Dec. 25, 1956 F. E. STIRN ET AL. 2,775,267

METHOD AND APPARATUS FOR FILLING CAPSULES

Original Filed March 23, 1948 6 Sheets-Sheet 1

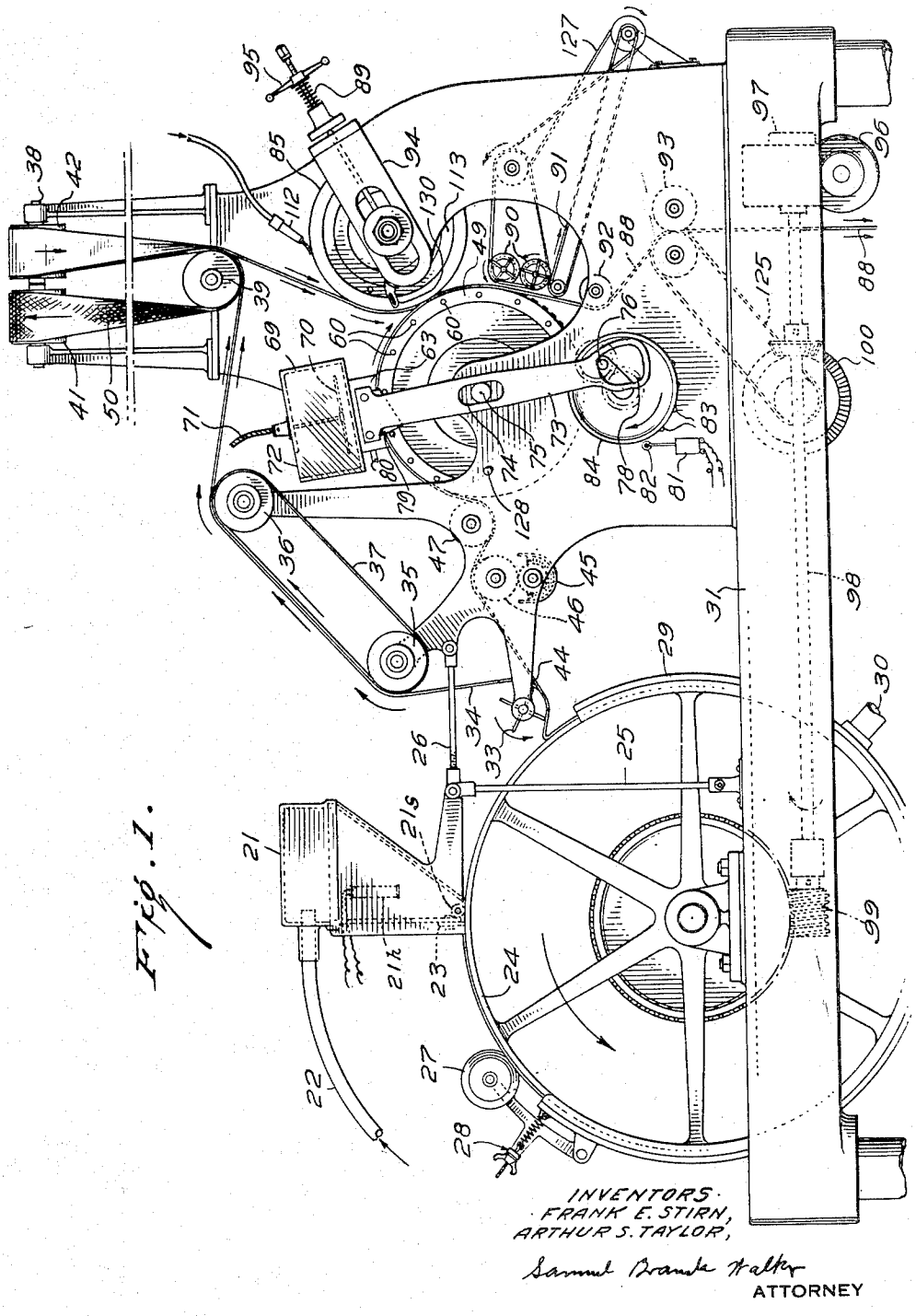


Fig. 1.

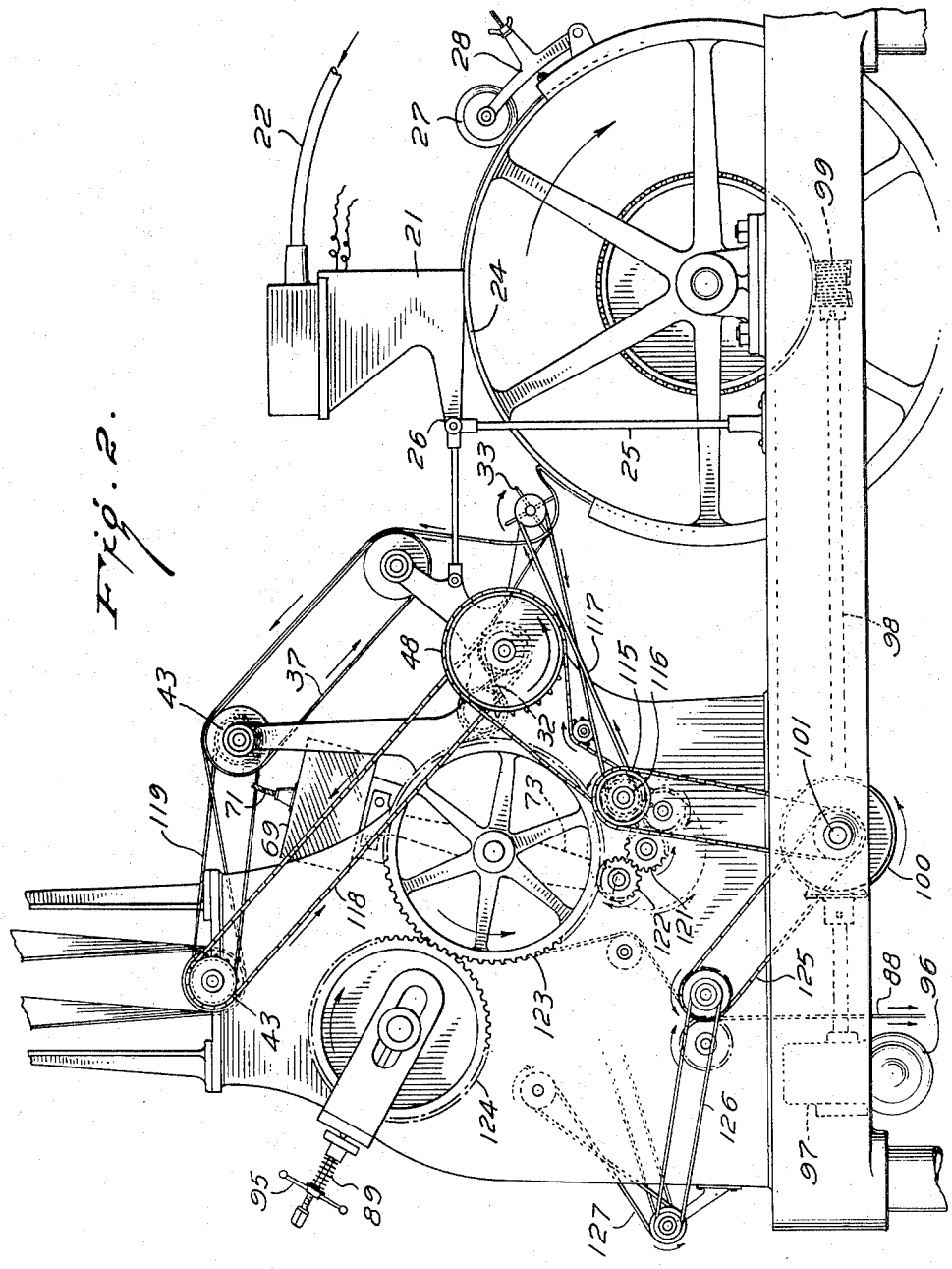
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METHOD AND APPARATUS FOR FILLING CAPSULES

Original Filed March 23, 1948 6 Sheets-Sheet 2

Fig. 2.



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METHOD AND APPARATUS FOR FILLING CAPSULES

Original Filed March 23, 1948 6 Sheets-Sheet 3

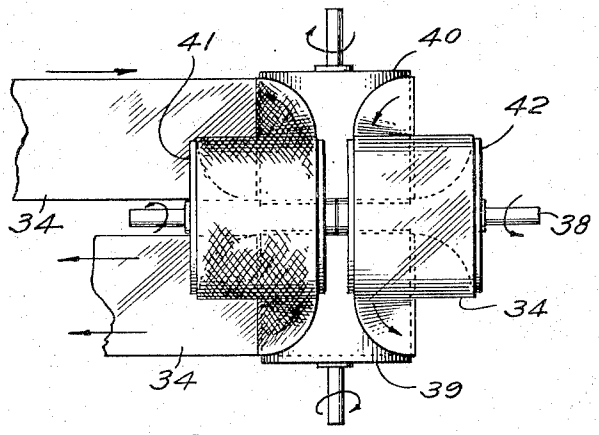


Fig. 4.

Fig. 3.

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METHOD AND APPARATUS FOR FILLING CAPSULES

Original Filed March 23, 1948 6 Sheets-Sheet 4

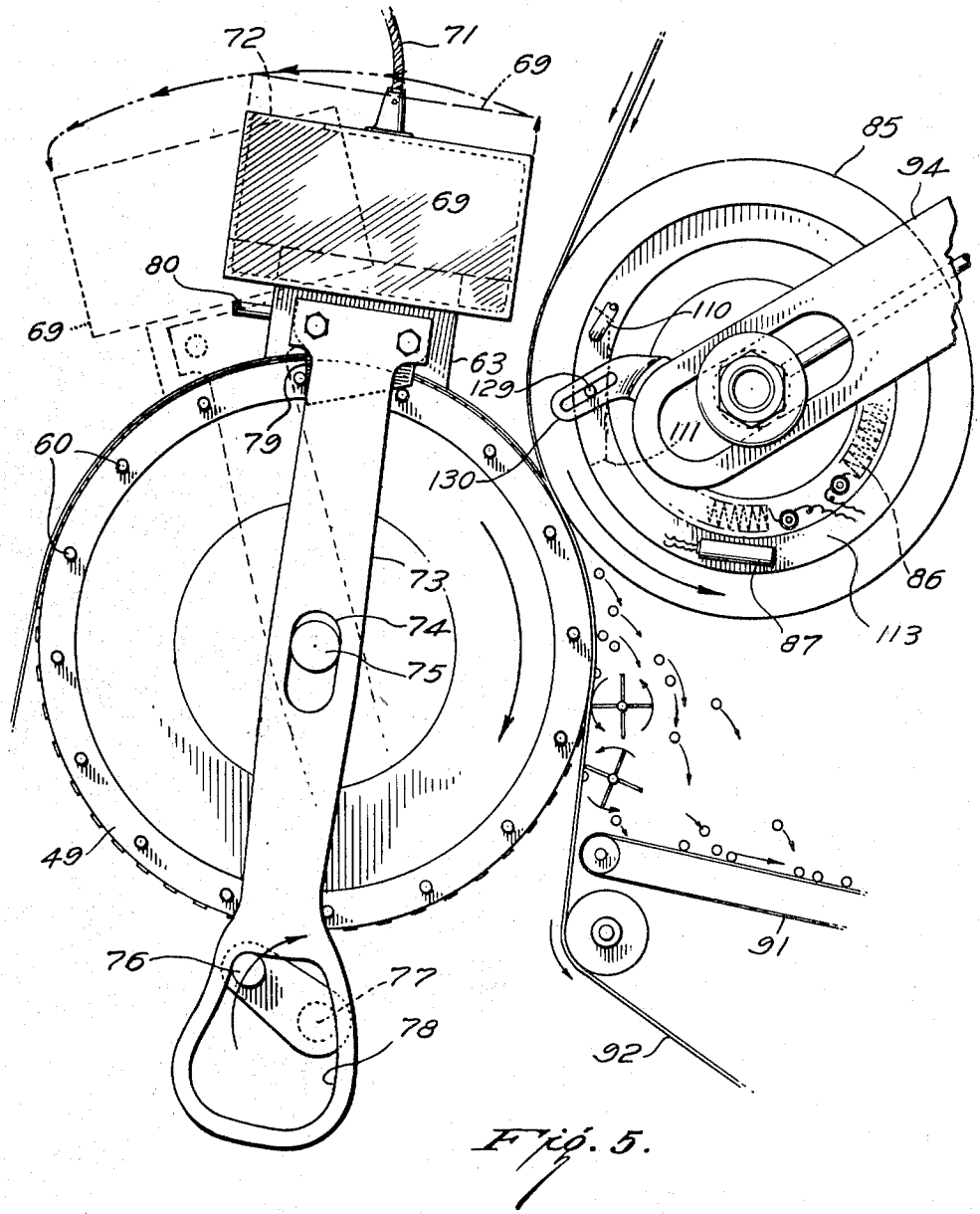


Fig. 5.

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Original Filed March 23, 1948 6 Sheets-Sheet 5

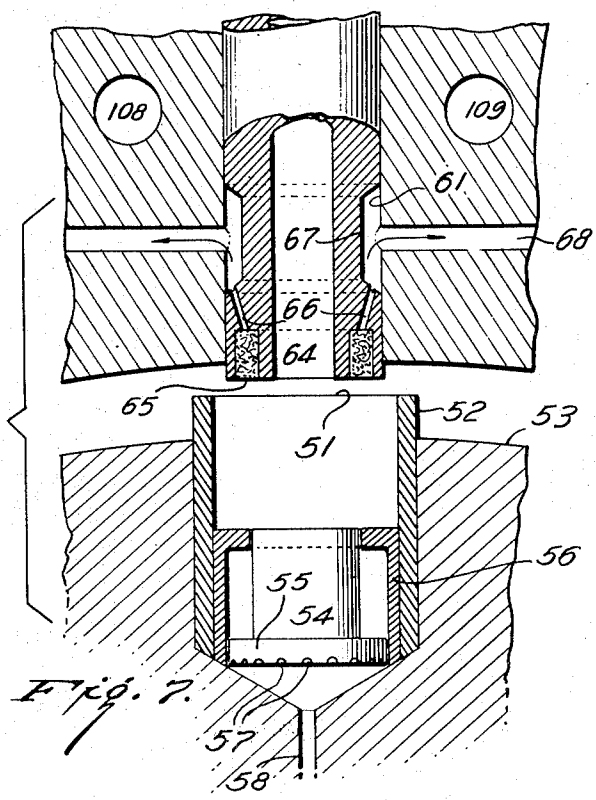


Fig. 7.

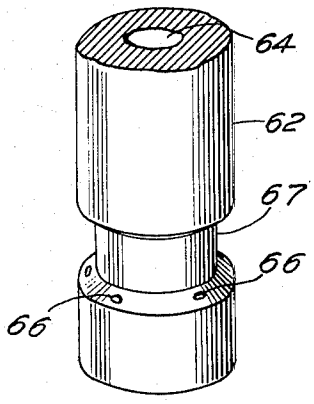


Fig. 8.

Fig. 6a.

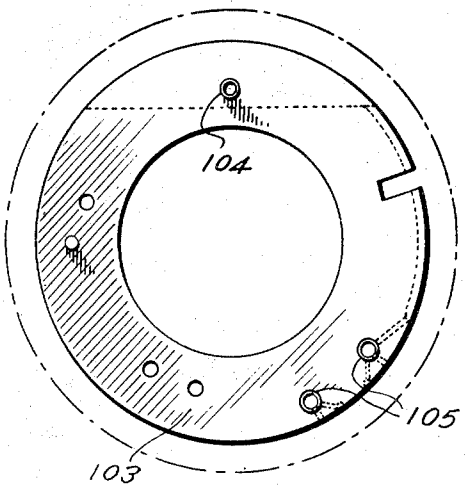
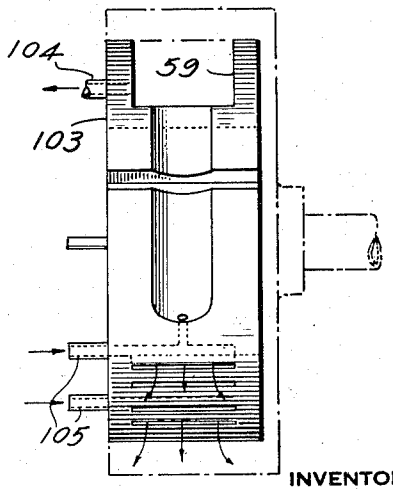


Fig. 6.



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METHOD AND APPARATUS FOR FILLING CAPSULES

Original Filed March 23, 1948 6 Sheets-Sheet 6

Fig. 9.

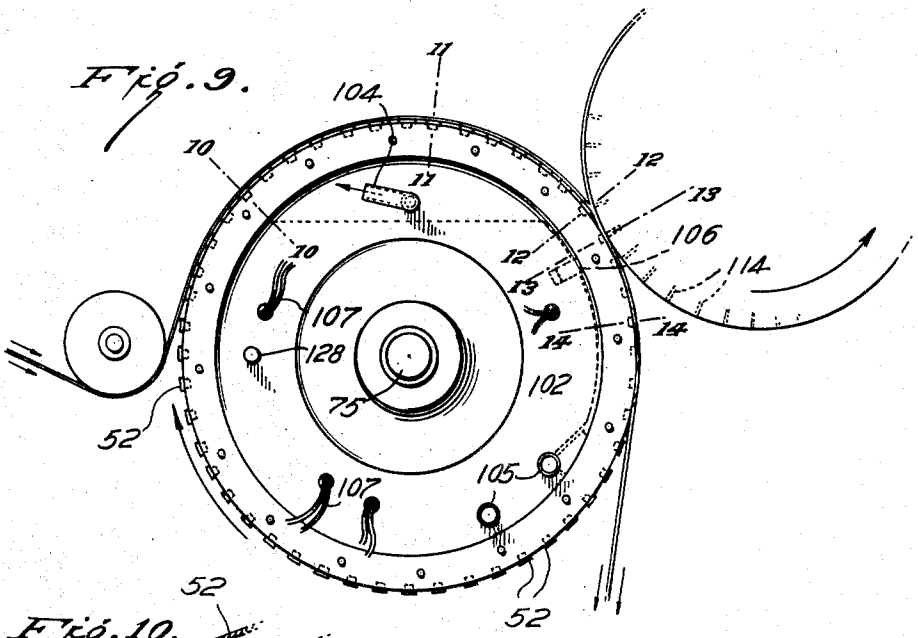


Fig. 10.

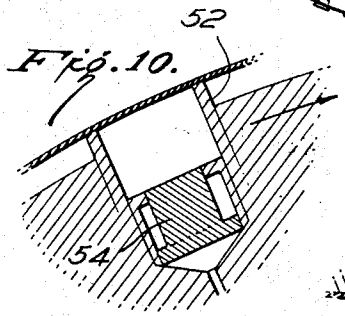


Fig. 11.

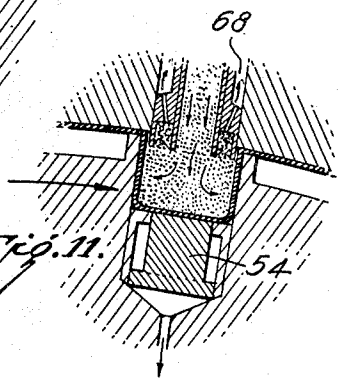


Fig. 12.

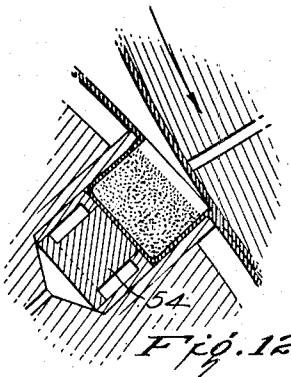


Fig. 14.

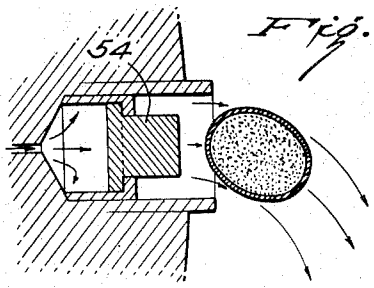
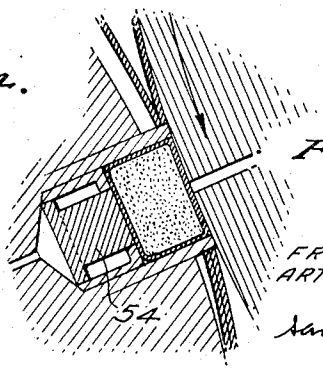


Fig. 13.



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METHOD AND APPARATUS FOR FILLING CAPSULES

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Original application March 23, 1948, Serial No. 16,554, now Patent No. 2,663,128, dated December 22, 1953. Divided and this application April 27, 1953, Serial No. 351,106

6 Claims. (Cl. 141—1)

This invention relates to a method and apparatus for filling a powder into a capsule forming shell in a plastic strip lined capsule forming cavity. This application is a division of our co-pending application Serial Number 16,554, entitled Method and Machine for Making Capsules, filed March 23, 1948, now Patent No. 2,663,128, dated December 22, 1953.

The complete operation of the capsule forming machine is described in order that it may be clearly seen how the powder filling operation cooperates therewith.

It is an object of this invention to fill a flowable powder into a capsule shell formed by sucking a plastic strip into a capsule forming cavity which is lined thereby. A soft gelatin composition is readily obtainable commercially and accordingly gelatin capsules are most common. Gelatin substitutes may be used.

It is another object of this invention to compact a powder to a uniform density and volume in a capsule forming shell in a plastic strip.

It is an additional object of this invention to suction fill, with powder, capsule forming shells in a vacuum retained plastic strip which lines capsule forming cavities in a cavity die roll.

It is a further object of this invention to provide a filling head block which is juxtapositioned, during a filling cycle, in timed relationship with a plastic strip, which covers capsule forming cavities in a cavity die roll.

It is a still further object of this invention to provide a filling block having passages for a powder to flow from a superposed hopper to the capsule shells beneath the block during the filling cycle, and having either integral or assemblable in the block a foraminous material, through which a suction acts to cause the powder to flow through the passage and into the capsule shell.

It is an object of this invention to provide heating means for the filling block so that the passages in the block and through the foraminous material will not be clogged by moisture condensing therein.

Further objects, advantages and meritorious features will appear from the following description, appended claims and accompanying drawings.

Figure 1 is a side elevation of a particular form of an apparatus embodying the present invention.

Figure 2 is a rear elevation showing more particularly certain of the drive mechanisms for the various gears, cams and rollers.

Figure 3 is a pictorial view showing the paths of the plastic strips as they pass through the machine.

Figure 4 is a top view of the sealing film turn-over mechanism.

Figure 5 is an elevation of a portion of the die roll structure showing temperature control elements and the positioning mechanism of the filling heads.

Figure 6 is a front view of the stator of the cavity die roll, showing the pressure and vacuum chests, heat control, etc.

Figure 6*a* is a side view of the stator.

Figure 7 is an enlarged view of a single die of the die roll and its cooperating filling head.

Figure 8 is a pictorial view of a filling head.

Figure 9 is a view showing the various coordinated phases of the die wheel operation.

Figure 10 is a fragmentary view on an enlarged scale taken along the line 10—10 of Figure 9, showing the lower film in position over the die cavity.

Figure 11 is a similar view along the line 11—11 of Figure 9 showing the die cavity containing the deformed lower film with the filling head in filling position as the powder flows into the cavity.

Figure 12 is a similar view along the line 12—12 of Figure 9 showing the filled individual cavity as the upper sealing film is positioned thereover.

Figure 13 is a similar view along the line 13—13 of Figure 9 showing the joining and cutting out of portions of the two films to form the individual capsule.

Figure 14, along the line 14—14 of Figure 9, shows the air ejector mechanism whereby the capsule is ejected from its mold, showing more particularly how the capsule rounds out as it is ejected, forming with a substantially equatorial joining line.

This improved apparatus is designed to rapidly and efficiently produce capsules of consistent size. In the past it has been common to produce soft gelatin capsules filled with liquid or with pastes. If solids were to be encapsulated, such solids were dispersed in a liquid to form a paste so that the materials could be filled on the then existent machines.

With the development of purer and more potent vitamin products, the use of materials such as fish liver oil has given way to the use of more constituents of vitamin capsules in solid form. Many of the vitamins are now obtainable or may be converted to a particulate form, and their use in a powdered form possesses certain conveniences and therapeutical advantages, the full commercialization of which has been handicapped by the lack of a suitable encapsulating machine.

The use of powders has long been known in hard gelatin capsules, in which the capsule body is first formed, then filled, and then a cap placed thereupon. The prior art has been uniformly unsuccessful in producing satisfactory, adequate, and cheap machines for the filling of powders into soft gelatin capsules. Our machine fills the need. It will rapidly, easily and accurately form such powder filled capsules. This machine can be readily and conveniently adapted to fill liquids or pastes or can be used with films of material other than gelatin, if such materials are plastic, are capable of being formed into films, and if such films will unite with each other when passed through sealing rolls.

More particularly, in our machine, molten gelatin as described below, is prepared and fed into the hopper 21. For temperature control it is desirable that the hopper be equipped with a thermostatically controlled heater element 21*h* so that the gelatin may be kept at a desired temperature. If the hopper is constructed of brass the heat conductivity of the material will enable the heat to be applied at one location, as shown in Figure 1. If other materials of construction are used, a more uniform distribution of heat over its surface may be desirable. A jacketed hopper may be used with a suitable fluid heat transfer medium. The hopper 21 may be filled by a gelatin supply line 22 connected to a suitable source by which the gelatin in the hopper is maintained at a reasonably uniform level. The gelatin hopper may be equipped with a transparent plastic top or itself be of transparent materials in order that the gelatin level may be observed, but yet maintained free from danger of contamination, and from loss of volatile constituents. The gelatin feeds

through the hopper under a doctor blade **23**. The gelatin doctor blade may be separate or formed integral with the hopper, which may ride on the surface of the casting wheel **24**, which wheel is formed preferably from a metal such as cast iron which should be given a highly polished surface, as for example by chrome plating. The hopper with the attached doctor blade is preferably adjustably locatable by means of links **25** and **26** and adjustable shoes or rollers **21***s*, riding on the surface of the casting roll so that the thickness of the gelatin film may be conveniently regulated. The hopper may be rigid if the doctor blade floats in the desired relationship to the drum surface.

The doctor blade may be divided vertically in the center and each division made independently adjustable so that two separate thicknesses of film may be cast at the same time so that the two different films will each be of independently adjustable thickness. This individual adjustability is of value in adjusting the position of the equatorial seal and in insuring that the wall thickness of the different portions of the capsule will be in accordance with the operator's desires.

The gelatin film is split into two portions by a splitting roll **27** which is a reasonably sharp rotatable knife, spring loaded by an adjustable spring mechanism **28** so as to separate the cast film into two separate strips. The splitting roll may be located adjacent to the gelatin hopper as shown, or may be located further around the casting wheel. It is only necessary that the gelatin film be somewhat solid at the splitting point, so that the gelatin will not flow back together after being split.

The entire mechanism is best located in an air conditioned room so that both temperature and humidity may be controlled so as to maintain the gelatin film in the desired condition throughout. The casting wheel is covered with a shield **29** which is located so that it is adjacent to but does not interfere with the rotation of the wheel. An exhaust duct **30** is provided through which the air is exhausted so that dry conditioned air from the room is pulled through the casting wheel shield **29** where it dries and conditions the surface of the gelatin film, and is exhausted either into the room or an exhaust duct, depending upon moisture load conditions. The casting wheel is suitably supported from a main frame **31** and driven in suitably timed relationship with the rest of the mechanism by a mechanical drive means.

The partially dried and conditioned gelatin strip is removed from the casting wheel by a stripper paddle **33**. The stripper paddle is driven by a belt or other suitable drive at a faster speed than the peripheral speed of the casting wheel so as to pull off the gelatin film by its action. The repeated soft blows of the leading edges of this paddle as the paddle is rotated has a tendency to strip the gelatin film without damaging or stretching the film. It is highly advantageous in the production of spherical capsules that the gelatin film be not stretched.

Under certain operating conditions as is later described, it is desired to stretch markedly the gelatin film by keeping it under tension, and forming the capsule while under tension. Under such conditions, a stripping roll may be substituted for the paddle. When so formed the gelatin strip material attempts to pull back to its original shape to relieve the strain and accordingly, elliptical capsules are produced from round molds. If elliptical shaped capsules are desired, they may be produced in round dies by prestretching the film. Under the normal relationships, where it is desired that a round die cut a round capsule, it is accordingly equally desirable that the gelatin film be not stretched and remain substantially isotropic, so that the finished capsule will retain the desired shape.

As shown particularly clearly in Figure 3, the two gelatin strips take separate paths from the stripper paddle. The sealing film **34** goes above the die roll and may be supported over guide rolls **35** and **36** on which may be placed a carrier belt **37**. The carrier belt and rollers should be of a material which will not stick to the gelatin. It is possible and frequently convenient to use rolls made from "Teflon" (polytetrafluoroethylene, see U. S. Patent No. 2,230,654 to Plunkett), or from sintered metals which are fed with an oiler to form oiled surfaces to which the gelatin strip will not adhere. If several rollers are used, a carrier belt is not necessary.

After passing over these guide members the strip itself is fed under and over a turnover mechanism **38**. It has been found that for the gelatin sealing film to properly adhere to the lower film it is necessary that the casting wheel side of the gelatin sealing film **34** be placed in juxtaposition with the casting wheel side of the lower strip **44**. The outer face of the strip forms a toughened and hardened surface, apparently from the evaporation of the moisture therein, so that it is not nearly as adhesive as the protected side of the strip. The outer tough side seals only with difficulty, and such a seal is more fragile and shows a greater tendency to split.

The turnover mechanism as illustrated, consists of two suitably journaled rollers **39** and **40** on a shaft parallel to the die roll axis and two suitably journaled rollers **41** and **42** on an axis perpendicular to the previously mentioned axis and thereabove, so that a belt **50** traveling over these pulleys in the order **40**, **42**, **39**, **41** and back to **40** will pick up the film as shown in Figure 3, lift the same through 90° to a vertical direction, rotate through 90°, reverse the film into another twist of 90° so that the film is fed out of this turnover mechanism with the casting roll side reversed, and shifted laterally so that this film is now in the same frontal plane as is the lower film. The guide rolls **35** and **36** may be driven by a suitable drive system **43** as is shown more clearly in Figure 2. Some of the rolls may be driven by traveling belts, as for example the carrier belt **37**, or the turnover carrier belt **50**. Certain of the rollers may indeed may be allowed to be idlers if they are journaled on comparatively friction free bearings so that the gelatin film itself will cause such guide rolls to rotate.

The lower strip of the gelatin **44** is, after being stripped from the casting wheel by the stripper paddle **33**, fed over guide rolls **46** and **47**. Guide roll **46** may be oiled by means of a brush **45**, rotating in a shallow bath of oil. Alternately this guide roll may be made of foraminous material, as for example sintered brass, through which oil is fed from a suitable feed mechanism. It is desirable that a thin film of oil be maintained on the surface of this roll so that the outside surface of the gelatin film is oiled so that it will not adhere as readily to later portions of the mechanism. The guide roll **46** is preferably driven by a sprocket drive **48**, shown in Figure 2, so that the surface speed of the pulley is substantially the same as the surface speed of the casting drum. The roll **47** is driven from roll **46** by a crossed belt roll drive system **32**. The lower strip of gelatin **44**, thence passes to the cavity die roll **49**.

The cavity die roll is a most important feature of the instant machine. The cavity die roll is designed with a plurality of cavities in its peripheral surface, each cavity forming a single gelatin capsule with each rotation of the cavity wheel. The individual capsule charge is placed in this cavity and it is important that the machine work done in forming the cavity die wheel be of a high order so that the cavities will be of precisely identical dimensions. The consistency of successive charges and the consistency of the size of the filled capsules depends, to a large extent, upon the accuracy of this cavity die wheel. The exact number of cavities in the face of the die wheel is not of critical importance except to the extent that it determines the number of capsules filled in each revolution. As shown in the sketch in Figure 3, there are three rows of cavities in staggered relationship around the periphery of the wheel. A single row or any number of rows may be used as desired. There may be any desired

number of cavities per row around the circumference of the cavity die roll. For illustrative purposes there are 48 cavities shown in each row in the accompanying drawings. As shown more clearly in Figure 7, each cavity 51, which serves as a filling chamber is cylindrical in nature and has a raised rim 52. The raised rim preferably has a width of approximately one to two times the thickness of the gelatin strip. For small size capsules a width of 0.030 inch has proved satisfactory. The height of this raised rim 52, above the surface of the cavity roll should be at least twice and preferably about three times the thickness of the individual gelatin film. The cavity roll surface 53 is in general the surface of a cylinder but its accuracy is not particularly critical. The surfaces of the raised rim are necessarily very accurate as this raised rim must contact the sealing roll at all portions, during rotation, to give cut-out of the capsule.

The cavities may be elliptical, hexagonal, square, or such other shape as may be desired. The cavity may taper towards the bottom, although no particular advantage is found therein. Such modifications are within the scope of the invention, but are not frequently useful, as the complexity of the machining operations involved usually outweighs the advantages.

Each cavity has inserted therein an ejector plug 54. For cylindrical cavities this plug is cylindrical in configuration with a rim 55 thereon. These plugs fit loosely into a plug retainer 56. The plug retainer should fit rather snugly into the cavity so that it will retain its position therein during operations. It may, of course, be held by pins, set screws, or other suitable means if desired, but with good machine shop facilities available it is usually cheaper to merely make this plug a press fit. Either the rim of the plug or the bottom of the cavity should be slightly rough or serrated as shown at 57, so that the plug can not seal tight against the bottom of the cavity. The bottom of the cavity has an air duct 58 leading from its bottom through the cavity die rolls to pressure and suction chests, as later described. In operation the plug should be of such height that when in its lower position it is substantially even with the upper surface of the plug retainer, so that the filling cavity is a flat bottomed cylinder. The depth of this cylinder determines the depth of the fill for each individual capsule and should be consistent for all the cavities in the cavity die roll. This is best obtained by using precise machine operations throughout the construction of the cavity, the ejector plug and ejector plug retainer. There must be sufficient clearance around the edges of the plug so that air from the air duct 58, can raise the ejector plug until its rim contacts the retainer and is thus held in a raised position by air pressure and so that air may be evacuated from the cavity during the evacuation portion of the filling cycle. It is desirable but not necessary that the plug come to approximately the top of the cavity when raised by air pressure as it aids in the ejecting of the capsule. The cavity rim may be built up or the rim and the plug retainer made integral and screwed into the surface of the die roll, or such other construction used as may be more convenient under particular manufacturing conditions, with equipment available.

The individual cavities should be fairly accurately spaced around the periphery of the cavity die roll for convenience, as shown in Figure 3. The cavity rolls should be accurately and firmly journaled, as for example by roller bearings upon a very solid shaft, or the shaft should be solidly journaled upon appropriate bearings, because pressures induced by air pressure and vacuum applied during the filling operations may otherwise cause deflection, undue friction, and chattering of this roll.

By suitable manifolding means, as for example illustrated by Figure 6*a*, the inside of the cavity die roll 49, has a die roll stator 103 containing a suction chest 59 in contact with the interior surface of the cavity die roll so that air is evacuated through air duct 58, during suitable portions of the filling cycle. Air pressure acts through duct 58 during other portions.

This is most easily arranged by a stator 103 in which is arranged the suction chest 59 which has as an integral part thereof manifolding means such that suction is applied over the desired portion of the filling cycle, i. e. from the point 10—10 to 13—13 as shown in Figure 9. The suction may be applied through a suction connection 104. Air pressure is applied through the air pressure lead 105, which supplies pressure so that the ejector plugs 54 are raised at approximately the point 14—14, shown in Figure 9. The use of multiple air blasts, by manifolding as shown, is particularly effective in clearing the cavities. A spring loaded sealing member 106 may be used to separate the vacuum from the pressure chests, which member may float in the stator so that any wear or unavoidable irregularities in the internal surface on the die roll will be compensated.

Whereas it is possible to use a stationary shaft upon which the stator is locked, for convenience of drive though the die roll is solidly attached to the axle 75, which is gear driven, and the stator is kept from rotating by a stator positioning pin 128.

For temperature control of the die roll it is particularly convenient to install heating members in this stator, which may well be of brass. Leads to this heating element are shown diagrammatically at 102. For temperature control it is desirable that the temperature of this stator be controlled, as by a thermostat. Leads to a thermostat are shown at 107. Any suitable type of thermostat may be used, including either one which is integral and individually adjustable or one may be used in which thermocouple leads are taken to an outside control. Many variations of temperature control will be obvious to those skilled in the art, and the exact type of thermal control is not an essential feature of the instant invention.

As shown in Figures 3 and 1, there are positioning pins 60 on the front surface of the cavity die roll which pins are accurately positioned with respect to the cavities and are used for the positioning of the filling head. In the particular configuration shown there are sixteen pins for forty-eight holes so that three sets of cavities, that is three cavities in each of the three rows, are filled with each stroke of the filling head. The filling head block 63 is arranged to function in timed relationship with the cavities so that during operation it performs a cyclic shift whereby it is lifted from the surface of the cavity roll, shifted backwards and allowed to drop to position, being accurately positioned by the pins 60 and remaining in contact with the cavity roll mechanism during a suitable portion of the rotation of the cavity wheel, after which it is raised to repeat the cycle.

The individual filling heads are shown in Figure 7. Each of them consists of a cylinder 61 in which fits a filler assembly 62. The filler assembly is positionable axially so that its lower edge projects below the surface of the filler head block 63 by an adjustable amount, usually equal to from 1 to 2 times the thickness of the film. The filler assembly 62 may be integral or built up and consists of a cylindrical shell through which passes a filler passage 64. This filler passage extends from the supply means, as described later, in a hopper through the filler assembly. Around the lower end of the filler assembly is an annular space filled with a foraminous material 65. The foraminous material may consist of felt, sintered glass or sintered metals. For filling routine vitamin products sintered metal is usually particularly convenient because it may be turned to size and even soldered or brazed in location so that the sizing is accurate, and it may be readily sterilized. From the upper surface of this foraminous material there is an exhaust duct 66. The exhaust duct leads into an exhaust annulus 67 cut into the periphery of the filler assembly which is in turn positioned opposite the exhaust mani-

fold 68, which in turn is connected to the exhaust tubing 80.

During the fill operations the filler head block 63 comes down into juxtaposition with the gelatin film riding on the cavity die roll 49. The exterior diameter of the filler assembly should be such that there is sufficient clearance between it and the cylindrical surface of the cavity for the thickest gelatin film which is to be used with the machine.

A plurality of these filler assemblies are positioned so that the 3 by 3 block of cavities has a filler head in each. The filler heads are mounted in a filler head block 3.

As shown diagrammatically in Figure 7, this filler head block may be equipped with a filler block heater element 108, and a filler block thermostat 109. As mentioned elsewhere, any of the conventional types of heaters and thermostats may be used. Electrical control is particularly convenient. Heating of the block is not always necessary but it is particularly convenient, when the machine is used for hygroscopic powders, as it keeps the block warm so that moisture will not cause the powder passages or the foraminous material to become clogged.

The filler head block has mounted thereon a powder hopper 69. The powder hopper is preferably made of transparent material so that its contents may be readily observed. As shown in Figure 1, the powder hopper has a stirrer 70 mounted therein which consists of wires mounted on a shaft which is mounted in the top of the powder hopper and is turned by a flexible shaft 71 driven by a suitable source of power. The filler passages extend up to this powder hopper. It is desirable that the stirrer be rotated sufficiently rapidly to avoid caking or bridging of the powder. If desired the powder hopper 69 may be provided with a feed opening 72 in which a flexible duct carrying additional powder may be inserted so that the hopper may be filled automatically or manually as may be desired with additional powder during operation of the machine so that the powder hopper is maintained sufficiently filled for constant operation without shutdown. For satisfactory results it is necessary that sufficient powder be maintained in the hopper at all times so that no filler passage draws air instead of powder from the hopper.

The filler head block assembly is positioned in relationship to the cavity die roll by means of the eccentric assembly system shown in Figure 5. The block 63, is mounted on a lifting arm 73, which lifting arm has a slot 74 therein through which is assembled the cavity die roll axle 75. At the lower end of the lifting arm there is an eccentric 76 mounted below the mid position of the cavity block on a suitable eccentric shaft 77. The eccentric itself, revolves in the eccentric guide opening 78. This opening is so proportioned that with the eccentric shaft rotating in the same direction as the cavity die roll, clockwise as illustrated, the eccentric 76 contacts the lower end of the lifting arm in approximately the position as shown in Figure 6. At this point the eccentric lifts the arm substantially radially relative to the cavity die block until the positioning block 79 clears the positioning pin 60. As soon as this pin is cleared the friction and direction of motion of the eccentric pulls the arm and the accompanying filler head block assembly in a counterclockwise direction in an elevated position to approximately the position shown at the dotted line in Figure 5. At this point the eccentric pin having passed its top center and having started downward, lowers the arm and the filler head block assembly until the pins 60 pick up the positioning block 79 and cause the entire assembly to rotate clockwise again. As the block is rotated clockwise the eccentric continues to drop until the entire weight of the filler head block rests upon the positioning pins and/or the gelatin film and cavity die roll, at which point the eccentric turns free in the eccentric guide opening until time for the cycle to begin again.

An identical mechanism is present on the back side of the cavity die roll so that the powder hopper is supported both in front and in back by an identical symmetrical mechanism. It is usually most convenient that this mechanism be behind the drive for the cavity die roll. For normal operations it is desirable that the weight of the cavity block rest on the gelatin film rather than on the positioning pins, so that the gelatin film acts as a seal and prevents the leakage of air around the periphery of the filler. It is desirable but not necessary that the positioning pins and positioning block bear a relationship such that if the gelatin film is removed by inadvertance, or at the beginning or end of operation, the weight of the filler block is taken by the pins rather than by the raised rims of the cavities. If the block is allowed to pound on the cavities with no gelatin in between, the rims may become battered.

By this mechanism and method the filler head block assembly is raised during the non-filling portion of the cycle and positioned again over a new set of cavities. Of course, the filler head block may have more or less filler heads to fill more or less cavities than shown per operation provided that the pins are positioned for each group of cavities as desired. Usually for the size capsules which are desired it more convenient if more than one capsule be filled per row per cycle. As illustrated three are filled.

The gelatin strip is fed under the guide roll 47 and into contact with the cavity die roll 49. As shown by the schematic Figure 9, this gelatin strip is positioned on the die roll resting on top of the raised rims 52. At the point shown by the line 10—10, Figure 9, the suction manifold admits suction to each cavity through the air ducts 58 which causes the gelatin film to be pulled tight against the raised rim 52 and drawn down therein to form a cup shaped lining in the filling chamber 51. Figure 10 shows the lower film positioned on the raised rim and Figure 11 shows the film having been pulled down into contact with the ejector plug and plug retainer. The suction is maintained on the chamber until after the capsule is sealed and cut-out. Usually a higher degree of vacuum is maintained under the gelatin film than is used above it in the filling operations.

As the gelatin lined chamber advances the filler head block is lowered into contact therewith, as described above, and shown schematically in Figure 11, taken on line 11—11. The filler assembly may enter partially into the gelatin lined container. The filling head itself preferably rests on the gelatin film.

At this portion of the cycle, at about the point 11—11 of Figure 9, the filling occurs. The filled powder should be of such consistency in relation to the size of openings that it will not flow through the filler passage 64 under the influence of gravity and such vibrations as occur, but instead, after the machine is in operation, blocks or bridges across the passage.

When the filler assembly is in position, vacuum is applied through the exhaust manifold 68. To insure adequate and proper filling, it is desirable that the air be evacuated through the passage 68 in slugs. This is accomplished by connecting the exhaust tubing 80 to a solenoid operated valve which is connected to a vacuum pump (not shown). The solenoid valve may be actuated by a microswitch 81, which has a contact member 82, riding upon actuating pins 83, on a cam plate 84. These contacting pins are so arranged that the solenoid releases the air through the exhaust duct 68 into the vacuum pump in bursts which gives a pulsating flow to the powder and causes it to compact to a uniform density in the filling chamber. The foraminous material 65 prevents the powder from flowing through the exhaust ducts and insures a comparatively uniform and consistent density of the powder. Under normal operating conditions, if subjected to a series of bursts of vacuum, five being a suitable number although from a single burst to as many

as a dozen (for different powders) may be used if desired, a powder may be compacted to a remarkably uniform density. It has been found that homogeneous powders will be normally compacted by such an arrangement so that the density of a charge will not ordinarily vary more than a fraction of one percent. If the charge chambers are of consistent size and the gelatin film is cast to a consistent thickness, this will mean that the individual chambers will be filled uniformly so that the final capsules contain equal dosages.

The size of these charges may be adjusted by varying the amount which the filler assembly **62** projects into the charge chamber, or by varying the depth of the charge chamber. Some variations may be introduced varying the pressures and vacuums used.

After the filling operation is completed, and the vacuum is released, the filling head block assembly is lifted by means of the cam and lifting arm, as explained above, the filled chamber rotates past the point shown by **12—12** as shown by the sketch in Figure 12, at which point the sealing film **34** is brought into juxtaposition with the filled charge chamber by the sealing roller **85**. The sealing roller **85** is spring mounted by a sealing roll spring assembly **89** so that the pressure between it and the cavity die roll may be readily varied and so that any irregularities may be compensated by spring action.

As shown in Figures 3 and 5, this sealing roll may have small apertures therein, conveniently though not necessarily mated to match with the cavities in the die roll, through which vacuum is applied as by the manifold **111** and the vacuum connection **110**. The suction through these orifices assists in positioning the sealing film so that it will not slide unduly on the surface of the sealing roll. If the particular gelatin compound used appears to stick to the sealing roll, an air pressure assembly, such as is used in the cavity die roll, may be embodied in the sealing roll to assist in releasing the gelatin film and capsules from the sealing roll. As shown at **112**, an oil fed wick may rest upon the surface of the sealing roll, being in turn supplied by a suitable oil supply so that a thin film of oil is maintained on the surface of the sealing roll at all times to prevent adherence of the gelatin to this roll. It will be found that if the roll is over-heated the gelatin is particularly apt to stick, and that if a gelatin mix requires a higher temperature, particular care is necessary to insure that this roll have a high gloss and be adequately oiled to prevent sticking or building up of gelatin on the surface.

As more particularly shown in Figure 5, a heater member **86** is in contact with the side of this sealing roll stator **113**, and is thermostatically controlled by means of a thermostat **87** so that the temperature of this roll may be maintained as desired. Whereas the thermostat and the heater are shown in a stator, they may be built as sliding upon the side surface of this sealing roll or the heater and the thermostat may be built integral with this sealing roll and connections may be by sliding contacts brought out through the axle if desired. The stator is retained in position by the sealing roll stator positioning pin **129** and its associated bracket **130**. The temperature adjustment of this roll may be critical as will be later described.

As the cavity die roll and the sealing roll rotate together, the spring action above described, first causes the sealing film **34** to contact the lower strip **44** and then to press upon this lower strip which in turn is supported by the raised rim **52**, until the raised rim cuts into the combined gelatin films, as shown at Figure 13. The compression action caused by this pressure causes the gelatin caught between the raised rim and sealing roll to be extruded and as it is pressed between these members it unites with itself so that a sealed joint is formed. The two gelatin films under proper operating conditions are so uniformly united that it requires inspection to locate the seal and the seal is nearly as strong as the wall of the capsule. The residual web **88**, is forced down on the outside of the raised rims **52** and into the space provided therein. As the two rolls separate as they turn, air pressure may be applied by means of a manifold under the cavity die so as to raise the ejector plug **54** as shown in Figure 14, taken along the line **14—14**. This action of raising the ejector plug causes the filled capsule to be pressed out of the chamber and allows it to spring to its natural shape.

To give a good clean seal and to cut the gelatin completely out of the web it is desirable that the sealing spring assembly **89**, press comparatively firmly upon the surface of the sealing roll. If there are any irregularities in the rim, a small flash may remain which may cause the capsule to stick in the web, but under normal operating conditions, if the rolls are accurately made, the capsules will be completely detached. As shown in Figure 1 and in Figure 9, the capsules after passing the line **14—14** have a tendency to be ejected by the plug and air pressure. This is followed by the action of two revolving brushes **90**, which rotate in a counter-clockwise direction at a comparatively high rate of speed, their peripheral speed being several times the surface speed of the cavity die roll. These brushes have an additional tendency to throw the capsules upon a conveyor belt **91** which removes the capsules to a discharge point. The web with the capsules cut out thereof is pulled around the web roller **92** and through the web removal rollers **93**, which rollers are rotated at a slightly higher surface speed so as to pull the web and stretch it so that it is easily removed. The web from this point is fed to a waste container or otherwise disposed of. Other means may be used to remove the residual web, as frequently just gravity is adequate. Individual suction cups, brushes, and other methods shown in the prior art may be used.

The sealing roll spring assembly **89** may be any conventional universal assembly whereby the spring loaded sealing roller **85** is permitted to run in contact with the gelatin contacting the cavity die roll. As shown, the axles of these two rollers are maintained essentially parallel by the slots in the retaining frame **94**. However, in and out motion in the direction of the line of centers is permitted and occurs against the spring, compression of which is adjustable by means of the tightening handle **95**.

Figure 2 shows in diagramatic form the driving belt system for the machine. For normal operation, as herein described, it is desirable that the gelatin strip remain slack but not loose at all points. Tension should be avoided in the gelatin strip. This is most easily accomplished by insuring that the surface speed of each of the gelatin contacting rollers is the same as the surface speed of the casting wheel. Normally the gelatin film will have a tendency to shrink from drying after it is removed from the casting wheel, but at the same time will have a tendency to stretch because of the warming of the gelatin and because of the natural weight of the gelatin tending to stretch it as it passes over the rollers. In general, it will be found preferable to drive the rollers by positive means by either sprockets and chains or by direct gearing. This automatically tends to stabilize the length of the cast film. The number of teeth in each of the gears is not critical nor is the size of the rollers, but they should be so related that the surface speed of all rollers be substantially uniform throughout; with the exception of rollers **93**, the web removing rollers, which may be driven at a higher speed to remove the film.

Because of the peculiar properties of gelatin, it has a tendency to be slowly elastic. If stretched, a film of gelatin has a tendency to recover its original shape slowly. Accordingly, if the gelatin strip is stretched at any point during its passage through the machine it will tend to recover to its original dimensions, though slowly. If desired, advantage may be taken of this characteristic by stretching the film by driving the casting roller slower than the other rollers in the machine. If this is done,

after the capsules have been cut and emerged from the die roll as essentially spherical, the gelatin films forming the capsule will shrink in the direction in which they were originally stretched in such a fashion as to give a football shaped capsule. This casting of elliptical capsules from round cavities is an important feature of this invention, but is not necessarily an essential feature; as if it be desired to cast spherical capsules, by the same token, this same stretch must be avoided.

As shown in Figures 1 and 2, a drive motor **96**, through a worm gear system **97** drives the main shaft **98** which in turn drives the casting wheel by means of the casting wheel gear system **99**. In the particular modification shown, beveled gears **100** drive a jack-shaft **101** on which are mounted sprockets for driving various parts of the machine. Each of the rotating drive wheels is preferably driven in some fashion from a powered shaft with the exception of spring loaded roll **85**, which may be driven merely by contact because of the high pressure between it and the cavity die roll.

If mated vacuum openings **114** are used, the roll **85** should be geared or otherwise positively driven in timed relationship with the cavity die roll as shown.

Only one drive pulley is necessary for each of the belted roller systems.

Figure 2 shows diagrammatically certain aspects of a particular system of roller drives which has proved satisfactory. It is readily within the range of anyone skilled in the art to work out other methods of drives which are satisfactory for driving the various members at the speeds shown to be desirable elsewhere in this specification. As shown in Figure 2 from the jack-shaft **101** there is a main chain roller drive **115** which drives the cluster shaft **116**. From this cluster shaft by means of a paddle drive belt **117** the paddle **33** is driven. By means of the sprocket drive **48** and an associated belt drive the guide rollers **46** and **47** are driven from the same shaft. The turnover mechanism is driven by means of a turn-over mechanism chain drive **118**. The carrier belt **37** is driven by an appropriate carrier belt drive **119**. From the cluster shaft **116** by means of a suitable idler gear **120** is driven the eccentric shaft **77** and related mechanism, by an eccentric shaft gear **121**. In turn therefrom, through idler gear **122** is driven the cavity die roll gear **123** and in turn therefrom the sealing roll gear **124**.

From the jack-shaft **101** by means of the web removal roller sprocket drive **125** there is driven the web removal rollers and by an associated belt and pulley system functioning as a discharge conveyor belt drive **126**, the discharge belt and associated mechanism is driven. From this in turn is driven the revolving brush drive system **127**.

The entire drive system is within the skill of the art and may be readily modified in any number of various ways without departing from the scope of the invention. It is to be noted that, in the system as shown, by changing one sprocket in the main chain roller drive **115** and coordinating the sprocket drive chain length therewith, it is possible to change the speed relationship between the cavity die roll and all gelatin strip contacting members affiliated therewith and the casting wheel itself, so that it is possible to readily arrange various degrees of stretch in the gelatin film when and if desired. If greater flexibility is desired a variable speed drive system may be installed at this point so that variations in the degree of stretch may be accomplished while the machine is in actual operation.

It is desirable that both the temperature and humidity of the room or area in which the machine is operated be controlled. Whereas the exact temperatures and humidity at practically every point of operations may be varied over a rather wide temperature and humidity and still give satisfactory results, the relative relationships for a particular operation are comparatively critical, and for any given run should remain reasonably constant. For example the proportion of water in the gelatin film may be decreased as the temperature is raised. A higher temperature may be used for the casting roll and throughout if less glycerine is used. A longer drying time is required at lower temperatures or if the relative humidity is higher. The relative temperature between the cavity die roll and the sealing roll is extremely important in adjusting the position of the sealing line. For example warmer gelatin flows more readily than cold. The temperature of the cavity die roll is controlled by thermostatic means from a thermostat, diagramatically illustrated as **102**, which controls the heat supply to the stator **103**. The heater element may lie in or on the non-rotating members of the cavity die roll assembly and may be an electrical resistance element or other source of thermal energy as shown at **107**. The amount of energy being supplied must be under rather adequate and rapid control to insure proper temperature relations. As set forth in certain of the specific examples, if this cavity die roll is kept at a slightly lower temperature than the sealing roll the gelatin strips in contact with each will be at those respective temperatures. When sealed together the portions contacting the walls and bottom of the cavity will be cooler than the portion constituting the top. When released, the hot portion will stretch more easily. The cool portions will tend to shrink. As the capsule assumes its normal rounded shape, the cool portion of gelatin, by attempting to shrink to its original dimensions, will stretch the portion constituting the top and because this portion is warmer it will stretch more readily, and if the relative temperatures are properly adjusted, the line of seal will be equatorially located on the capsule. It is not necessary that this sealing be equatorial and by temperature adjustment the line of seal may be adjusted as desired. The equatorial seal is suggested as the type of seal which in the past has most readily met with consumer acceptance.

The guide rollers, oil rolls, turnover rolls, etc., are normally permitted to remain at room temperature or at such temperature as they assume from their contact with the gelatin film and no temperature control is necessary. However, for certain operative conditions, as for example where it is desired to use a lower water content in the film so as to give a more rapid drying in the final capsule, it may be desired that these rollers in turn be temperature controlled. The casting wheel roller is normally permitted to assume its natural temperature. As the average gelatin fluid flows upon it this film will be somewhat cooled and will solidify rather rapidly but then as the moisture begins to evaporate from the surface of the film it will tend to cool the wheel below room temperature and by the time the gelatin film leaves the casting wheel it may be below room temperature. If extremely stable or fast setting gelatin film is used it may be desirable to warm the casting wheel so as to cause more rapid evaporation of the moisture and thus permit faster operation of the machine. Additional speed may be obtained from some gelatins by using warmer air to set the film.

The operation of the present machine is described in detail in our above-mentioned Patent 2,663,128.

As our invention, an improvement to the art of making capsules, we claim:

1. The method of filling flowable powder into soft plastic capsule shells which comprises: continuously moving in a circular path a continuous plastic strip having a plurality of capsule shells formed therein, sealing a group of flowable powder sources in a filler head block adjacent to a moving group of such capsule shells, one such source for each such shell, with said block resting on the plastic strip which itself forms a resilient part of the seal, reducing the pressure within each of the sealed shells whereby powder flows into said each sealed shell, and restraining the flow of powder outwardly from each shell by foraminous material in the filler head block adjacent each of the flowable powder sources, until each of said shells is filled with powder, discontinuing the reduc-

tion in pressure, removing said group of flowable powder sources, and emplacing said group of flowable powder sources adjacent a subsequent, adjacent group of capsule shells.

2. The method of claim 1 which comprises the step of warming the foraminous material to prevent moisture condensation and caking of the powder.

3. In a machine for filling soft plastic capsules with powder: a continuously rotating cavity die roll having a plurality of capsule forming cavities therein, adapted to be lined with a soft plastic strip; filling head block positioning means in spaced relationship to the cavities in the die roll; a filling head block having a curved lower surface adapted to fit against and match the curvature of a portion of the die roll containing a group of cavities; a plurality of filling heads in said block, one for each of said group of cavities, comprising a filler passage for a flowable powder, a foraminous material having an area on the lower surface of the head, and suction means on another area of the foraminous material; coordinate positioning means in spaced relationship with said block; a powder hopper above and attached to said block; and means to place said filling head block adjacent to and in strip-sealed relationship with a group of strip-lined cavities in said die roll, and cause said block to rotate with said die roll for the duration of a filling cycle, with said coordinate positioning means in contact with said filling head block positioning means, and after a filling cycle to lift said filling head block from said group of strip-lined cavities, and reposition it adjacent a following subsequent group of strip-lined cavities.

4. The apparatus of claim 3 in which the filling head block has heating means therein.

5. In an apparatus for forming soft gelatin capsules, a cavity die roll having capsule forming cavities therein, pins in spaced relationship to the cavities in said cavity die roll, a filling head block, a positioning block fastened thereto and adapted to position said filler head block in spaced relationship to a group of cavities in said cavity die roll by contact with certain of said pins, and an eccentric means whereby said filler head block is consecutively positioned over consecutive groups of such cavities.

6. In combination, a cavity die roll, a filling head block, filling units therein, comprising a powder passage surrounded by a foraminous material connectable to a suction means, lifting arms attached to said block, and means to lift said block above, move it backward, and lower it into spaced relationship with a group of plastic strip lined cavities in said cavity die roll.

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