Nov. 9, 1965 E. W. MERRILL 3,216,850

METHOD AND APPARATUS FOR LINING CONTAINER CLOSURES

Filed Jan. 23, 1962

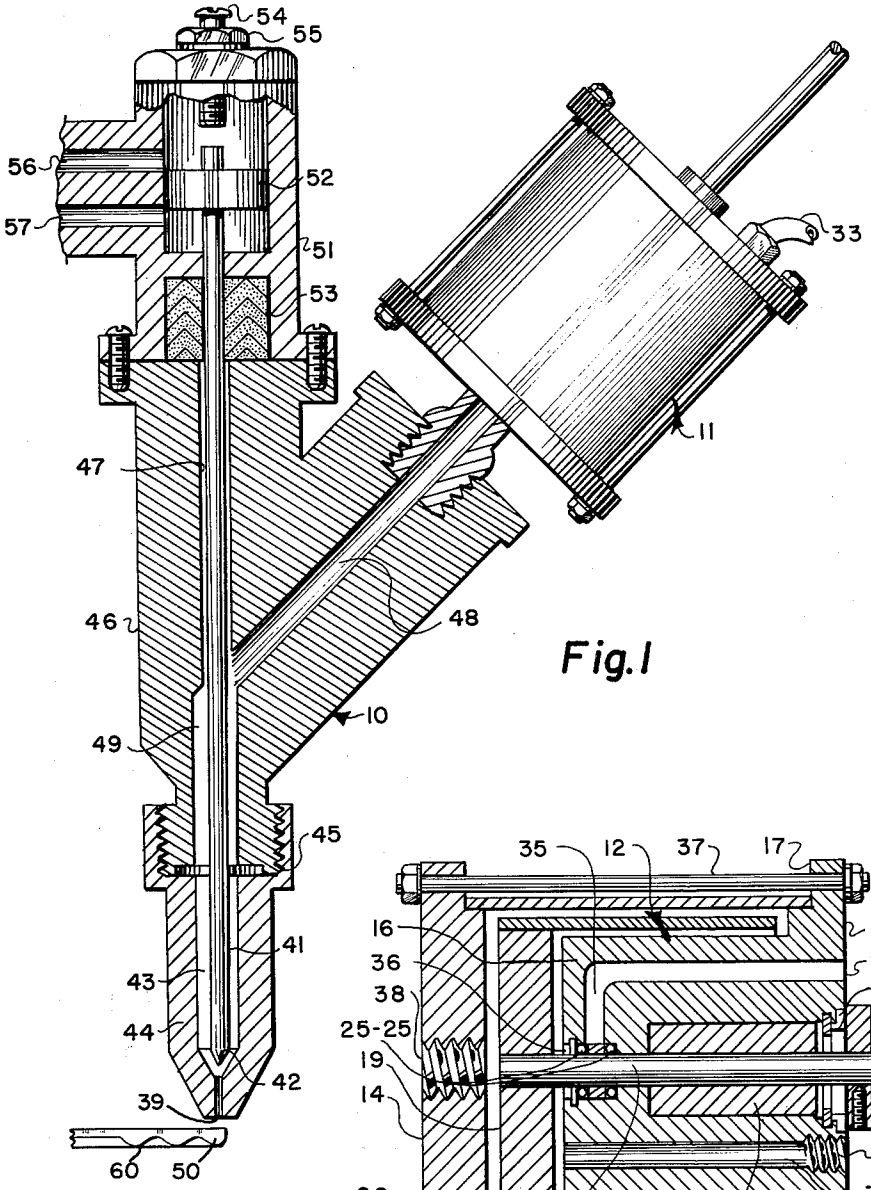


Fig. 1

Fig. 2

United States Patent Office

3,216,850

Patented Nov. 9, 1965

3,216,850

METHOD AND APPARATUS FOR LINING CONTAINER CLOSURES

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Filed Jan. 23, 1962, Ser. No. 168,035
4 Claims. (Cl. 117—97)

This application is a continuation-in-part of application Serial Number 12,403, filed March 2, 1960, now abandoned. This invention relates to the lining of container closures and is directed to a method and to an apparatus which permits smooth, uniform gaskets to be laid down on container closures from compositions which although they possess most desirable chemical and mechanical characteristics as container seals nevertheless cannot be applied to the closure either by conventional or modified container closure lining machinery because of the highly erratic viscosity characteristics which they exhibit.

The material which later forms the gasket which is placed between the mating parts of a container initially is a colloidal system of complex composition. The solid phase of the colloidal system is one or more of a variety of high polymers, those most commonly used possessing elastomeric properties in varying degrees. Loading materials and sometimes substances which promote the adhesion of the compound to the tinplate also appear in the solid phase. The liquid phase of the composition may be either aqueous or organic. In the following specification, words of art will be used which are defined as follows. The gasket forming materials are known as "lining compounds" specifically, water-based lining compounds and solvent-based lining compounds. Also, in terms used in the industry both the strip of liquid compound which is laid down on the joint area of the closure and the dry gasket which subsequently evolves from the liquid composition is known as a "lining." The operation of placing the liquid composition on the closure also is known as "lining"; and, therefore, the machines on which this operation is performed are known as "lining machines."

In the common form of lining machine an unlined closure is stripped from the bottom of a stack of such closures by a slide and transported to a rotating chuck which, at the moment of loading, drops beneath the longitudinal path of the slide. The chuck and closure then rise to receive a stream of lining compound from a nozzle directed at the joint area. Because of the rotation of the closure, the stream is distributed in a band which covers the joint area. At the close of this operation the chuck falls and the slide advances to remove the closure from the chuck and place a new closure in position. The flow of compound is controlled by a valve which must open and close in timed relation to the revolution of the chuck. The opening and cut-off of the valve must be rapid and exact to prevent a gap between the two ends of the lining or to prevent an overlap which would result in a "bump."

The continuous development of sealing compounds, able to withstand the environmental conditions which the container contents impose, is necessary to keep abreast of the great variety of materials which are or may be packed in containers. It is a common disappointment for workers in the sealing compound art to find that a compound which in the dried gasket form seals excellently and performs well, nevertheless cannot be used industrially because the liquid lining composition exhibits anomalous viscosity and that imperfect linings result.

The importance of viscosity control in the lining operation cannot be overemphasized. Whether a closure will form a hermetic seal with the container body and make a package in which foodstuffs may safely be stored or whether the joint will leak and so cause the contents to become a health hazard in very large measure depends upon the quantity and the uniform distribution of the amount of container compound which forms the seal. Too little will result in a "leaker." Too much will result in "squeezing" or a cracked end-seam.

As an example of the accuracy which is demanded in this operation, a number two can end, for example, has an end to body joint lining which is approximately ten inches long. It is flowed onto the joint area of the can end at the rate of 300 or more ends per minute. This ten-inch peripheral lining of a "liquid" composition, which is laid on the closure in 0.2 second, does not vary in dry weight more than ±3.4 milligrams. Most of the billions of cans which are manufactured in the United States today meet this standard of precision.

Primarily, this degree of accuracy is secured by an exacting control of the viscosity of the lining compound. Once the lining machine is set in operation, the physical conditions, time, the diameter of the orifice, and the delivery pressure are fixed. If the viscosity changes, the amount of compound delivered under a fixed head pressure and through an orifice of fixed dimension and during unit time varies and variation is not permissible.

In my investigations of the behaviour of numbers of these intractable but otherwise desirable compositions, I discovered that many of them can temporarily be given workable viscosities if, just prior to the actual lining of the compound on a closure, the compound is subjected to unidirectional forces giving rise to definite but intermediate rates of shear.

The phenomena associated with viscosity breakdown are far too varied to permit a rigorous explanation of this effect at this time. It is my present belief, however, that such unidirectional forces of such intermediate shear rates cause the original entangled network of the macromolecules to separate into smaller aggregates which, however, are still larger than the individual macromolecules. These aggregates presumably lock together again when in a state of rest for increase in viscosity after resting a few seconds has been observed as characteristic. The restoration of higher viscosity in these troublesome compounds is often astonishing. A sheared workable liquid compound may return to a jelly or to a stiff paste in a few seconds.

I have found that the optimum shear rate which produces compounds which have usable viscosities and smooth flow characteristics varies with the nature of the polymer, the other ingredients in the solid phase, and with the nature and concentration of the suspending medium, but shear rates lying between 200 and 10,000 reciprocal seconds have given effective results. Shearing at such rates causes a temporary decrease in the viscosity of the compound, but does not result in changes in the internal structure of the suspended particles. The treatment thus contrasts sharply with the effect, for example,

of a colloid mill where the very much higher rates of shear frequently lead to permanently lowered viscosity and to such substantial internal structural change that the sealing efficiency of the solid film is lowered and may even vanish.

The principal objects of this invention are to give the compounding chemist considerably more flexibility in his choice of materials and in the range of proportions which may be used; to permit lining compounds to contain a higher amount of solids than previously has been possible; to save costs in solvent consumption; and to increase the speed of drying.

In the drawings:

FIGURE 1 is an elevation, partially in section, of the viscosity-reducing lining compound applicator.

FIGURE 2 is a longitudinal section through the viscosity reducing element and showing a partial cross-section of a can cover in position to receive a lining in its channel.

The viscosity reducing element **11** of the device **10**, comprises a three part stator, generally indicated at **12**. It consists of an inner stator **13**, an end-plate **14**, and an outer tube or jacket **15**.

The body portion **16**, of the inner stator **13**, is an accurately finished cylinder, the outer end of which terminates in the stepped flange **17**. The cylindrical body portion **16**, is surrounded by a cup-shaped rotor **18**, having a flat, circular head **19**, and a skirt **21**, which extends backwards from the head to enclose almost the entire length of the body portion of stator **13**. The rotor **18**, is revolved by shaft **22**, which is fastened centrally in the head **19**, and extends through a bore **23**, drilled along the longitudinal axis of inner stator **13**. Bore **23**, is counterbored from its outer face to receive the bearing bushing **24**, and counterbored from its inner face to receive the O-rings **25—25**, and their retainers. The longitudinal position of the rotor is maintained by the thrust washer **26**, and the shaft collar **27**.

The rotor is surrounded by a cylindrical outer wall or jacket **15**, which is seated on the step **28**, of the stepped flange **17**, and is similarly seated on the step **29**, of end-plate **14**.

Lining compound enters the coaxial space through the passage **31**, which is threaded at **32**, to connect with the flexible lining compound conduit **33**. A weep passage **34**, is drilled longitudinally in the inner stator **13**, to intersect a lateral passage **35**, leading into the counterbore **36**, which houses the O-rings **25—25**. The assembly is held together by the through-bolts **37—37**.

Conveniently, the power connection between the power source, which usually is a variable speed motor (not shown), is made by a flexible shaft which is connected to rotor shaft **22**.

Compound, after experiencing viscosity reduction, leaves the reducer through the threaded port **38**, which is located in the center of end-plate **14**. All parts are machined to a high degree of accuracy and particular attention is given to the maintenance of concentricity between the stator and the rotor parts.

Since high viscosity so quickly re-establishes itself, it is necessary to discharge compound from the device as quickly as possible after the compound has experienced shear. For this reason, it is necessary to make the length of the passageways leading to the discharge orifice as short as is practicable and to keep their diameter small so that the entire inventory of compound which has experienced viscosity reduction may be discharged from the orifice before viscosity build-up takes place. These conditions are met in the specific example herein described: by spacing the walls of the rotor 0.045 inch from the stator wall, and by making the volumetric capacity of the bores, **48** and **49**, only 11.7% of the volume of compound undergoing shear in the viscosity reducing element **11**.

Discharge from the apparatus takes place through the orifice **39**, and is controlled by an air-operated valve needle **41**, which seats in the conical end **42**, of bore **43**, formed in the lining tip **44**. Tip **44**, is screwed at **45**, on to a Y-branch element **46**, which is bored axially at **47**, to receive the needle **41**. The Y-branch is also bored axially as shown at **48**, to form a passageway leading from the port **38**, and intersecting the bore **47**. Below the intersection point, bore **47** is slightly enlarged as shown at **49**.

Valve needle **41**, is actuated by a double-acting air-cylinder **51**, the piston **52** of which is fastened to the needle **41**, which also acts as a piston rod. Chevron packings **53** prevent compound from working into the air-cylinder. Lift of the valve is adjusted by screw **54**, and lock-nut **55**.

The needle valve is opened and closed by the alternate admission and discharge of compressed air through the air passages **56** and **57**. The admission and discharge of air is controlled by an electropneumatic spool-valve (not shown) the operation of which is controlled by an electrical contactor which is tripped by an adjustable cam associated with the main drive of the lining machine. In this manner, opening and closing of the valve is accurately synchronized with the arrival, spin, and removal of the closure beneath the orifice **39**.

The apparatus of FIGURE 1 is held on the lining machine by an adjustable bracket which allows radial and some vertical angular adjustment to make it possible for the flow of compound issuing from orifice **39**, to be depends upon the radius of the rotor, the width of the the sealing area adjacent the closure periphery.

In operation, compound is supplied under a considerable head-pressure through the flexible conduit **33**. Pressure may be derived from a remote tank under pneumatic head-pressure or developed by a positive displacement pump equipped with a proper by-pass valve. Compound entering the device through conduit **33**, passes along the passageway **31**. It moves radially between the stator **13**, and the inner wall of the rotor **18**, flows around the end of the rotor skirt **21**, and then flows outwardly over the end of rotor **18**, and out through the port **38** and flows from the orifice **39** into the channel **50** of the closure **60**.

For clarity in illustration, the drawing is not made to scale. Clearances, passage diameters, linear dimensions and some wall thicknesses have been greatly exaggerated.

As the rotor turns, any compound occupying the gaps between the stator and rotor is subjected to a shearing action, the intensity of which, measured as rate of shear, depends upon the radius of the rotor, the width of the gap and the speed of rotation. The shear rate may be calculated as follows:

$$D=\pi(r_1+r_2)N/[60(r_1-r_2)]$$

where

D=shear rate, reciprocal seconds
π=3.1416
r_1=radius to outer cylindrical surface
r_2=radius to inner cylindrical surface
N=rotational speed of rotating cylinder, revolutions per minute

Because the purpose of the invention is to bring the viscosity of the compound down to definite known values which may be relied upon to give the definite required film weights, the advantage of the coaxial arrangement in the viscosity reducer is apparent. All parts of the compound in the shear space experience substantially identical shear rates. There are no indeterminate dimensions. The particular design assures that all parts of the compound which issue through the orifice **39** will have been sheared at within ±5 percent of the mean shear rate.

Example I

One commercial compound which produces commercial linings when run at 35 to 37 percent total solids but which at 45 percent total solids exhibits highly erratic,

normally unworkable viscosity was introduced into the device under the following conditions:

Solids concentration of the compound: 45 percent.

Estimated Viscosity: 100 poises.

Original Pneumatic Head Pressure, pounds	Width of Each Cylindrical Shearing Cap, r_1–r_2, inch	Volume of Compound Undergoing Shear, cubic centimeters		
80	0.045	19.5		
Flow Rate Through the Device, cubic centimeters per second	**Residence Time in the Shearing Device, seconds**	**Volume of Sheared But Undelivered Compound, cubic centimeters**		
1.34	14.5	2.3		
Rotor Speed, revolutions per minute	**Shear Rate, Mean, seconds^{-1}**	**Radii of Gaps, inches**		
			r_1	r_2
1,725	4,750	Outer Gap..	1.252	1.207
		Inner Gap..	1.163	1.118

Results: Temporary viscosity, 1 poise. Smooth closure linings meeting commercial weight tolerance standards were produced. This compound had never before been successfully run at a greater solids concentration than 37 percent.

Example II

Another compound which exhibits erratic, unworkable viscosity was adjusted to 41 percent total solids and run through the device under the same conditions as above except that the rotational speed of the rotor was reduced to produce a rate of shear of 500 reciprocal seconds. Smooth closure linings meeting commercial weight tolerance standards were produced.

Not only is the device successful in making many otherwise intractable compositions useful, but, as shown by Example I, this invention permits a lesser amount of the suspending medium to be used. When the medium is solvent, this represents a considerable cost saving, for all of the medium is evaporated and lost in the subsequent drying operation. But whether the medium be solvent or water, the reduced amount results in a shorter drying time and a consequent increased throughput in the dryers.

I claim:

1. The method of lining container closures with container lining compounds which, in a state of rest, exhibit intractable viscosity which includes forcing the compound between spaced, coaxial, cylindrical surfaces, exerting an essentially unidirectional force upon the compound by rotating one of the surfaces to impart a mean shear rate lying between 200 and 10,000 reciprocal seconds, the spacing between the cylindrical surfaces being such as to subject all increments of compound passing through the device to shear rates lying within + or −5% of the mean shear rate value thereby to produce a compound having temporarily reduced viscosity and smooth-flowing characteristics, and, thereafter, discharging the inventory of sheared compound on successive container closures at such a rate that the incremental inventories of compound having lowered viscosity are placed on the closure before any significant restoration of the viscosity of the compound takes place.

2. A device for use in conjunction with container closure lining machinery capable of producing temporary reductions in the viscosity of container closure lining compounds by subjecting the said compounds to predetermined

substantially uniform rates of shear, having a stator element comprising a cylindrical outer jacket and an inwardly projecting cylindical body coaxially positioned with respect to the jacket, an end plate, a rotor element comprising a cylindrical cup-shaped rotor mounted coaxially between the body and the jacket and surrounding substantially the entire surface of said body, means to rotate the rotor including a shaft journalled in said body, a bore for introducing compound between said rotor and body formed in said body, an exit port formed in the end plate, each of said cylindrical elements being spaced apart to form a uniformly spaced, compound-shearing gap approximately .045 of an inch in width, with the result that compound passing between static and moving parts will be subjected to a shear rate of no more than 5% above nor less than 5% below the mean shear rate value and whereby shear rates lying between 200 and 10,000 reciprocal seconds may be developed upon the rotation of the shaft at appropriate rates of revolution.

3. A viscosity reducer for use in combination with a container closure lining machine nozzle, the said nozzle having a flow-controlling valve and means to open and close the valve, the said reducer being capable of subjecting all increments of closure lining compound passing through the device to shear rate values varying from the mean shear rate value by no more and no less than 5%, the said device having a stator comprising a hollow outer cylinder having inner and outer walls, a rotor comprising a rotatably mounted inner cylinder coaxially positioned within said outer cylinder and narrowly spaced from the inner wall of said stator, ends closing the outer cylinder, a port formed in one of said ends to admit lining compound to said narrow space, an exit port in the opposite end to conduct compound from said space, a passage leading from said exit port to the valve means of said nozzle, means to rotate the rotor including an axially positioned shaft journalled in the said entrance end, the spacing between the said stator and rotor being of uniform width and of a radial dimension sufficiently small to thereby subject all increments of compound in the said space to rates of shear lying within + or −5% of the mean shear rate value, and the length and diameter of the passage leading from the exit port to the said valve having a volumetric capacity of but a minor proportion of the volume of material undergoing shear, whereby the entire inventory of sheared compound contained in the said passage may be discharged through the valve before a significant rise in the viscosity of the sheared compound can take place.

4. A viscosity reducer as claimed in claim **3**, wherein the width of the spacing between the stator and rotor walls is substantially uniformly 0.045 inch, and wherein the ratio of the volumetric capacity of the passage connecting the exit port to the nozzle valve is substantially 11.7% of the volume of compound undergoing shear.

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