Sept. 28, 1954 F. E. STIRN ET AL 2,690,038

LIQUID-FILLED CAPSULE FORMING METHOD AND APPARATUS

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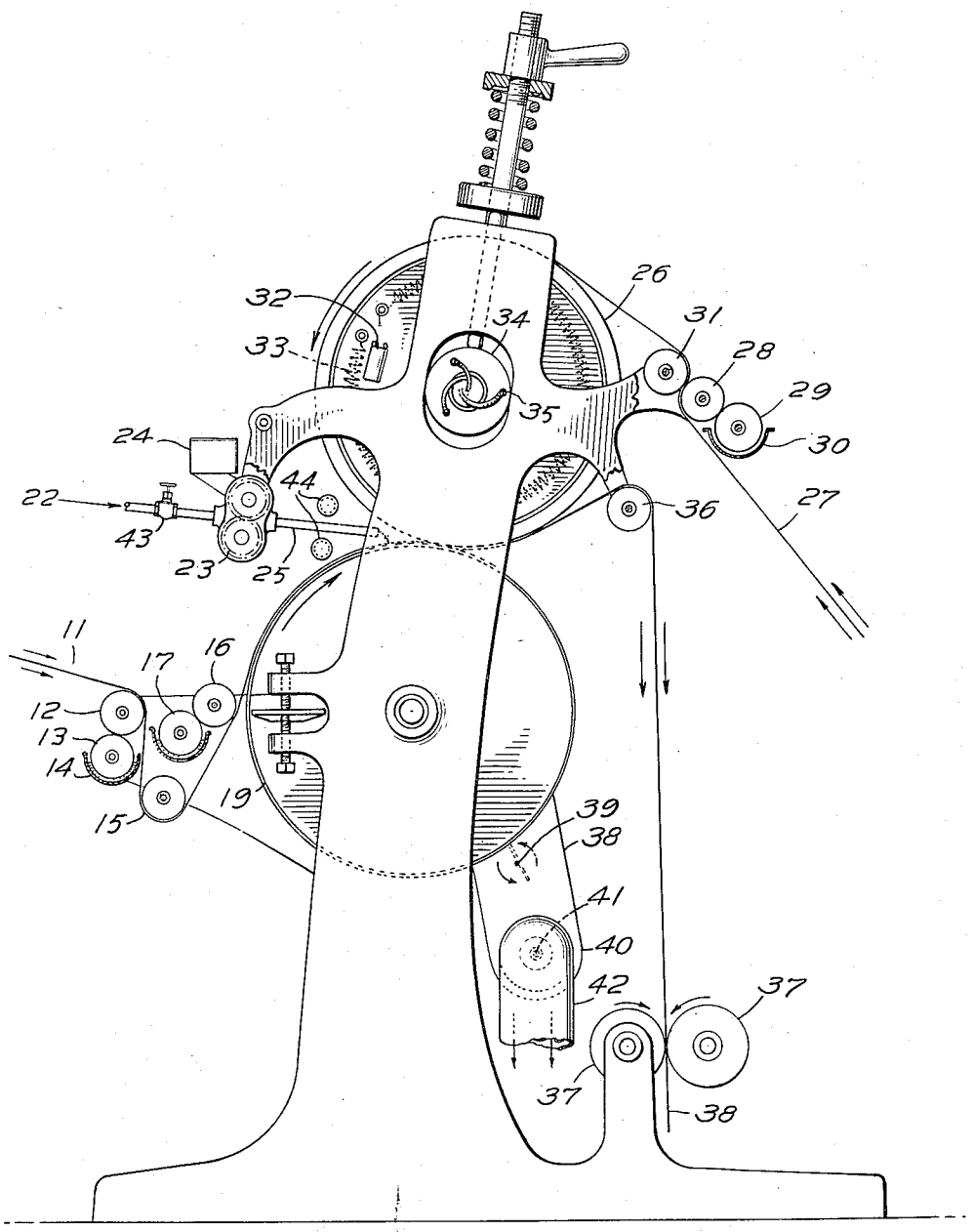


Fig. 1.

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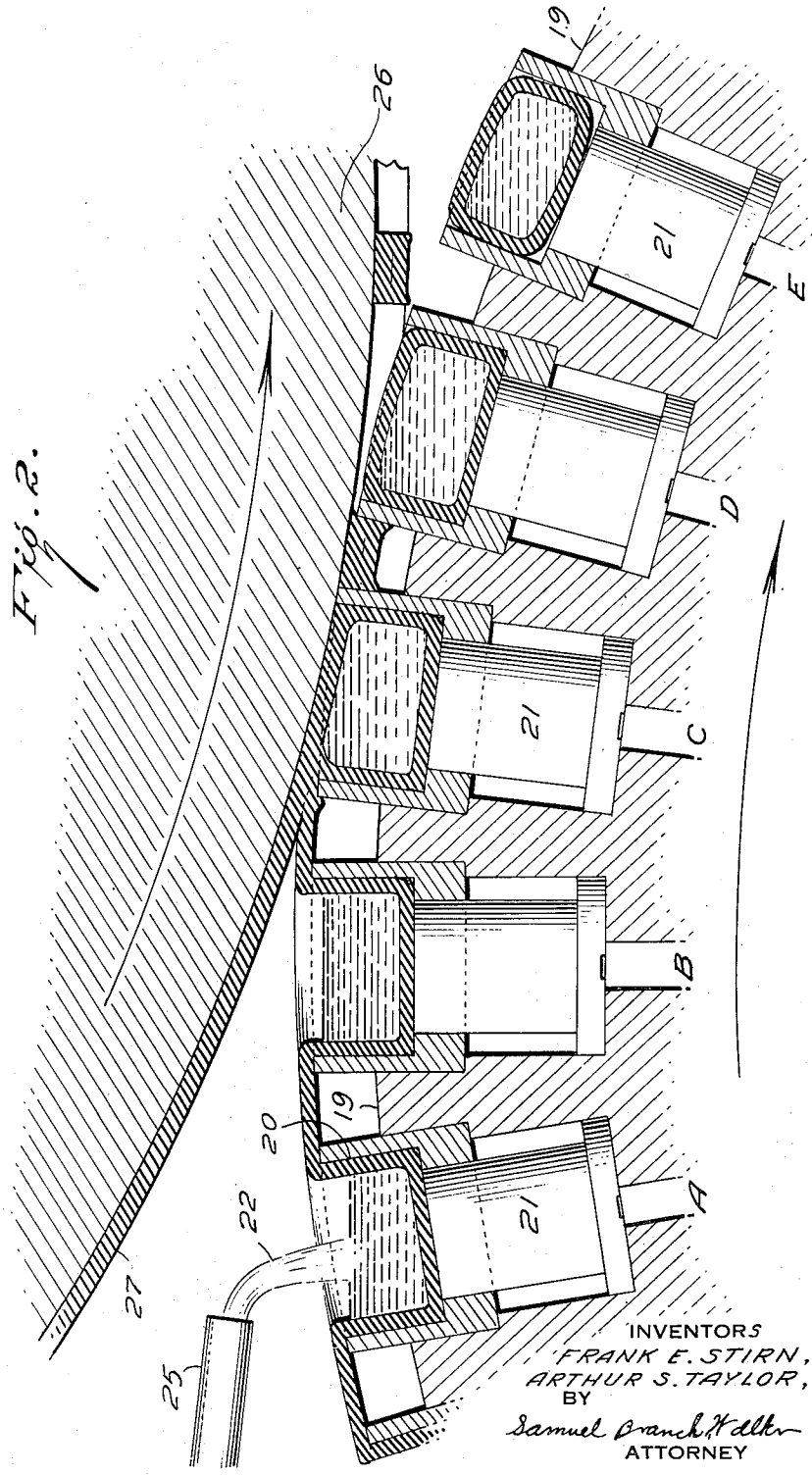


Fig. 2.

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LIQUID-FILLED CAPSULE FORMING METHOD AND APPARATUS

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15 Claims. (Cl. 53—10.5)

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This invention relates to improvements in a machine for, and methods of making, a liquid-filled capsule from a plastic film such as soft gelatin in which the film is sealed to itself by a pressure cut-out while still soft.

It is an object of this invention to provide a machine for forming symmetrical capsules filled with liquid by asymmetric die means.

It is a further object of this invention to provide a method and machine whereby liquid-filled capsules containing uniform contents may be formed without individually measuring the charges for these capsules.

It is a still further object of this invention to provide a machine and method whereby a liquid is discharged at a uniform and continuous but adjustable rate into a series of plastic film lined capsule forming cavities which pass at a uniform rate under a liquid discharge, whereby the liquid uniformly and continuously is distributed into these cavities so that each cavity contains a substantially uniform charge without this charge having been individually measured.

It is an object of this invention to eliminate the necessity for an accurately constructed charge measuring pump operating in timed relationship with the capsule-forming die means.

Whereas our machine and method are for the filling of a liquid, the liquid may have suspended in it small solid particles so as to form a thin paste; and whereas a liquid is disclosed as such, it is to be understood that a liquid having suspended therein certain solid particles will operate in the same fashion and is to be construed as within the meaning of the term "liquid."

Our capsules may be formed from materials such as soft gelatin or other similar plastic materials which have the property of uniting to each other when two adjacent films of the material are cut with a dull cut-out blade. Capsules formed from such materials may be used as containers for vitamins, for dyestuffs, plasticizers, modifiers, etc. Such capsules have been used as containers for ether to assist in starting internal combustion engines. A wide-spread range of the usages will suggest itself to those skilled in the art.

For pharmaceutical purposes, soft gelatin has been found particularly useful because when ingested, it is definitely not harmful and by some is thought to have food value. The gelatin is plasticized with materials such as glycerin and water, etc., as may be required, and may contain flavors, odors, coloring material, etc.

Because our machine and method are of particular value in connection with these therapeutic capsules, an embodiment thereof will be described in connection with the manufacture of an oil-filled capsule having vitaminaceous materials in the oil. In the past, various types of apparatus have been used for making these soft gelatin capsules with a variety of disadvantages. In continuous production machines in general soft gelatin strips have been formed into symmetrical die cavities which have been filled by the individual action of a metering pump and then sealed in the die cavities as formed. In some instances, the operation has been conducted entirely submerged in a liquid so that the cavities are formed in the liquid and the gelatin strips sealed to each other while submerged. Both of these methods have marked disadvantages. When the capsules are formed under liquid, the surfaces are coated with the liquid. With expensive liquids such as vitamins, this is apt to run up the cost unduly because of the inevitable loss of the liquid and its exposure to contamination. A much more common type of machine is the one in which the capsule cavities are formed in conjunction with the feeding thereto of a pre-measured liquid charge. For such machines, it is necessary that a metering pump with accurate displacement be provided which pump must be operated in timed relationship with the die cavities with intricate problems of timing thereby necessary.

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It is convenient to produce capsules in a die cavity of an entirely different configuration than the finished capsule. We have found that by using a single cavity die roll in contact with the gelatin film and applying a vacuum underneath the film, the gelatin film is sucked down into the die cavity to form a gelatin-lined die cavity, and held against the roll. The cavity may then be filled, a second smooth gelatin film placed in juxtaposition thereto, and the final cut-out of the portions of the two films forming the capsule be performed by the operation of raised edges on the cavity die roll operating against a smooth seal roll. Because the seal roll is smooth and cylindrical, there is no problem as to timing and the machine is thereby markedly simplified.

We have found that if the gelatin-lined capsule cavities are passed at a uniform rate under a uniformly flowing liquid discharge the liquid fills into the gelatin-lined cavities in a uniform manner so that successive charges are uniform. Substantially all of the liquid is displaced into the cavities, and that if the discharge rate of the liquid is carefully adjusted, and if the cavity die roll is of uniform construction, there is neither waste liquid, nor air bubbles in the capsule.

By the use of an accurate gear pump driven cooperatively through a variable speed drive in conjunction with the capsule forming die roll, there are obtained capsules of a uniformity at least as great as that previously accomplished by the individual metering of charges to the individual capsule. Under readily attained commercial operating conditions and accuracy of better than 1% it is easily maintained over prolonged periods of time.

The sealing areas of our machine can be enclosed in an inert atmosphere such as nitrogen, carbon dioxide, etc., if the moisture or oxygen of the normal atmosphere has a deleterious influence on the capsule contents.

A coating may be applied to the inside of the film-forming material. This is possible because no portions of the machine contact the portions of the film forming the inside of the capsule. With the various forms of metering devices, a material used on the inside would tend to gum or build up on various surfaces and incapacitate the machine. As such a material may be used gum mastic, gum sandarac, a silicone type resin, etc.

Other objects as well as those pointed out, and advantages and improvements as a result of our invention, will be readily apparent to those skilled in the art as brought out by the following description in conjunction with the accompanying drawings in which:

Figure 1 is a schematic side view of our improved capsule-forming machine.

Figure 2 is an enlarged view at the actual point of the filling and sealing of the capsules.

The size and shape of the completed capsules are a matter of choice for the operator. The capsules may be round, elliptical, the so-called long oval, which consists of a cylindrical portion with two hemispherical ends, or such other shape as is desired.

Our new machine is particularly useful with the long oval type because the cut-out is so effective that undistorted long ovals are easily formed. Figure 2 shows a cross section of the forming cavities and insofar as the method and operation of our machines are concerned, the ratio of length to width of the forming cavities in the cavity die roll is not an essential feature of the machine as herein described and claimed.

Our machine will be described in the order of the parts acting on the gelatin film.

In Figure 1, a lower gelatin film **11** which may be supplied by any standard gelatin film casting means, is fed over the oiler roll **12** which oiler roll in turn contacts an oil feed roll **13** rotating in an oil bath **14**. The oil bath is preferably maintained at a constant level. The gelatin film may then pass under a positioning roll **15** and thence into contact with the inside coating roll **16** which roll contacts a coating roll **17** which rotates in a coating trough **18**. The film next contacts cavity die roll **19**. The details of this cavity die roll are described and claimed in our co-pending application Serial No. 164,426, filed May 26, 1950.

The cavity die roll as shown in Figure 2 has in its surface a series of capsule forming cavities **20**. As shown, the sides are substantially parallel to give a cylindrical, although not necessarily circular, cross section. The cylindrical forms are easier to machine, and save much labor in construction. At the bottom of each cavity is at least one capsule ejector plug **21**. As the gelatin film comes in contact with the cavity die roll, it is pulled down into the capsule forming cavity by the effect of reduced pressure, thereby forming a gelatin-lined capsule-forming cavity. As the cavity die roll rotates, a series of such gelatin lined cavities are uniformly and continuously formed. As these cavities pass by the position shown at A in Figure 2, the liquid capsule contents **22** are uniformly and continuously discharged into the passing series of cavities. The liquid may be uniformly discharged by means of an accurate gear pump such as is shown at **23**, such as is described in Patent 1,785,386. The gear pump is preferably driven by a positive infinitely variable drive as shown diagrammatically at **24**, which drive is in turn driven from the main capsule machine drive so that the ratio of the rate of discharge of the pump to the speed of the cavity die roll may be continuously and accurately varied. Other means for such variation in the rate of feed will suggest themselves to those skilled in the art.

The liquid is discharged from the pump through the discharge nozzle **25**. This nozzle should be of such size that the liquid contents being discharged will flow therefrom in a continuous non-broken stream. If a series of drops rather than a continuous stream is formed, there is more of a tendency for non-uniformity of fill, although, of course, even with drop formation a comparatively accurate fill is easily maintained.

The series of thus filled capsule cavities rotate towards the seal roll **26**. The upper gelatin film **27** is fed as shown, from the right, contacting an inside coating roll **28**, which is in turn contacted by a coating feed roll **29** in a trough **30**. The coated film passes over the positioning roller **31** and into contact with the seal roll **26**. The coating may of course occur at some other portion of travel of the gelatin film or the inside coatings may be entirely omitted, if there would be no undesired interaction between the gelatin of the film and the capsule contents. The seal roll **26** is preferably of a material which has a high heat conductivity and has temperature control means associated therewith. There is shown diagrammatically a thermostat **32**, heater elements **33**, and a slip ring system **34** whereby electrical leads **35** supply power to and indicate the temperature of the seal roll. The temperature of the seal roll is normally somewhat higher than that of the cavity die roll and for smooth operation must be carefully maintained at a constant temperature. The upper gelatin film **27** after being warmed by its contact with the seal roll is brought down adjacent to the gelatin lined cavities as shown in positions B and C of Figure 2.

The two gelatin films approach each other at B and contact each other as shown at C. The gelatin films contact each other as the rim edge of the cavity approaches the seal roll. The rim bites into the gelatin film and because of the peculiar characteristics of soft gelatin, this not only cuts through the films but causes the gelatin films to unite to each other so as to make a smooth homogeneous seal. If the gelatin films are coated, the coatings contact each other so as to form a smooth continuous interior coating inside of these gelatin capsules.

It is necessary that the liquid feed be comparatively accurately adjusted if the capsules are to be filled completely so that no air bubble occurs, and yet not be overfilled so that liquid is wasted. Any extra liquid on the web between the cavities tends to be forced back along the surface of the films just ahead of the bite of the rolls so that any drops of liquid are pressed back into the next approaching capsule-forming cavity.

It is indeed surprising that this type of action should give uniform fills without wasting any liquid and without causing compressibility troubles at the point of bite, but in actual operation completely filled capsules are easily formed.

After the cut-out, as the capsule passes towards the station shown at D, the capsule is retained in the forming cavity by suction. The residual web is held against the seal roll by a web take-off roll **36** and is fed between web tensioning rolls **37**. The residual web **38** after passing through the tensioning rolls may be either discarded or reclaimed.

In the sealing of the capsules, it is desired that the vacuum holding the gelatin film in the cavity be released at the actual point of seal, position C to position D so that the gelatin film is free from external stresses at the time of seal. This release of external forces insures a more uniform and straighter line of seal and permits straight long oval shapes.

As the cavities pass onward to position E the film tension in the gelatin causes the thus formed capsule to assume a more round configuration. The capsule may be retained in the cavity as it passes around the periphery of the cavity die roll's travel to a discharge shield **38**. As the capsule passes into the discharge shield **38**, the capsule ejector plug **21** may be raised by air pressure causing the capsule to be released. A stripper **39** rotates closely adjacent to the cavity die roll and may consist of at least one blade of a fairly soft material such as for example a sheet of polytetrafluorethylene, plastic, or a heavy canvas, etc.

The capsules as formed drop by gravity to the bottom of the discharge shield where they may be picked up by a pneumatic discharge system **40**. As shown this consists of a center jet **41** of low pressure air such as for example discharged from a vacuum cleaner, which operates as a Venturi jet to pick up the capsules as they form, and convey them to a discharge tube **42**. This discharge tube may have elbows, flapper valves, etc., in it to direct the filled capsules to any desired location.

In operation it is convenient to install a feed valve **43** in the liquid contents feed line so that the machine may be brought up to speed and the capsules filled with air while adjusting various temperatures and control pressure and until symmetrical well sealed capsules are formed. Thereby the liquid contents are conserved until the capsuling machine is in proper operation. At this point, the valve **43** may be opened, the liquid contents discharged, and filled capsules be formed. If a flapper valve is installed in the discharge tube **42**, the air filled capsules may be discharged into one container and as soon as the filled capsules start appearing, the flapper valves may be quickly shifted and the perfectly filled capsules deflected to production.

Radiant heaters, as shown at **44**, are installed near the bite of the rolls so that the gelatin film may be warmed by radiant energy just prior to the sealing of the strips to each other.

For operation with liquid-filled capsules, the gelatin strip should have a slightly lower moisture and glycerin content than is used with powder, and a slightly higher temperature is required for satisfactory sealing of the films to each other. Under many conditions of operation, depending upon the exact film composition and the liquid being filled, it is not necessary that additional heat be supplied at the bite of the rolls, all of the heat required being supplied through the seal roll, but under other conditions heat just prior to the point of seal adds to the ease of operation. With our apparatus either mode may be readily used.

The various gelatin film contacting rolls should be driven in the same peripheral speed so that the gelatin film is not stretched at any point for normal operation. If desired, by stretching the gelatin between the point at which it is cast and the point at which it is fed to our machine the film has induced strains which cause deformation of the capsules after they are formed so as to produce ellipitical capsules from round dies.

The drive means may conveniently consist of ordinary gears between the cavity die roll and the seal roll and of gear trains between the other gelatin film contacting rolls. It is convenient for the size of each of these rolls to be such that a sprocket may be fastened on the shaft and a continuous chain drive used to drive the entire group of sprockets. The web take-off roll **36** and the web tensioning rolls **37** should be driven at a somewhat higher rate of surface speed than the rest of the strip contacting rolls so that the web is smoothly and uniformly pulled from contact with the seal roll.

As shown in the drawings the seal roll is slightly, about 5° to 15°, beyond the vertical position. This permits the filling nozzles to be closer to the top of the roll, and permits the elimination of air bubbles in the capsules. The exact angle varies with construction details. With 8 inch rollers, and about 0.030 inch thick films, 10° beyond the upper vertical is very effective.

The liquid used may be a vitamin-containing oil, as for example vitamins A and D in a cotton seed oil base together with such other vitamins suspended in the oil as may be desired, or may consist of liquid dyes, liquid petroleum products, ether, or other products which it may be desired to have filled into capsules. Other modifications and suitable coating compositions to protect the gelatin from the effects of these various fills will suggest themselves to those skilled in the art.

Having thus described certain modifications thereof, as our invention we claim:

1. A capsuling machine comprising a single horizontal die roll provided with a plurality of mold cavities each surrounded by a sealing and cutting ledge, means for passing a strip of gelatin over said die roll, means for exhausting air from beneath the dies in said die roll, an injection nozzle located adjacent to but sufficient distance from the cavity die roll so that a gelatin strip on said die roll will not contact said nozzle, means for injecting fluid at a predetermined rate through said nozzle which rate is proportional to the number of cavities passing under the nozzle, but at a rate not greater than the rate of encapsulation of the liquid, means for applying a plastic cover to said cavities and simultaneously cutting out and sealing the two films to each other around the periphery of said cavities, and means for ejecting the thus formed capsules.

2. A method of forming liquid-filled, symmetric, plastic film capsules which comprises sequentially forming at least one row of cup-shaped cavities in a single moving plastic strip, uniformly, continuously and freely discharging a liquid, at a rate proportional to the rate of movement of said strip, along such row of cavities, thereby filling the cavities, juxtapositioning a second, moving, essentially flat seal strip of plastic film on top of the row of filled cavities, said cavities then containing all of the discharged liquid,

simultaneously sealing together and cutting out the portions of the strips around each of the liquid-filled cavities by the action of pressure, releasing the thus formed capsules, and maintaining the capsules free from external forces, whereby the differential strains in the cut-out portions of the plastic strips cause the thus formed capsules to assume the desired symmetrical rounded shape.

3. A method of forming liquid-filled, symmetric, plastic film capsules which comprises sequentially forming in rows a plurality of cup-shaped cavities in a single moving plastic strip, continuously, uniformly and freely discharging a liquid, at a rate proportional to the rate of movement of said strip and at the rate of encapsulation of the liquid, along each row of cavities, thereby filling the cavities, juxtapositioning a second, moving, essentially flat seal strip of plastic film on top of the filled cavities in the first strip, said seal strip being at a higher temperature than the first strip, simultaneously sealing together and cutting out the portions of the strips around each of the liquid-filled cavities by the action of pressure, releasing the thus formed capsules, and maintaining the capsules free from external forces, whereby the differential strains in the cut-out portions of the plastic strips cause the thus formed capsules to assume a symmetrical shape.

4. A method of forming liquid-filled capsules which comprises forming a series of cup-shaped cavities in a single strip of plastic material, depositing liquid uniformly, continuously and freely along the series of thus formed cavities at the rate of encapsulation of the liquid, covering the cavities with a substantially flat cover strip of plastic material, simultaneously sealing and cutting out the adjacent portions of each strip around the cavities by cutting through the combined strips, whereby the cut-out portions are caused to adhere around their peripheries to form a single capsule from each cup-shaped cavity, ejecting the thus formed capsules from the cavities, and permitting the thus formed capsules by the release of natural inherent strains to form themselves into the desired configuration.

5. A method of forming liquid-filled capsules which comprises forming a series of cup-shaped cavities in a single strip of plastic material, depositing liquid uniformly along the series of thus formed cavities at the rate of encapsulation of the liquid, covering the cavities with a cover strip of plastic material at a temperature higher than the temperature of the first strip of plastic material, simultaneously sealing and cutting out the adjacent portions of each strip around the cavities by cutting through the combined strips, whereby the cut-out portions are caused to adhere around their peripheries to form a single capsule from each cup-shaped cavity, ejecting the thus formed capsules from the cavities, and maintaining the capsules free from external forces whereby the differential strains in the various portions of the plastic films cause the thus formed capsules to assume a symmetrical shape.

6. A method for the asymmetric manufacture of symmetric liquid-filled plastic capsules that comprises forming a series of cup-shaped cavities, successively, in a single plastic strip only, moving the strip containing the cavities uniformly, continuously and freely under a uniform, continuous and free discharge of liquid, the rate of discharge being such that all of the discharge is encapsulated, uniformly and continuously bringing into juxtaposition with the filled cavity-containing strip a substantially smooth second plastic strip, thereby covering each filled cavity and successively cutting out by pressure the portions of each strip surrounding the filled cavities, whereby the thus cut-out portions are peripherally united to each other, separating the thus formed capsules from the remainder of the strip, and permitting the thus formed capsules by the release of natural inherent strains to form themselves into the desired configuration.

7. A method for the asymmetric formation of symmetric liquid-filled capsules which comprises supplying a continuously moving single plastic strip, successively applying subatmospheric pressure to portions of said strip in a uniform and continuous manner, thereby forming cavities, uniformly, continuously and freely discharging a liquid onto the cavity-containing moving strip, thereby depositing in each of the cavities a uniform charge of the liquid, the discharge being at such a rate that all of the discharged liquid is encapsulated, continuously bringing into juxtaposition with the liquid filled cavity-containing strip a substantially smooth second strip, thereby covering the filled cavities, and successively cutting out by pressure portions of each sheet surrounding the filled cavities whereby the thus cut-out portions are peripherally united to each other, separating the thus formed capsules from the remainder of the strips and permitting the thus formed capsules by the release of natural inherent strains to form themselves into the desired configuration.

8. A machine for forming liquid-filled soft gelatin capsules comprising means for oiling the cavity die roll contacting side of a gelatin strip, means for applying a protective coating to the side of the gelatin strips which form the inside surface of the capsule, a single cavity die roll having therein a plurality of capsule forming cavities, a continuous, uniform and free flowing liquid supply means, said means including discharge nozzles spaced from said cavity die roll by more than the thickness of the gelatin strip, a variable speed drive means for said liquid supply means to cause the supply of the encapsulated liquid at a rate not greater than the rate of encapsulation, and a substantially smooth sealing roll contacting said cavity die roll and in rolling contact therewith at a line beyond the highest part of the travel of said cavity die roll, whereby capsule cavities are formed in one side only of one strip only, filled with a liquid, supplied with a gelatin cover strip, cut-out, and permitted to assume a desired configuration.

9. A capsuling machine comprising means for forming a series of single empty capsule shells in a single moldable plastic film, means for continuously and uniformly feeding a liquid content at a uniform rate not greater than the rate of encapsulation of the liquid to a series of such capsule shells, said means including discharge nozzles spaced from said means for forming by more than the thickness of the plastic film, means for placing in juxtaposition to said capsule shell a substantially flat cover sheet of moldable plastic film, means for sealing the two films to each other while simultaneously cutting them from their individual films, and means for ejecting them from the forming means.

10. A capsuling machine comprising means for supplying a single moldable plastic film, means for forming a plurality of empty hollow shells in said film, means for supplying a liquid content for said shells at an adjustable rate proportional to

the rate of shells being supplied, said rate being not greater than the rate of encapsulation of the liquid content, said means including discharge nozzles spaced from said means for forming by more than the thickness of the plastic film, means for applying a second, substantially flat plastic film over said hollow shell as filled, and means for simultaneously sealing together and cutting out portions of said film thereby forming sealed capsules which, when released, will form themselves to the desired configuration.

11. The method of claim 6 which includes the step of coating the surfaces of the plastic strips which form the inside surface of the capsule with a protective coating.

12. The method of claim 7 which includes the step of coating the surfaces of the plastic strips which form the inside surface of the capsule with a protective coating.

13. The machine of claim 1 which includes means for coating with a protective coating the surfaces of each of the strips of gelatin which form the inside surface of the capsule.

14. In a method of forming liquid filled symmetric plastic film capsules the steps which comprise, sequentially forming in rows a plurality of cup shaped cavities in a single moving plastic strip, continuously discharging the filled liquid at a rate proportional to the rate of movement of said strip along each row of cavities and in such quantity that all of the liquid is filled into the cavities and that the formed capsules are completely filled with the liquid, and covering the thus filled cavities with a second moving essentially flat seal strip of plastic film.

15. In a machine for forming liquid filled soft plastic capsules, means for forming a series of single empty capsule shells in a single molded plastic film, means spaced from the plastic film for continuously and uniformly feeding the liquid contents at a uniform rate just equal to the rate of encapsulation of the liquid, but at such a rate that the formed capsules are completely filled, and means for placing in juxtaposition to the thus filled capsule shells a substantially flat cover sheet of moldable plastic film.

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