United States Patent

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[54] **METHOD FOR WELL CLEANOUT**

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Related U.S. Application Data

[63] Continuation of Ser. No. 807,766, March 13, 1969, abandoned.

[52] **U.S. Cl.**.....**166/312,** 175/69

[51] **Int. Cl.**.....**E21b 21/00**

[58] **Field of Search**.....166/312, 311, 309, 67, 224; 175/69, 318

[56] **References Cited**

UNITED STATES PATENTS

2,880,965	4/1959	Bobo	175/69
3,318,387	5/1967	Jones	175/318 X
3,268,017	8/1966	Yarbrough	175/69 X
3,130,798	4/1964	Schramm	175/69
3,463,231	8/1969	Hutchison	175/69 X

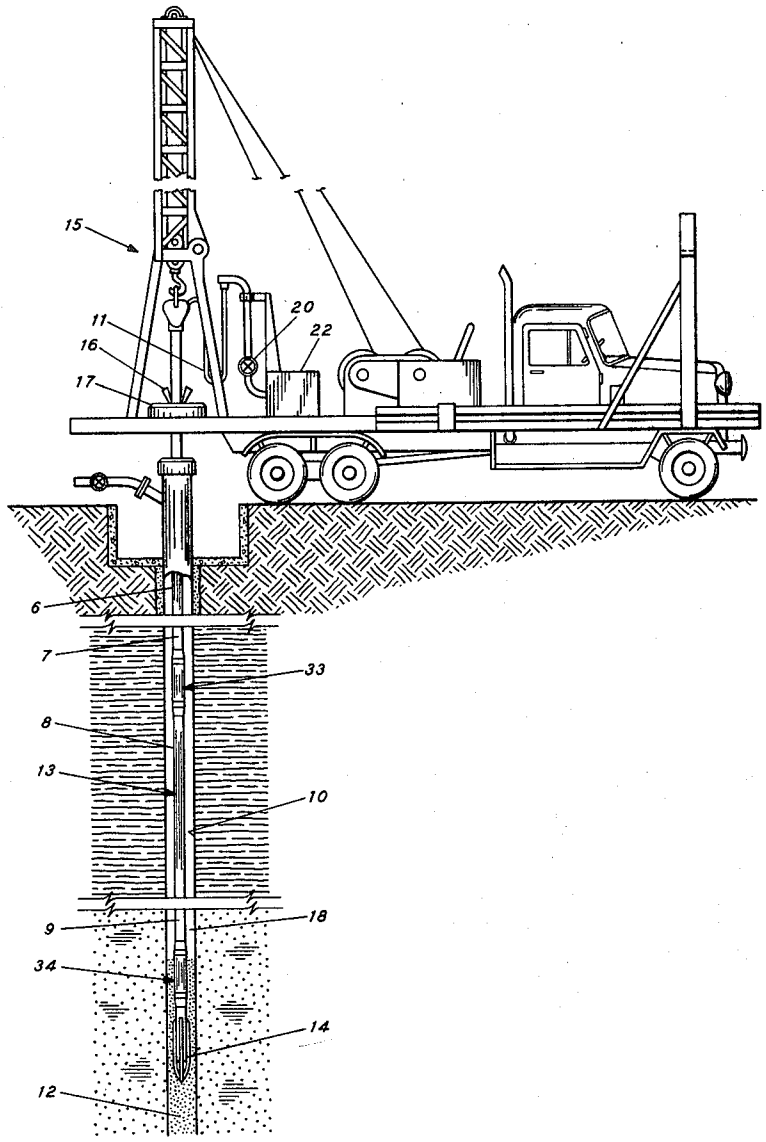
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[57] **ABSTRACT**

A method of well cleanout by circulating preformed foam in a well through a segmented tubing string and the annulus between the tubing string and the well wall to remove sand and fluids from the well. Check valve means are placed in the segmented tubing string at preselected positions to maintain control over the foam in the well while foam injection is temporarily halted to permit addition of another tubular section to the tubing string. The check valve means insures that the foam in the well remains in a dynamic condition during such temporary halts so as to prevent sticking of the tubing string in the well.

5 Claims, 6 Drawing Figures



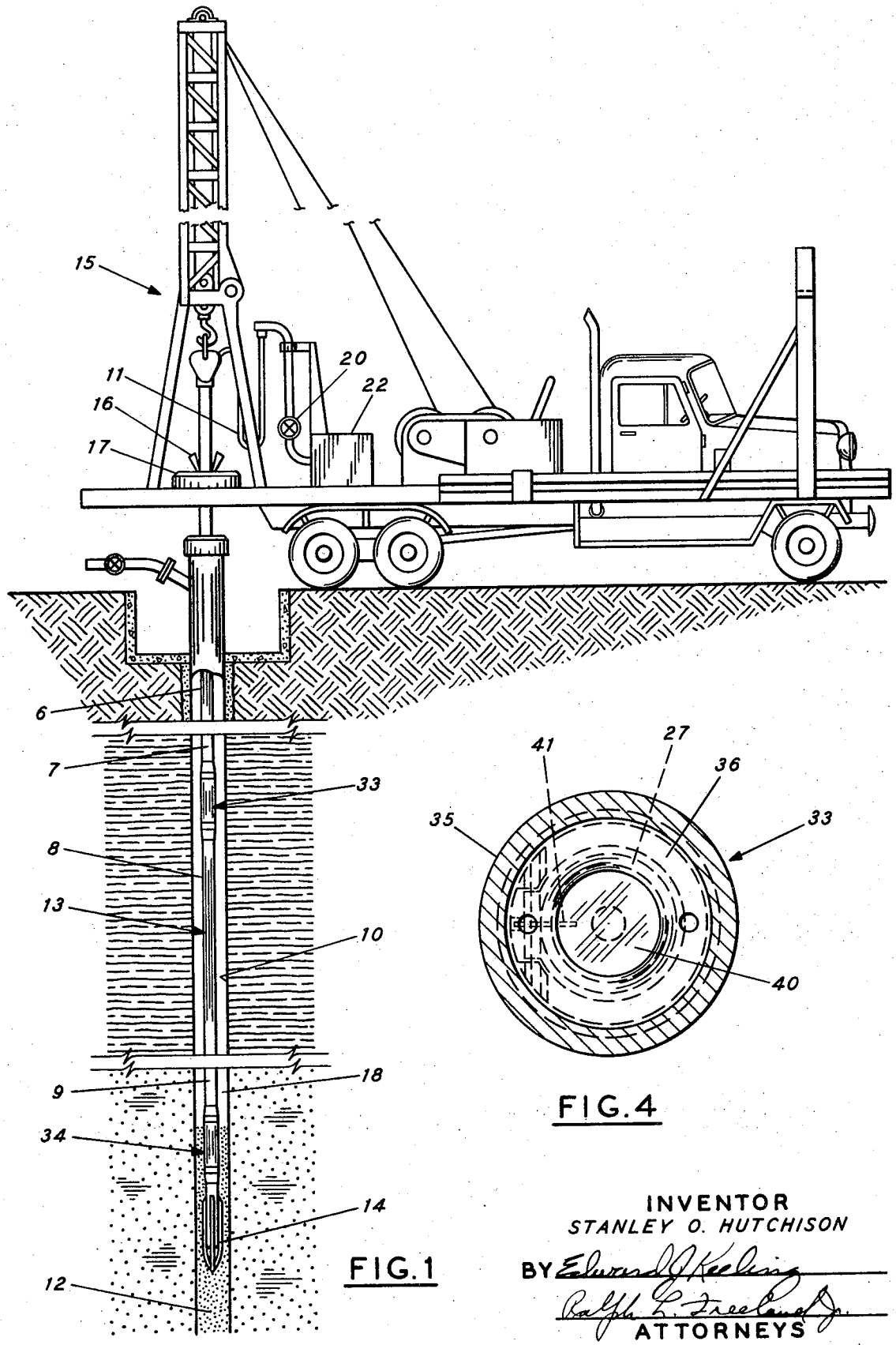


FIG. 1

FIG. 4

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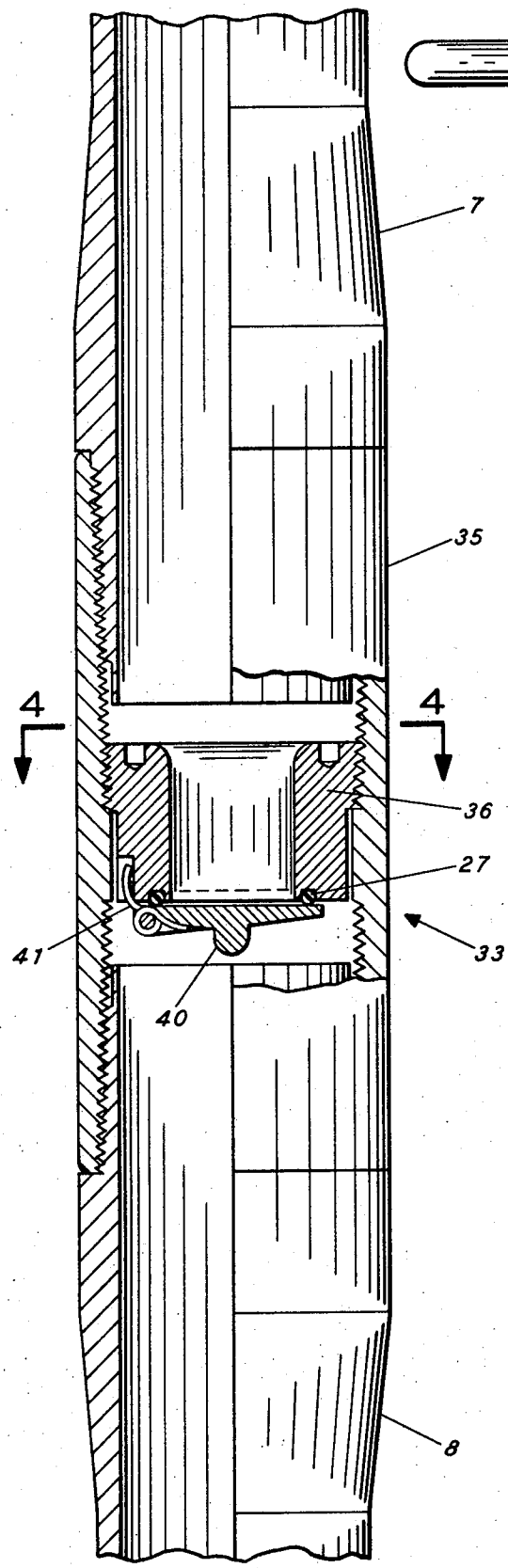


FIG. 2

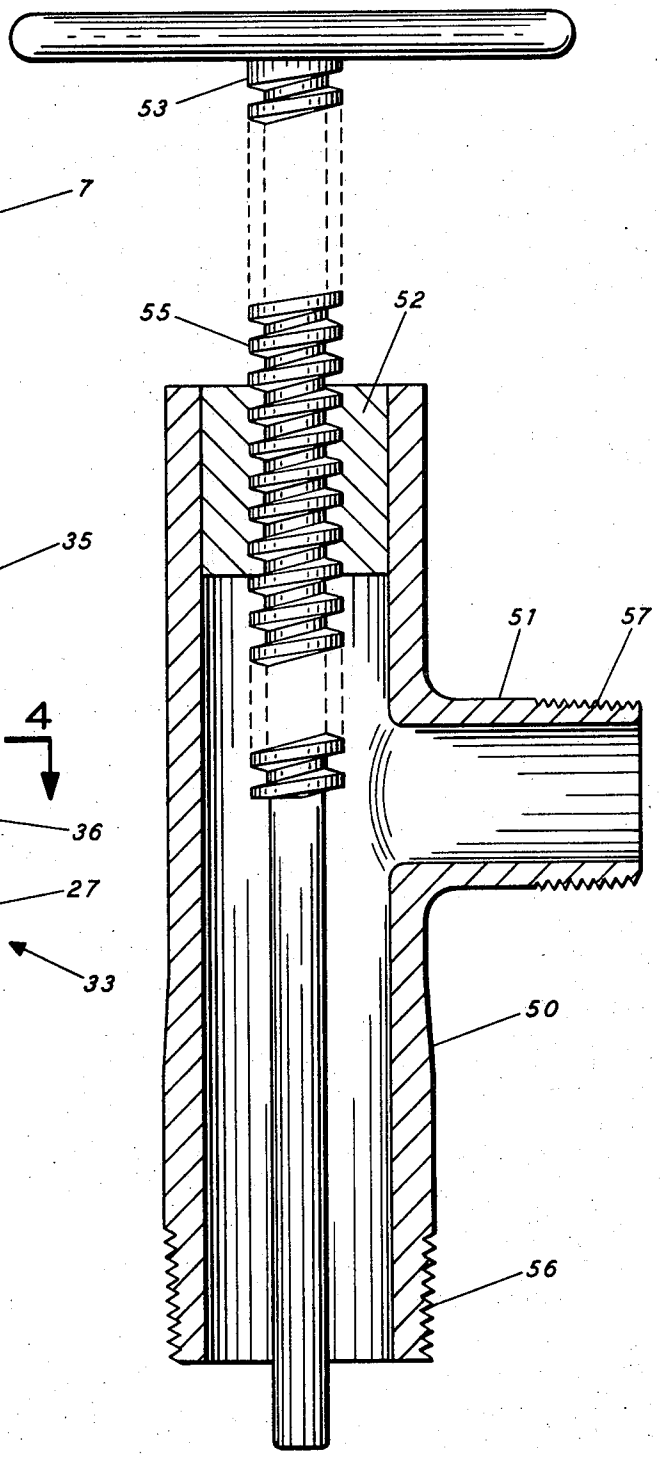


FIG. 3

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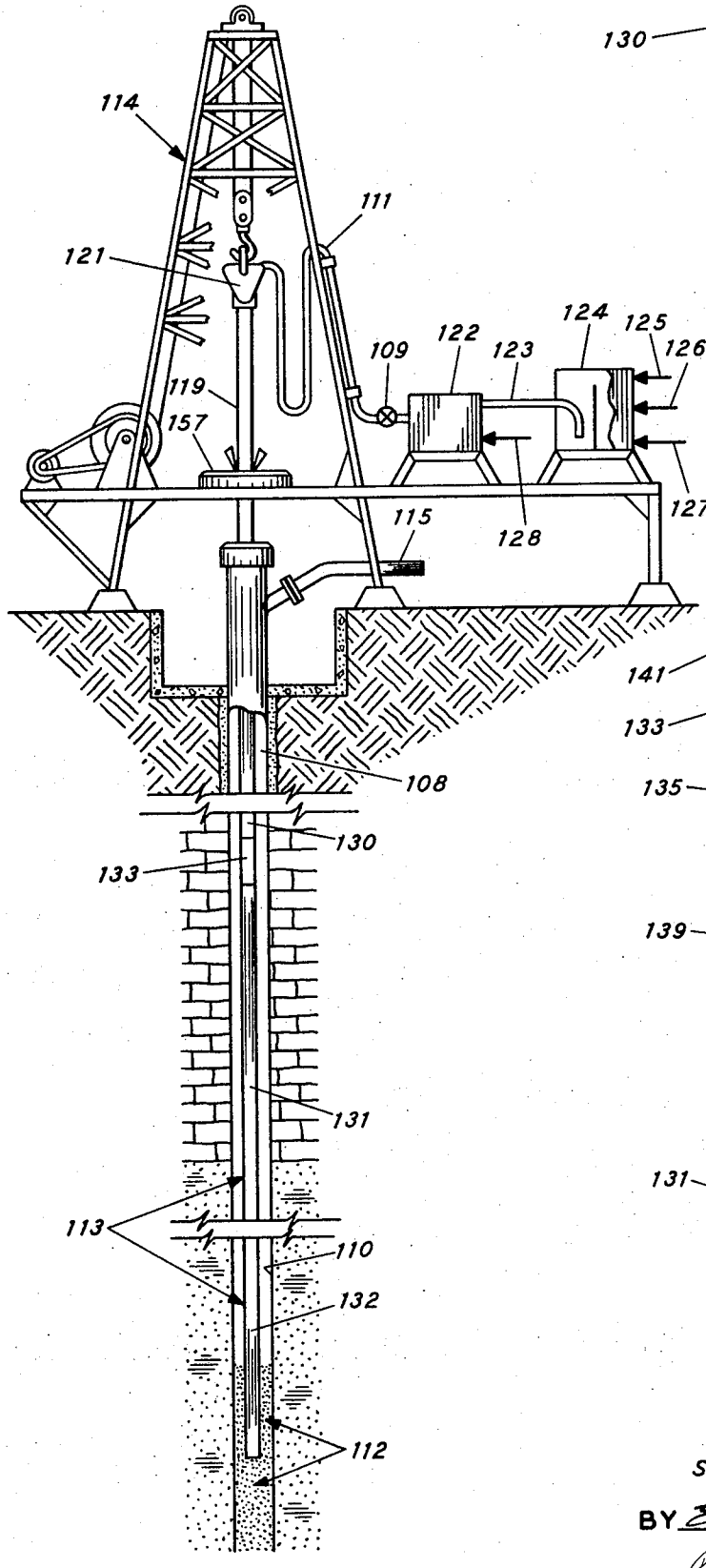


FIG. 5

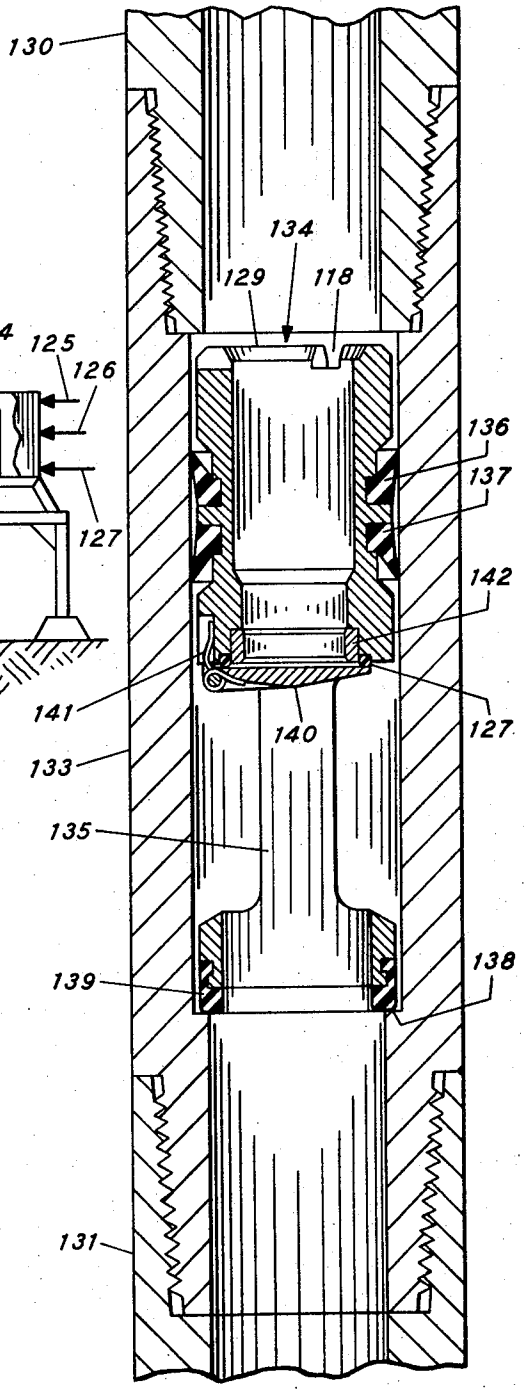


FIG. 6

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METHOD FOR WELL CLEANOUT

This is a streamline continuation of application Ser. No. 807,766, filed Mar. 13, 1969 and now abandoned.

This invention relates to a method of well cleanout such as removing chips, sand and the like from a well using foam as a circulating medium and, more particularly, this invention relates to a method of utilizing foam as a circulating material in a well having a segmented tubing string located therein. Check valve control means are positioned at preselected locations in the tubing string to control foam in the well by allowing foam to flow down the well through the tubing string but preventing flow of foam up the tubing string. Such control of the foam in the well insures that the foam will be maintained in a dynamic condition in the well during temporary interruption of foam injection.

Well cleanout, which includes the removal of drill chips, sand or other unconsolidated materials and fluids from a well, has long been a problem. Thus the removal from a well of drilled solids produced while penetrating a formation with a drilling string and also the removal of produced solids which flow into the well during oil production have both continued to be a problem to the oil industry. This is particularly true when formations penetrated during drilling or from which fluids are produced are unconsolidated low pressure formations. Various techniques including the use of wire line bailers and various circulating fluids have been heretofore suggested for removing such material from wells.

One such circulating fluid found successful in such applications is a stable, low density foam. Foam of this type has proven quite successful in removing solids and fluids from wells. However, it has been found that certain techniques must be utilized to overcome problems encountered in the use of foam as a circulating fluid for removing sand and the like from a well.

In a typical well cleanout operation utilizing foam as the circulating medium, a segmented tubing string is used to inject foam down a well to the position in the well from where it is desired to remove sand and/or fluids. The foam picks up the sand or fluids and carries them out of the well via the tubing-well wall annulus. The tubing string is made up of a plurality of individual pipe sections coupled together. A rig or hoist is used to lower each successive pipe section into the well to approximately its full length. After the pipe section has been lowered to such a position it is gripped near its upper end by various means such as power tongs or slips to suspend it in the well. The hoist is then released from the pipe section and a second pipe section is connected to the first section. The hoist is then connected to this second pipe section and it is lowered into the well to near its full extent where it is held by the tongs and the above sequence repeated. As this action is repeated, successive pipe sections form a tubing string which progressively goes deeper and deeper into the well. Once the lower end of the tubing string has reached a level from where it is desired to remove sand or liquid, a flexible tube is connected onto the topmost pipe section and foam is injected into the tubing string and circulated down the string out the bottom end of the string and up the annulus between the tubing string and the well wall or well casing to the surface. As foam is circulated, it carries up the fluids and/or sand from the well. The tubing during this foaming period is

progressively lowered deeper into the well. This necessitates, of course, adding additional pipe sections to the tubing string at the wellhead. When such pipe sections are added, the flexible foam tube must be disconnected from the top of the pipe section forming the uppermost joint of the tubing string and reconnected to the top of the newly connected pipe section. Thus for a short time, foam injection down the tubing string is stopped. It has been found necessary to prevent backflow of foam up the tubing string. If foam is allowed to backflow up the tubing, uncomfortable and dangerous conditions will exist at the wellhead. Even more seriously, such backflow has resulted in loss of a dynamic condition of the foam in the annulus of the well which can allow solids to settle out of the foam and bridge against the tubing string causing it to become stuck in the well. The present invention is directed to solving these problems.

Briefly, the present invention provides a method of cleaning out a well utilizing a foam circulating medium. A segmented tubular string is used to circulate the foam down the well. Undesirable material such as sand and/or fluid is then carried by the foam up the annulus between the tubing string and the well casing. The invention provides for incorporating into the tubing string at a predetermined location means for closing off the tubing string to flow of foam up the tubing string during the period when foam injection is temporarily stopped. This occurs, for example, during the period when foam injection is stopped so that another pipe joint may be added to the tubing string.

In a broad aspect, the present invention provides for removing undesirable material such as sand and/or fluid from a well utilizing a foam circulating medium. An elongated segmented tubing string is inserted into the well and foam is injected down the tubing string into the well and forced up the annulus between the tubing string and the well wall or casing to remove the undesirable material from the well. The injection of foam into the well is temporarily halted during this operation to connect additional pipe sections to the tubing string so that it may be lowered further into the well. During such temporary halts, the tubing string is closed off to the flow of foam up the tubing string. After such additional pipe section or sections is added to the upper end of the tubing string foam is again circulated down the tubing string and forced up the annulus to continue to remove undesirable material from the well.

In a more specific aspect, the present invention provides for cleaning out a well utilizing a foam circulating medium and includes forming and inserting into a well an elongated tubing string by successively connecting together a series of pipe sections and lowering the so-formed tubing string into a well. The tubing string is lowered into the well until the time the lower end of the tubing string reaches the undesirable material which is to be removed from the well. At such time a check valve flow control means is added to the upper end of the tubing string. Such flow control means permits flow of foam down the tubing string but prevents flow of foam up the tubing string. The foam generating means is again connected to the upper end of the tubing string above the check valve flow control means and foam is injected down the tubing string through said flow con-

trol means and into said well to assist in moving sand and/or fluid up the annulus between the tubing string and the well casing. When foam injection is again temporarily halted to connect still another pipe section onto the tubing string, the flow control means prevents flow of foam up the tubing string and traps a column of foam in said tubing string below the flow control means. This column of foam is under pressure and tends to expand for some time. Such expansion serves to maintain the foam in the annulus in a dynamic condition thus preventing the undesirable material from falling back down the annulus against the tubing string. After the pipe section is connected into the string, foam is again injected down the tubing string through the flow control means and into the well to assist in moving the undesirable material up the annulus to remove it from the well.

It is a particular object of the present invention to provide for cleaning undesirable material from a well using stable foam as a circulating medium through a tubing string, which method includes preventing backflow of foam up the tubing string during temporary halts in the injection of foam down the tubing string into the well.

Further objects and advantages of the present invention will become apparent from the following detailed description read in the light of the accompanying drawings which are made a part of this specification and in which:

FIG. **1** is a view, partially in section, of an earth formation penetrated by a well and illustrates the preferred arrangement of apparatus assembled in accordance with the present invention;

FIG. **2** is an enlarged view, partially in section, of a portion of the apparatus shown in FIG. **1** and illustrates check valve flow control means connected into a tubing string in accordance with the present invention;

FIG. **3** is a sectional view of apparatus used with the present invention for unloading foam from a tubing string as it is pulled from the well;

FIG. **4** is a sectional view taken at line **4—4** of FIG. **2**;

FIG. **5** is an elevational view, partially in section, of an alternative embodiment of apparatus assembled in accordance with the present invention; and

FIG. **6** is an enlarged sectional view of a portion of the apparatus of FIG. **5** and illustrates flow control means assembled in accordance with the invention.

Refer now to the drawings and to FIG. **1** in particular where a well **10** is shown penetrating the earth. The lower portion of well **10** has an accumulation of undesirable material such as, for example, sand or liquid as indicated generally by the number **12**. A segmented tubing string as indicated generally by the number **13** has been run down the well **10** to a position where the lower end of the tubing string **13** is just entering the sand-liquid accumulation zone **12** of the well. A suitable bit **14** is connected to the lower end of the tubing string **13**. The tubing string **13** is made up of a number of individual pipe sections **6, 7, 8** and **9**. The sections of pipe forming the tubing string are connected together and are lowered into the well by means of a hoist as generally indicated by the number **15**. The hoist may include a power swivel. A flexible foam hose **11** is connected to the uppermost pipe section of the elongated tubing string **13**. Each section of pipe, after it is connected to the tubing string, is lowered by means of the hoist until its upper end is located just about the slips **16** in collar **17**. The slips **16** are then set to hang the tubing string in the well and the hoist and power swivel disconnected from the uppermost pipe section **6** and a new pipe section is lifted and connected to the pipe section **6** held in the slips. After this operation is accomplished, the hoist and the power swivel are connected to the upper end of the newly connected pipe of the tubing string. The tubing string may then be lowered further into the well.

Foam is used as the circulating medium and is injected down the well to the position in the well from where it is desired to remove sand and/or fluids. The foam picks up the sand or fluids and carries them out of the well via the tubing-well wall annulus **18**. The tubing string **13**, during the foaming period, is progressively lowered deeper into the well **10**. Additional pipe sections must be connected to the tubing string at the wellhead. When such pipe sections are added, the flexible foam tube **11** must be disconnected from the top of the pipe section forming the uppermost section of the tubing string **13** and reconnected to the top of the newly connected pipe section. Thus for a short time, foam injection down the tubing string is stopped. It has been found necessary to prevent backflow of foam up the tubing string. If foam is allowed to backflow up the tubing, uncomfortable and dangerous conditions will exist at the wellhead. Even more serious, such backflow has resulted in loss of a dynamic condition of the foam in the annulus of the well which can allow solids to settle out of the foam and bridge against the tubing string **13** causing it to become stuck in the well.

Foam must be retained in movement in the annulus during the time the tubing string is being lowered into the sand zone and while it is located in the sand zone to prevent falling sand causing sticking of the tubing string in the well. Suitable apparatus for supplying foam to the elongated tubing string via line **11** includes foam generator **22** utilizing gas pressure for generation of a suitable aqueous-gas foam. Water and a detergent and, if desired, a concentrated caustic solution or other suitable stabilizing agent, are supplied to foam generation at rates sufficient to produce a foamable mixture. Such a suitable foamable mixture may contain, for example, in parts by weight for each 100 parts thereof, about 0.1 to 1 part of an organic foaming agent, for example, the sodium salt of a linear C_{12}–C_{16} alkyl benzene sulfonic acid mixture. The foamable solution is delivered to the foam generator and a gas, for example air, is also delivered to the generator **22** and a foam is formed. Such a suitable foam preferably has a gas-to-liquid volume ratio in the range of 3–**50** to 1. The preformed foam is directed to the tubing string by line **11** through valve **20** where it is circulated to assist in cleaning out a well.

In accordance with the invention, the elongated tubing string **13** is formed by successively connecting together pipe joints to form the tubing string. As each pipe joint is added, the tubing string is progressively lowered into the well. The tubing string **13** is lowered to a position where the lower end thereof contacts the top of the sand or liquid region **12**. At this time, a check valve means such as a flapper valve located in a sub such as illustrated in FIG. **2** and indicated generally by

the number 33, is connected into the upper end of the elongated tubing string. The flapper valve 33 allows foam to pass down the tubing string into the well for circulation up the annulus but prevents foam from backflowing up the tubing string 13. In well cleanout work it has been found critical to maintain a moving or expanding foam system in the annulus during cleanout work to prevent sand from falling back down the annulus and packing around the tubing string and sticking it in the well. Heretofore this has required continuous circulation of the foam during the time that a new pipe section was added to the upper end of the tubing string. Continuous foam circulation requires special equipment. However, it has been found that where a check valve means such as downwardly opening flapper valve 33 is used in the upper end of the tubing string 13 the energy in the foam in the tubing string 13 maintains the motion of the foam up the annulus during a period of time sufficiently long to add a pipe joint to the upper end of the tubing string, reconnect the foam line and to again circulate foam.

Thus the energy needed to maintain the sand and foam in the annulus in a dynamic condition can be acquired by means of the expansion of foam in the lower part of the tubing string when the upper part of the tubing string is blocked off to prevent backflow of foam. It is necessary that the upper flapper valve 33 be added as high in this tubing string as possible after the lower end of the tubing string contacts the upper surface of the liquid or sand zone 12. If desired, the upper flapper valve may be added to the tubing string slightly before contact is made. However, in no event should the tubing string be substantially inserted below the upper part of the sand zone and foam circulated prior to the time a flapper valve is added to the tubing string. It has been found that the addition of a flapper valve to the upper part of a tubing string has caused foam to emerge from the annulus during periods when foam injection has been stopped for as long as 4 minutes after the termination of foam injection through the upper end of the string. The emergence of this foam indicates that the sand and liquid in the annulus is in a dynamic condition and thus cannot fall back down the annulus and cause sticking of the tubing string. In an actual field trial where an upper check valve means such as valve 33 was not added to an upper end of a tubing string and foam stopped for a similar amount of time, the tubing string was stuck in the hole by collapse of the foam and settling of the sand around the lower end of the string.

It is preferred in accordance with the present invention to also incorporate a lower check valve means into the lower end of the tubing string 13 as immediately above the bit 12. Thus a lower downwardly opening flapper valve 34 is connected into the tubing string above the bit 14. The lower flapper valve reduces the tendency for the plugging of the tubing to occur while the tubing is being run into the hole. The lower flapper valve 34 is downwardly opening and thus permits foam to flow through the tubing string. The lower flapper valve may be of the same construction as the upper flapper valve.

FIGS. 2 and 4 show sectional views of a highly preferred flapper valve useful in accordance with the present invention. In FIG. 2 a sectional view is shown illustrating a flapper valve indicated generally by the number 33 contained in a sub 35 which is connected at a suitable location in the tubing string as, for example, between pipe sections 7 and 8. A downwardly opening flapper valve is contained in sub 35. The downwardly opening flapper valve comprises a generally tubular body 36 having appropriate threads for securing it inside of the sub 35. The tubular body thus provides a central passageway through the sub 35. A flap 40 is provided to close off flow through the tubular body 36 and thus through the interior of the tubing string. The flap 40 is arranged to be normally closed by means of resilient means 41. The flap is openable by means of downward pressure. An O-ring 27 seal is provided to seat and seal the flap in a closed position. Thus the flapper valve 33 permits flow of foam down the tubing string but closes and prevents flow of foam up the tubing string.

It has been found that the type of flapper valve or check valve used is critical to the success of the foam cleanout operations. Thus a flapper valve of the type illustrated in FIGS. 2 and 4 has proven successful in operations involving injecting foam down the well. It has been found, however, that check valves which require the foam to move through an orifice arrangement at critical velocity cause separation of the foam into separate water and surfactant solution phases. Thus if the check valve is not of a suitable type, breaking of the foam can occur and there will be no foam available for circulating out undesirable solids or liquids from the well. For example, stem type check valves generally do not function in accordance with the present invention because of the high velocity of the foam through the restricted opening of the valve and the resulting breaking of the foam. Thus the one way check valve useful in the present invention must be one that allows relatively easy flow of the foam through the valve with a minimum pressure drop. In order to accomplish this the check or flapper valve should provide as large an opening for foam as possible and in all events the opening must be such that the foam flowing therethrough will be moving at below critical velocity at which separation of the phases occurs. For example, a check valve of the type shown in FIGS. 2 and 4 was successfully used in foam operations in a tubing string having an inside diameter of 2½ inches. The check valve opening had an inside diameter of 2 inches. The arrangement functioned well. In still another such arrangement a check valve having a 0.75 inch inside diameter opening was successfully used in tubing having 0.97 inch inner diameter.

In the optimum utilization of the present invention it is desirable that there be two flapper valves used in the elongated tubing string. Each flapper valve should be of the type described herein. One flapper valve should be located as near as possible the bottom of the elongated tubing string. The other flapper valve should be incorporated into the tubing string as described above at as high a location as possible after the bottom of the tubing string has entered or is about to enter the zone of fluid or liquid deposition in the well. Both flapper valves are downwardly opening. The foam column that is located between the two check valves when foam injection is stopped will flow out of the bottom check valve and into the well to provide for a dynamic foam condition in the well annulus for a sufficient time to

add a new pipe joint to the tubing string and to again inject foam down the well.

An unloading valve for use in unloading foam from a tubing string is shown in FIG. **3**. The unloading valve is used when it is desired to break down the tubing string as when pulling it from the hole. If the sub containing the upper check valve is simply unscrewed from the tubing string the compressed foam contained in the lower part of the tubing will be free to come out the top of the tubing. The unloading valve is used to open the flap of the flapper valve and to direct the foam to a suitable line for disposal.

Thus the unloading valve is formed of a tubular member **50** having a side entry arm **51**. The upper end of the tubular member **50** is provided with a threaded insert **52** which accommodates the threads **55** of a shaft **53**. The lower end of shaft **53** protrudes out the bottom of the tubular member **50** and is adapted to engage against and open a flap of a flapper valve when the shaft is turned down in the threads **55** of shaft **53**. The lower end of the tubular member **50** has suitable threads **56** for engaging the threads of the sub which contains the flapper valve. Thus when it is desired to unload foam from a tubing string the unloading valve is screwed into the sub by means of threads **56**. A suitable dump base is attached to arm **51** by means of threads **57**. The shaft **53** is then turned down in the threads of member **52** causing the shaft to open the flap of the flapper valve. Foam is then allowed to bleed from the tubing string through side arm **51**.

Refer now to FIGS. **5** and **6** where an alternative embodiment of apparatus assembled in accordance with the present invention is shown. A well **110** is shown penetrating the earth. The lower portion of well **110** has an accumulation of undesirable sand and liquid as indicated generally by the number **112**. A segmented drill pipe string as indicated generally by the number **113** has been run down the well **110** to a point where the end of the pipe string **113** is just entering the sand-liquid accumulation zone **112** of the well. The pipe string is made up of a number of individual pipe sections **119**, **130**, **131** and **132**. The successive sections of pipe forming the pipe string are connected together and are lowered into the well by means of a hoist as generally indicated by the number **114**. The hoist includes a power swivel **121** for connecting a flexible foam hose **111** to the uppermost pipe section of the elongated pipe string **113**. Each section of pipe, after it is connected to the tubing string, is lowered by means of the hoist until its upper end is located just about the slips in collar **157**. At this point, the slips are set to hang the pipe string in the well and the hoist and power swivel disconnected from the pipe section **119** and a new pipe section is lifted and connected to the pipe section **119** in the slips. After this operation is accomplished, the hoist and the power swivel **121** are connected to the upper end of the newly connected pipe of the pipe string and it may then be lowered again further into the well.

Suitable apparatus for supplying foam to the elongated pipe string via line **111** includes foam generator **122** utilizing gas pressure supply via line **128** for generation of a suitable aqueous-gas foam. Water and a detergent and, if desired, a concentrated caustic solution or other suitable stabilizing agent, are supplied via lines **125**, **126** and **127**, respectively, at rates sufficient to produce in mixer **124** a foamable solution. Such a suitable foamable solution may contain, for example, in parts by weight for each **100** parts thereof, about 0.1 to 1 part of an organic foaming agent, for example, the sodium salt of a linear C_{12}–C_{16} alkyl benzene sulfonic acid mixture. The foamable solution is delivered into the foam generator **122** via line **123**. A gas, for example air, is also delivered to the generator **122** via line **128** and a foam is formed. Such a suitable foam preferably has a gas-to-liquid volume ratio in the range of 3–50 to 1. The so-formed foam is directed to the tubing string by line **111** through valve **109** where it is circulated to assist in cleaning out a well.

In accordance with the alternative embodiment of the invention, the elongated pipe string **113** is formed by successively connecting together pipe sections. As each pipe section is added, the pipe string is progressively lowered into the well. The pipe string **113** is lowered to a position where the lower end thereof contacts the top of the sand or liquid region **112**. At this time, a flapper valve located in a sub such as illustrated in section in FIG. **6** and indicated generally by the number **133**, is connected into the upper end of the elongated pipe string. The flapper valve allows foam to pass down the pipe string into the well for circulation up the annulus **108** but prevents foam from backflowing up the pipe string. It has been found that if a flapper valve is placed in the location of sub **133** in the upper end of the tubing string **113** the energy in the foam in the tubing string **113** maintains motion of the foam up the annulus during a period of time sufficiently long to add a pipe section to the upper end of the tubing string, reconnect the foam line and to again circulate foam. Thus the energy needed to maintain the sand and foam in the annulus in a dynamic condition is acquired by means of the expansion of foam in the lower part of the pipe string when the upper part of the pipe string is blocked off to prevent backflow of foam. It is thus necessary that the flapper valve be added as high in the pipe string as possible immediately after the lower end of the pipe string contacts the upper surface of the liquid or sand zone **112**. If desired, the flapper valve may be added to the pipe string slightly before contact is made. However, in no event should the pipe string be substantially inserted below the upper part of the sand zone and foam circulated prior to the time a flapper valve is added to the pipe string.

FIG. **6** shows a sectional view of an alternative flapper valve useful in accordance with the present invention. In FIG. **6** a sectional view is shown illustrating a flapper valve contained in a sub **133** which is connected at a suitable location in the pipe string as, for example, between pipe sections **130** and **131**. A downwardly opening flapper valve contained in sub **133** is indicated generally by the numeral **134**. The downwardly opening flapper valve comprises a generally tubular body **135** having portions cut away to allow downward movement of flap **140**. Seals **136** and **137** provide a fluid tight connection between the exterior of the tubular member **135** and the interior of sub **133**. A shoulder **138** is formed in the sub **133** for seating the tubular member **135**. A suitable shock absorber **139** cushions the tubular member on the shoulder **138**. A flap **140** is provided to close off flow

through the tubular member. The flap **140** is arranged to be normally closed by means of resilient means **141**. The flap is openable by means of downward pressure. A seat **142** and an O-ring **127** are provided to seat and seal the flap in a closed position. The upper shoulder **129** of the tubular member **135** is provided with slots **118**. The flapper valve **134** is held in place in the pipe string by means of the shoulder provided by pipe section **130**. Thus the flapper valve **134** permits flow of foam down the pipe string but closes and prevents flow of foam up the pipe string.

Although certain specific embodiments of apparatus have been described herein the invention is not to be limited to only such embodiments but rather by the scope of the appended claims.

I claim:

1. A method for cleaning undesirable material from a well utilizing an aqueous-gas foam circulating medium comprising inserting an elongated tubing string into a well, said tubing string being formed by successively connecting together a plurality of pipe sections, lowering the so-formed tubing string into the well until the lower end of the tubing string reaches the undesirable material which is to be removed from the well, then connecting a downwardly opening check valve into the tubing string near the upper end thereof, said check valve permitting flow of foam down the tubing string but preventing flow of foam up the tubing string and injecting foam down the tubing string through said check valve at a velocity less than the critical velocity required to break the foam into separate liquid and gas phases and into said well to assist in removing undesirable material from the well.

2. The method of claim **1** further characterized by connecting a second downwardly opening check valve into the tubing string near the bottom end thereof and passing foam through said second check valve at a velocity less than the critical velocity required to break the foam into separate liquid and gas phases.

3. A method for cleaning undesirable material from a well utilizing an aqueous-gas foam circulating medium comprising inserting an elongated tubing string into a well, said tubing string being formed by successively connecting together a plurality of pipe sections, lowering the so-formed tubing string into the well until the lower end of the tubing string reaches the undesirable material which is to be removed from the well, then connecting a downwardly opening flapper valve into the tubing string near the upper end thereof, said flapper valve permitting flow of foam down the tubing string but preventing flow of foam up the tubing string and injecting foam down the tubing string through said flapper valve at a velocity less than the critical velocity required to break the foam into separate liquid and gas phases and into said well to assist in removing undesirable material from the well.

4. The method of claim **3** further characterized by connecting a downwardly opening flapper valve into the tubing string near the bottom end thereof.

5. A method of circulating foam into a well comprising inserting an elongated tubing string into a well, said tubing string being formed by successively connecting together a plurality of pipe sections, lowering the so-formed tubing string into the well, connecting a downwardly opening flapper valve into the tubing string near the upper end thereof, said flapper valve permitting flow of foam down the tubing string but preventing flow of foam up the tubing string, preforming on the surface a gas-liquid foam, said foam formed from an aqueous surfactant solution and a gas and having a gas to liquid volume ratio in the range of 3–50:1, flowing said foam to the upper end of said tubing string and injecting said foam down said tubing string through said flapper valve at a velocity less than the critical velocity required to break the foam into separate liquid and gas phases and into said well.

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