This invention relates to method and apparatus for the production of seamless capsules, and has as its main object the improvement of such capsules by the provision of a covering or skin of improved character as to strength and uniformity.

Capsules of the seamless type have heretofore been produced by injecting drops of liquid content substance, such as fish oil, into a body of liquid capsulating material, ordinarily gelatin, through which the drops of content substance will rise while collecting a coating of the content substance. Superposed on the capsulating material is a body of liquid which is hardening as to the capsulating material and through which the gelatin is carried. Heretofore the supernant hardening liquid has ordinarily been carbon tetrachloride with added material for the suitable adjustment of the specific gravity. A sharp interface exists between the carbon tetrachloride and the capsulating material and the nascent capsule is frequently injured or ruptured as it breaks through this interface. In accordance with the present invention, cooled water is used as the hardening agent with greatly improved results. There is a short zone of intermersion of the two liquid bodies and this zone, as opposed to a sharp interface, is readily penetrated by the soft skinned capsule so that deformation or rupturing thereof is substantially eliminated. In view of the rather acid nature of the carbon tetrachloride, water is a much pleasanter agent to work with and, of course, involves practically no cost.

In the use of heat-liquided gelatin, the procedure is extremely critical since the gelatin deteriorates when heated to the required capsulating temperature for any extended period. If the gelatin is subjected to heat for any substantial length of time, it provides a weak covering very apt to be ruptured in passing the interface, where one exists, or later on in handling. Heretofore, the gelatin has been fed from a heated reservoir, and while it has been proposed to heat the gelatin in the reservoir only to a degree to render it able to flow to the capsulating apparatus where its temperature is raised to the necessary degree, this nevertheless kept the gelatin at a relatively high temperature for a substantial period. In accordance with another phase of the present invention, this difficulty is largely overcome by injecting the gelatin into the capsulating chamber from a mass which is in cold plastic form, liquefying heat being applied substantially only to the gelatin in the receptacle.
ment for one end of a compression spring 23 whose other end bears against the plunger to yieldingly retain the valve means in closed relation.

At its lower end, tube 13 is flanged outwardly to provide a cap 12' into which is threaded a cylinder 24 which has a bottom wall 25. Slidable in the cylinder 24 is a power piston 26 which is formed as part of a pump piston 27 working in the lower portion of tube 13. A compression spring 28 normally holds the piston against an adjustable stop 29 constituted by a screw threaded in the wall 25. Reference numeral 30 designates a stop collar surrounding the stem 27 and limiting the upward movement of the piston.

In Figure 1, reference numeral 31 designates a tank containing a liquid content substance and reference numeral 32 designates a pipe extending from tank 31 and through a check valve 33 into tube 13 above stem 27 as most clearly shown in Figure 3. The check valve includes a ball 34 and a compression spring 35.

Reference numeral 36 designates a rotary valve including a casing 37 and a cylindrical plug 38, the latter being provided with a diametrical bore 39. The casing 37 is provided with a radial inlet in connection with a source 40. Figure 1, of compressed air through a pipe 41 and has a radial exhaust opening in connection with an exhaust pipe 42. Interiorly the casing is arcuatly relieved at 43, Figure 3, and is provided with a radial opening midway between the ends of the recess and in connection with a pipe 44. The latter extends to cylinder 24 beneath piston 25 and is provided with a restricted orifice fitting or choke 45. A pipe 46 leads from pipe 44 in advance of fitting 45 to a bellows 47 which includes a top plate 48 carrying a block of insulation 49 cooperable with the lower spring arm 50 of a normally open switch 51 which includes an arm 52 engageable by arm 53 when the bellows is expanded from normally collapsed condition.

The tube 13, or at least its upper portion, is of non-magnetic material and is surrounded by a solenoid coil 54. Plunger 17, which is magnetic, serves as an armature for coil 53, the arrangement being such that when the coil is energized the plunger is retracted so that flow can occur through the bore 20, around valve portion 16, and through orifice 16. In Figure 4 a line conductor 54 is shown as being in connection with one side of coil 53 through a wire 55 and the other side of the coil is in connection with switch arm 52 through a conductor 56. The other line conductor 57 is in connection with the switch arm 52 and, consequently, when the switch is closed, coil 53 will be energized.

In Figure 1, the valve plug 38 is indicated as being driven by a motor 50 through a speed reducer 59 and in Figure 3 the direction of rotation of the plug is indicated as clockwise. With the plug in the position shown, air under pressure is being supplied from the source 40 to the casing recess 43 and thence to pipe 44. The bellows is immediately expanded closing switch 51, as shown, and thus energizing coil 50 so that plunger 17 is retracted and the valve member 18 is seated, as shown. Due to the lag caused in the choke 45, this energization occurs slightly prior to the limited upward movement of the pump piston and when this movement occurs, a drop of content substance, tube 13 being filled therewith, is forced through orifice 16, the size of the drop being determined by the length of the piston stroke as controlled by the abutment 28. The operated relation of the parts is maintained for the instant required for the end of the plug passage 39 to pass the end of recess 43 into register with the exhaust pipe 42 and, at that point, the opposite end of the plug passage has reached the opposite end of the recess 43 so that the system is exhausted. The bellows collapses, spring 33 returns plunger 17, Figure 1, and returns plug 26, and tube 13 is replenished by content substance drawn through the check valve 33 as the piston descends, spring 35 being substantially weaker than spring 23. When coil 53 was de-energized by the opening of switch 51, spring 33 snapped plunger 17 to seated position, imparting a substantial jar to the nozzle and thus sharply breaking the drop loose as assisted by the entry of stud 19 into orifice 16. The released drop is in effect, shot upwardly, but without disruptive result, into the body of encapsulating material in the lower part of cylinder 12 and quickly assumes a substantially spherical form.

Projecting through a radial opening adjacent the lower end of cylinder 12 below the level of encapsulating material desired to be maintained in the container 31, by the cylinder 24 in conjunction with the base plate, is the tip end of a nozzle 60. The extremity of the nozzle tip is closed and between it and on the wall of the cylinder the tip is provided with peripheral openings just beyond a seat which is provided for a spring pressed ball 61. The outer end of the nozzle is threaded in an opening in a housing 62 in which is reciprocable a nut 63 having a cylindrical extension 64 constituting a piston working in a cylindrical portion of the nozzle, the nut being held against rotation by means of a finger 65 which is received in a longitudinally extending groove 66 in a wall of the housing. The nut is engaged by a screw 67 journaled in an end wall of the housing and having fixed therein outwardly on the wall a ratchet wheel 68 with which is cooperating a pawl 69, Figure 4, pivoted to the armature 70 of a solenoid 71, the ends of the solenoid being in connection, respectively, with lead 54 through a wire 72 and with switch arm 52 through a wire 73.

With the piston 64 retracted, a stick of gelatin in plastic condition can be introduced into the nozzle through a door 74, Figure 3, which may then be latched closed in any suitable manner. Wheel 68 may now be manually turned to advance the piston so as to push the gelatin mass up to the check 61. Thereupon, the apparatus being set in operation, solenoid 71 will be energized each time switch 51 is closed so that wheel 68 is stepped around and gelatin is intermittently extruded past the check into the container. When the supply in the nozzle is exhausted, the piston 64 is again retracted and a new stick of plastic gelatin inserted. The check 51 prevents withdrawal from the container when the piston is retracted.

The lower part of cylinder 12 is heated, with the heat localized as far as possible in any suitable manner. Induction heating may be utilized as here indicated. In Figure 2, a coil wrapped around the lower portion of the cylinder 12 has its ends 75 and 76, Figure 1, in connection with a source of high frequency power and a second coil has its ends 77 and 78 in connection with a high frequency load tuner. Preferably, a gelatin is used having a relatively high gel point, for example 100° F. since such a gelatin has superior strength. The gelatin in the container should be
in free flowing condition such as is produced at a temperature, for example, of 115°, and may have a specific gravity of the order of 1.090.

Since the nozzle 66 projects into the heated container, the gelatin in its extremity will be relatively fluid but to prevent the heating of the plastic gelatin in the outer portion of the nozzle, the latter may be jacketed as indicated at 79, Figures 2 and 3 for the circulation of a cooling fluid. The point is that the plastic gelatin should be maintained in that condition as nearly as possible up to the time of its discharge into the container.

Furthermore, the volume of liquefied gelatin in the container should be maintained at a minimum. In general, the cross-sectional area of the gelatin body should be no greater than to enable the nascent capsules to rise without bumping the cylinder wall and without creating too much turbulence, and the depth of the gelatin body should be substantially only that necessary to permit the desired accretion of encapsulating material by the injected drops. In this manner, no gelatin will remain in the heated bath long enough to materially deteriorate. The gelatin in the bath is conditioned in relation to the size and frequency of the injected drops of content substance and the delivery rate of the gelatin extrusion apparatus is such as to maintain a substantially constant level of gelatin in the container, this level being generally indicated at L in Figure 1. Different pawl and ratchet drives may be used to obtain different rates of feed.

The upper end of cylinder 12 projects into and is sealed against the rabbeted lower margin of a circular opening 80 formed in a circular plate 81, the interior of the cylinder being flush with the opening. Threaded on the plate is a ring 82 having an annular groove receiving a gasket 83 which makes a peripheral seal with a cylinder 84 which is supported on the plate. Support for the portion of cylinder 85 is provided with a number of symmetrically disposed upwardly and inwardly directed openings 87. Reference numeral 88 designates an inlet pipe for the hardening fluid, which in this instance is water at the required temperature, the pipe being lead into the upper end of cylinder 84 to the annular space between the two cylinders.

Supported on the upper end of the cylinders is a pan 89 having a bottom opening 90 registering with the inner wall of cylinder 85. At one side the pan has a weir 91 below which is an inclined screen 92 whose lower end is above a conveyor 93.

Water introduced through pipe 88 flows down the annular space and into cylinder 85 in an upward direction and fills the container means from the gelatin level L up to the overflow. The flow into cylinder 85 is even, due to the symmetrical disposition of openings 87, so that turbulence immediately above the gelatin bath is minimized. The upwardly convergent currents tend to hold the rising capsules to the center line of the container. The temperature of the water may be maintained at, for example, from 60 to 75° F. By using a suitable anti-freeze, the temperature of the water can be maintained below 32° F. if desired, but the higher temperature range mentioned is ordinarily satisfactory. The water directly adjacent the gelatin bath of course graduates in temperature from that of the bath to that of the main body of water. There is an appreciable intermersion of the water and liquid gelatin with the beneficial effect, mentioned at the outset, of providing an easy passage of the soft skinned capsule from the gelatin body to the water body. However, there is no general dilution of the gelatin body by the water. In rising through the water column, which is also rising, the gelatin coating of the pellets hardens and the pellets pass over the weir 91 and then roll down screen 92 onto the conveyor 93 the water falling through the screen. The conveyor delivers the pellets for further processing or packaging.

The content material may be medicinal oils such as vitamin-rich fish oils, for instance a soup-fin shark oil having a specific gravity of 0.920 at 70° F. As above mentioned, the gelatin may have a specific gravity of 1.090, but since the content material constitutes the dominant part of the coated pellets, the specific gravity of the latter will still be less than that of pure water so that the pellets will readily rise through the latter.

I have shown the invention in one practical embodiment by way of example and it will be understood that other forms and arrangements of parts are possible and are contemplated under the invention as defined in the following claims.

I claim:

1. A capsulating apparatus comprising receptacle means containing a body of liquid encapsulating material, a conduit in connection with the bottom part of the receptacle means for the supply thereto of liquid content substance, valve means comprising a valve seat in the conduit adjacent said receptacle means and a spring loaded valve body cooperating with said seat and normally preventing discharge from said conduit, said valve body being magnetic, a coil with respect to which said valve body is arranged as an armature, an energizing circuit for said coil and a normally open switch therein, a source of content substance, a pump having its intake side in connection with said source and its output side in connection with said conduit, expansible chamber means associated with said pump for the operation thereof, expansible chamber means for operating said switch, a source of air under pressure, a control valve in connection with said air source and both of said expansible chamber means, means for operating said control valve for the intermittent supply of air to both of said expansible chamber means, and choke means between said control valve and the expansible chamber operating means for the pump.

2. In capsulating apparatus comprising a container for a liquid encapsulating material and a nozzle associated with the container for the intermittent injection of content material into the container, the combination of means for jarring the nozzle at each injection to detach a drop of the content material therefrom.

3. In capsulating apparatus comprising a container for a liquid encapsulating material and a nozzle associated with the container for the intermittent injection of content material into the container, the combination of a plunger slidable in said nozzle, an abutment for said plunger in the extremity of the nozzle, spring means urging said plunger against the abutment, and means
for retracting said plunger at each injection and releasing it for return by said spring means whereby to jar the nozzle to detach a drop of the content material therefrom.

4. In capsulating apparatus comprising a container for a liquid capsulating material and a nozzle associated with the container for the intermittent injection of content material into the container, the combination of a valve body movable in the nozzle, a seat at the tip of the nozzle for said valve body, spring means urging said valve body against said seat, and means for retracting said valve body at each injection and releasing it for return by said spring means whereby to jar the nozzle to detach a drop of the content material therefrom.

5. In the manufacture of seamless capsules by intermittently injecting liquid capsulating substance from a nozzle into a bath of liquid capsulating material whereby to form pellets comprising a core of the content substance and a soft coating of the capsulating material, and then hardening the coating, the method which comprises jarring the nozzle at each injecting action to facilitate the separation of a drop from the nozzle.

6. Capsulating apparatus comprising container means for a capsulating material, a vertically elongated tank above said container means in communication therewith and of larger horizontal section than the same, a curtain in said tank defining an annular chamber therewith spaced outwardly of said container means, an inlet at the upper end of said chamber for a liquid which is hardening as to the capsulating material, passage means between the lower part of said chamber and the interior of said curtain, an overflow at the top of said curtain, and means for injecting drops of content substance into the bottom of said container means, said passage means comprising a number of inwardly and upwardly directed openings in said curtain.

VERNON V. STEPHENSON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,612,167</td>
<td>Beardsley et al.</td>
<td>Dec. 28, 1926</td>
</tr>
<tr>
<td>2,342,601</td>
<td>Gunnell</td>
<td>Feb. 20, 1944</td>
</tr>
<tr>
<td>2,373,816</td>
<td>Mabbs</td>
<td>July 3, 1945</td>
</tr>
<tr>
<td>2,436,439</td>
<td>Lincoln et al.</td>
<td>Feb. 24, 1948</td>
</tr>
</tbody>
</table>