed to give the required amount of extrudate to seal a unit length of film driven by motor 10.

Constricting-closure unit, or clip head, drive motor 11 is a variable-volume motor, i.e., its speed can be varied mechanically although the amount of oil passing through it remains the same. Thus, the speed of motor 11 can be varied cooperatively, or in synchronization, with the speeds of motors 9, 10, and 12 by changing the output of pump 23; and independently of the speeds of these three motors by re-positioning the mechanical linkage in motor 11. Motor 11 is adjusted by pneumatic positioner 17, which is controlled from the manual load station 31, or automatically through the feedback loop shown in FIG. 1, as will be described later. The ability to change the ratio of the speeds of motor 10 and motor 11 allows the packaging of cartridges of different lengths, and trimming of the length of a fixed-diameter cartridge to the proper volume.

Feed pump motor 12, the speed of which can be varied cooperatively, or in synchronization, with the speeds of motors 9, 10, and 11 by changing the output of pump 23, also is variable in speed independently of the speeds of these three motors by virtue of being a variable-volume motor or by the embodiment shown in FIG. 2. In FIG. 2, motor 12 is a fixed-volume motor connected in parallel to variable-delivery hydraulic pump 24, which permits the speed of motor 12 to be varied independently by re-positioning of the mechanical linkage in pump 24. The latter embodiment is preferred when the machine is to make packages having a wide range of cross-sectional areas, e.g., when the area will need to be increased by more than about three times. Pump 24, in parallel with motor 12, subtracts from or adds to the amount of fluid delivered to motor 12 by pump 23, thus varying the speed of motor 12 without varying the other drive motor speeds.

If the machine is to make packages of only one diameter, or the cross-sectional area of the packages is to vary by a factor of less than about 3, and independent variability of the speed of motor 12 is needed to maintain cartridge tightness within such a narrow range of package sizes, feed pump motor **12** can be a variable-volume motor, and the parallel circuit including pump **24** can be eliminated. Pump **24** is adjusted by pneumatic positioner **21**, which is controlled from the manual load station **32**, or automatically through the feedback loop shown in FIG. **1**, as will be described later.

Each drive motor **9, 10, 11,** and **12**, is connected to a solenoid-operated hydraulic by-pass valve **27, 28, 29,** and **30**, respectively, which allows the motor to be stopped when the solenoid is energized, thus permitting the independent operation of each motor without any or all of the others.

In operation, motor **22** is energized to operate pump **23** at a selected low speed set at load station **25**, and by-pass valves **27, 28, 29,** and **30** are opened. When the thermoplastic hot-melt adhesive to be extruded in extruder **6** has attained the temperature required to seal the overlapping edges of tube **5**, valves **27** and **28** are closed so as to start extruder motor **9** and feed roller motor **10**, respectively. As the machine is now producing sealed tubing at a low rate, valve **29** is closed so as to start constricting/closure unit motor **11**. The mechanical linkage in motor **11** is adjusted at load station **31** via pneumatic positioner **17** so that the speed of motor **11**, associated with the speed of motor **10**, provides the desired cartridge length.

Finally, actuation of valve **30** causes pump **12** to operate, at a speed dependent on the speeds of pumps **23** and **24**, both operating at low start-up speeds. The speed of pump **24**, set at load station **32** via pneumatic positioner **21**, is increased gradually, whereby the speed of motor **12** increases, until the speed is reached at which the desired cartridge tightness or stiffness is obtained.

When motors **9, 10, 11,** and **12** are operating at the proper speeds to produce cartridges of the desired length and tightness, the overall operating speed of the machine is increased, e.g., to a film speed of about 80 feet per minute or higher, by increasing the speed of pump **23** at load station **25** to provide the selected film speed. This adjustment causes the speeds of motors **9, 10, 11,** and **12** to increase proportionately, thereby maintaining the previously achieved proportion required for correct package length and tightness.

While the machine is operating at the higher rate, minor adjustments in cartridge length or tightness can be made by adjusting the speed of motor **11** at station **31**, or pump **24** at station **32**, respectively.

When the sealing means for forming the longitudinal seam in the tube is a device which projects hot air under pressure against the film surface, e.g., by a method described in the aforementioned U.S. Pat. No. 3,795,081, the disclosure of which is incorporated herein by reference, a preferred means for cooperatively controlling the sealing means together with the feed rollers, feed pump, and constricting-closure unit comprises motors **10, 11,** and **12** in series with pump **23**, as shown in FIG. **2** (motor **9** being omitted), the mechanical linkage of pump **23** being connected to pneumatic positioner **26**, which in turn is connected to a ratio controller **39**, the latter being connected to a temperature sensor **35** via an electric-to-pneumatic converter **34**, as shown in FIG. **3**. Temperature control means **33** and electric-to-pneumatic converter **34** both receive a signal from temperature sensor **35**, e.g., a thermocouple, located in the hot-air sealing device **40**, e.g., the air heater (**17** or **18**) shown in FIG. **2** of U.S. Pat. No. 3,795,081.

In hot-air sealing, the temperature required for sealing increases as the advancement speed of the tube increases. Therefore, the advancement speed of the tube can be controlled by the sealing air temperature. In this embodiment, after the machine has been started up, as described above, at an initially low rate and the adjustments made to obtain the desired cartridge parameters, the film rate is increased by increasing the temperature of the air in the sealing device **40**. The air temperature in sealing device **40** is sensed by the temperature sensor **35**, which sends a signal to temperature control means **33** as a feedback signal thereto; and also, in turn, to electric-to-pneumatic coverter **34**, ratio controller **39**, and positioner **26**, which positions the mechanical linkage and delivery rate of pump **23**, thereby cooperatively increasing the speeds of motors **10, 11,** and **12** in a synchronized manner to maintain optimum packaging conditions. A signal modifier, e.g., a computing relay, may be used between ratio controller **39** and pneumatic positioner **26**. The computing relay is preferred when automatic controls are used for package length and tightness, as described below.

In a preferred machine of the invention, control of motor **11** and/or motor **12** to make minor adjustments in cartridge length or tightness while the machine is operating at high speed, is achieved automatically by means of feedback control circuits, as shown in FIG. **1**.

For automatic length control, an electronic digital pickup **13**, attached to one of the guide bars over which the web of film **1** passes, senses and records the speed of the film and transmits the speed to digital length indicator and control unit **14**. The vertical reciprocation of constricting-closure unit **8** actuates digital pulse transmitter **15**, attached thereto, which in turn transmits a signal (speed) to length indicator and control unit **14**. In the latter unit, the film speed is electronically divided by the constricting-closure unit speed and multiplied by a pre-set constant (to correct for the curvature at the cartridge ends for different package diameters), and the length of the cartridge being produced is indicated and matched against the pre-set desired length. If a correction is required, the necessary signal is transmitted from indicator and control unit **14** to electric-to-pneumatic converter **16**, which then adjusts pneumatic positioner **17** and consequently the speed of the constricting-closure unit motor **11**.

For automatic control of cartridge tightness or stiffness, a pressure probe, e.g., a pressure transducer, **18** is located inside mandrel **4** just above constricting-closure unit **8**, and inside filled tube **5**. The wire from probe **18** leads to pressure control unit **19**. Probe **18** measures the pressure in the cartridge and transmits a corresponding electrical signal to control unit **19**, which matches the signal against a desired pressure. If a correction is required, an electronic signal is sent to electric-to-pneumatic converter **20**, which in turn adjusts pneumatic positioner **21**, thereby adjusting pump **24** and the speed of feed pump motor **12**.

In some cases, e.g., with larger-diameter packages or multi-compartment packages, the pressure probe can be positioned on the outside of the finished package, and the signal transmitted as described above.

Although the use of hydraulic motors, pumps, and valves for most of the primary power units, pneumatic positioners for adjusting the mechanical linkages for variability in these hydraulic components, and electric-to-pneumatic converters from the electronic controls is specified in the foregoing description, it will be understood that, although less preferred, mechanical variable-speed devices driven from jack shafts, gears, and/or chains, or electrical variable-speed primary drives can be used in the synchronized machine of the invention.

We claim:

1. In a packaging machine of the type which forms a web of pliable film material into a tube, feeds material to be packaged into the tube, and constricts and seals the filled tube at intervals to divide it into a plurality of individual packages, said machine including (a) tube-feeding means for advancing said tube, (b) sealing means for forming a longitudinal seam in said tube, (c) a constricting-closure unit reciprocable in the direction of axial movement of said tube for constricting the tube at spaced intervals and applying a pair of successive encircling closure means to each constricted area, and (d) a feed pump for feeding material to be packaged into said tube through a hollow mandrel, the improvement comprising

1. for cooperatively controlling elements (a), (b), (c), and (d) so that the advancement rate of the tube, the reciprocating rate of the constricting-closure unit, the rate at which material is fed into the tube, and the rate at which the seam is produced are maintained in a selected proportion as the advancement rate of the tube is changed;
2. means for independently adjusting the reciprocating rate of the constricting-closure unit; and
3. means for independently adjusting the rate at which material is fed into said tube.

2. A machine of claim **1** wherein said sealing means is an extruder of hot thermoplastic material, and said means for cooperatively controlling elements (a), (b), (c), and (d) comprises a variable-delivery hydraulic pump connected in series with, and adapted to deliver fluid under pressure to, series-connected hydraulic drive motors for the tube-feeding means, constricting-closure unit, extruder, and feed pump, the output of said hydraulic pump being adapted to be changed manually.

3. A machine of claim **1** wherein said sealing means is a hot-air jet unit, and said means for cooperatively controlling elements (a), (b), (c), and (d) comprises a variable-delivery hydraulic pump connected in series with, and adapted to deliver fluid under pressure to, series-connected hydraulic drive motors for the tube-feeding means, constricting-closure unit, and feed pump, the output of said hydraulic pump being adapted to change in response to a change in the temperature of the air produced in said sealing means.

4. A machine of claim **2** wherein the drive motors for the tube-feeding means and extruder are fixed-volume motors, and the drive motors for the constricting-closure unit and feed pump are variable-volume motors.

5. A machine of claim **2** wherein the drive motors for the tube-feeding means, extruder, and feed pump are fixed-volume motors; the drive motor for the constricting-closure unit is a variable-volume motor; said variable-delivery hydraulic pump connected in series with said drive motors is a first hydraulic pump; and a second variable-delivery hydraulic pump is connected in parallel with said feed pump drive motor.

6. A machine of claim **1** wherein drive means for the constricting-closure unit is controlled by an automatic feedback control loop wherein the tube-advancement rate and reciprocation rate of the constricting-closure unit are sensed, and a signal is sent to said constricting-closure unit drive means whereby the rate thereof is adjusted as required to maintain a preselected package length.

7. A machine of claim **1** wherein drive means for the feed pump is controlled by an automatic feedback control loop wherein pressure in the package is sensed, and a signal is sent to the feed pump drive means whereby the rate thereof is adjusted as required to maintain a preselected package tightness.

* * * * *