

July 5, 1966

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3,259,192

METHOD AND APPARATUS FOR INJECTING FLUID

Filed Oct. 22, 1963

3 Sheets-Sheet 1

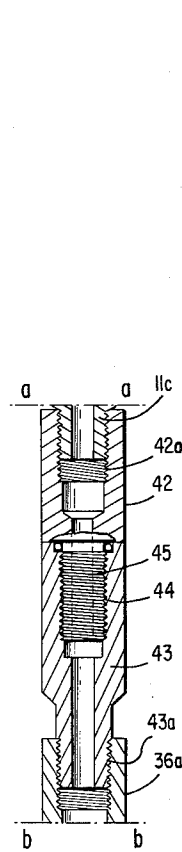
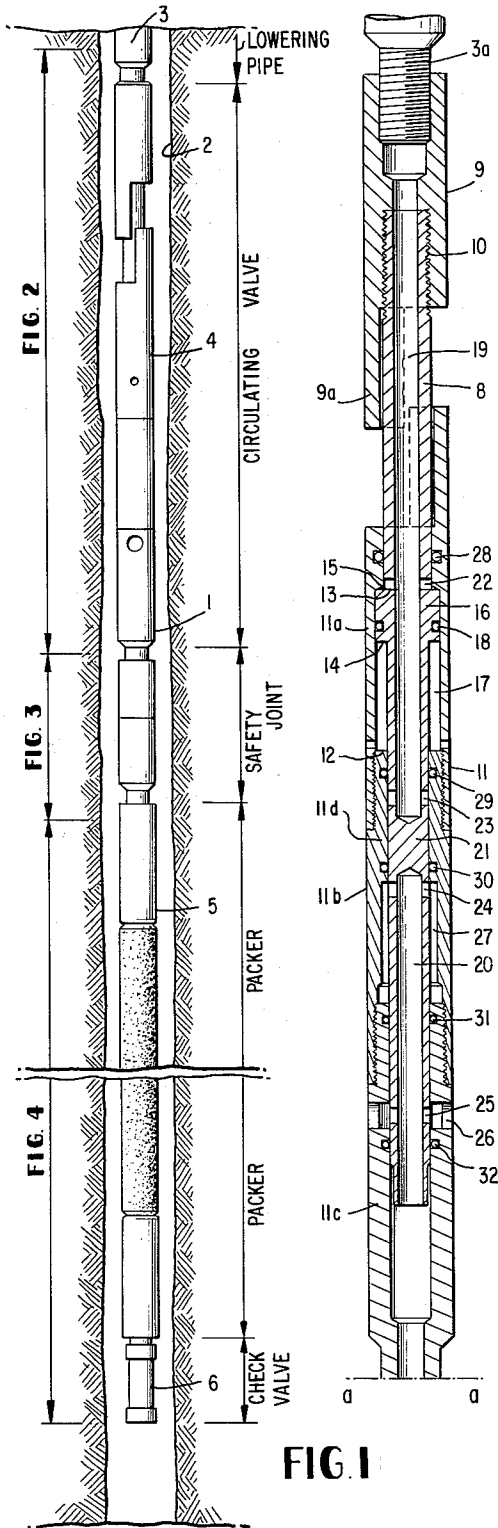
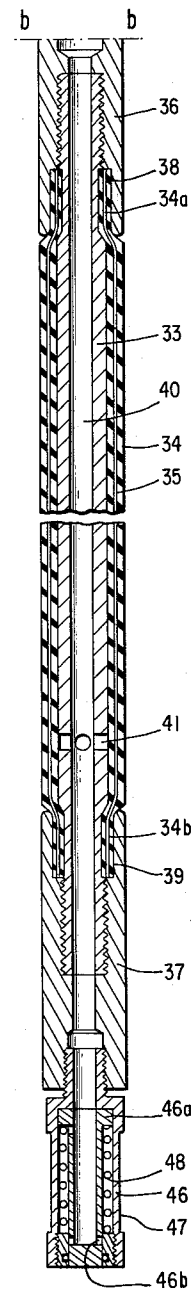


FIG. 3

FIG. 4

FIG. 2



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3 Sheets-Sheet 2

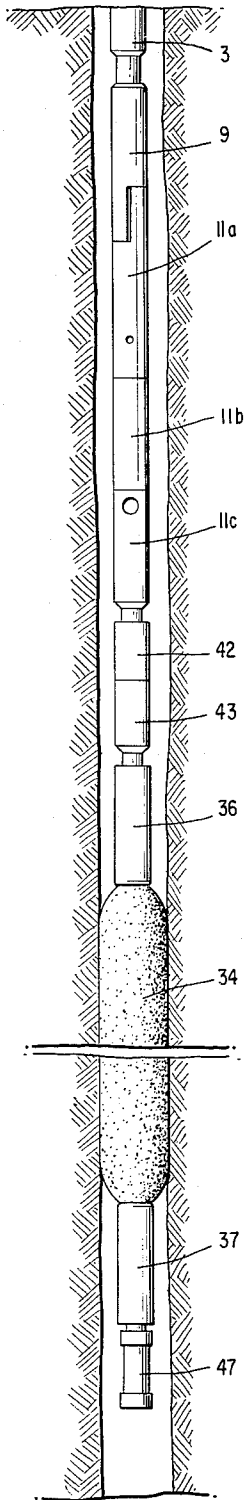


FIG. 5

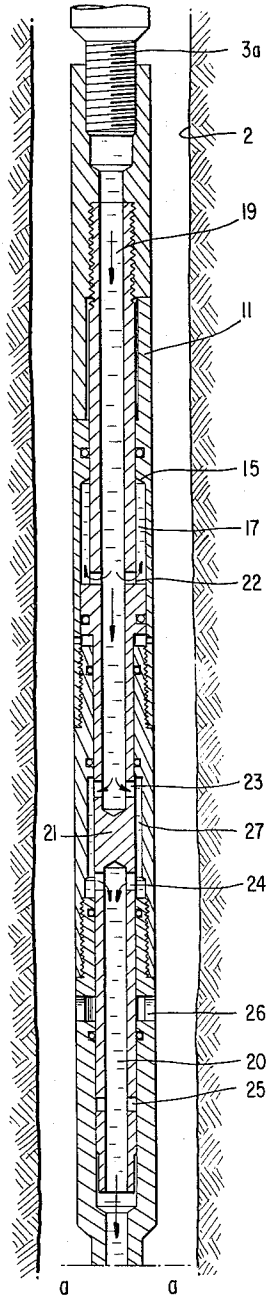


FIG. 6

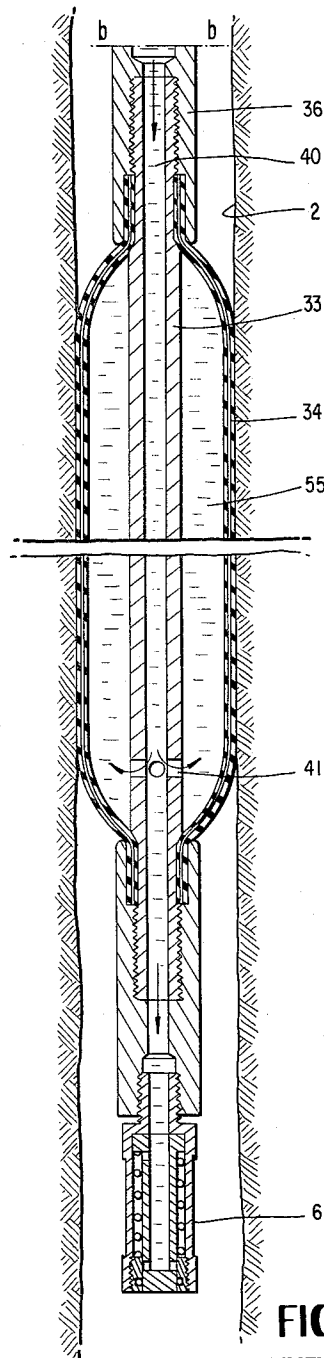


FIG. 7

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METHOD AND APPARATUS FOR INJECTING FLUID

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9 Claims. (Cl. 166—150)

This invention relates to methods and apparatus for injecting fluid into material. In particular, it relates to a method and apparatus for injecting grouting material into porous, fractured, unconsolidated, or other formations, the cohesion of which is to be increased and/or the permeability of which is to be decreased.

The art of injecting grouting fluid into formations for the purpose of increasing their cohesiveness or reducing their permeability is well established. While many techniques and tools are known for performing grouting operations, they often entail substantial operating drawbacks. For example, many grouting tools include slips or laterally extendable holding means which are employed to secure the tools while high pressure fluids are injected into formations. In practice it has been found that such slips are often difficult to set and may be difficult to release at the conclusion of a grouting operation.

While certain grouting tools have included elastic packer members designed to isolate a grouting zone, the setting and releasing of such packer members has often been difficult and tedious. In addition, in the use of such packers, when the pressure of the grouting fluid exterior of the tool exceeded the pressure of fluid employed to operate the packer, leakage of grouting fluid around the packer occurred. Certain problems have also been occasioned in attempting to release the pressure employed to actuate or set grouting tool packers.

Other difficulties involved in the operation of previously known grouting tools have involved an undue amount of time required for the setting of the tools and for the commencement of grouting as well as undue structural complexity which made the setting, use, and release of grouting tools tedious, time-consuming, and difficult.

In appreciation of the significant structural and functional disadvantages inherent in previously known grouting methods and apparatus, it is an object of the present invention to provide methods and apparatus for injecting fluid into material which are particularly adapted to grouting operations and which substantially obviate disadvantages of prior techniques and tools such as those heretofore described.

It is an additional object of the invention to provide such a method and apparatus which eliminates the necessity of employing slips or similar devices to secure a packer-carrying grouting tool.

It is also an object of the invention to provide such a method and apparatus, by means of which a tool such as a grouting tool may be secured within a passage in response to, but dependent on, the continued supplying of fluid pressure to the tool.

It is a further object of the invention to provide such a method and apparatus by means of which a tool may be released from a passage in response to a manipulation tending to withdraw the tool from the passage. It is likewise an object of the invention to provide a grouting tool including an elastic packer, expandable in response to the application of fluid pressure, wherein a predetermined pressure differential is maintained with respect to the packer-inflating pressure within the tool and the grouting pressure exterior of the tool.

It is a related object of the invention to provide such a tool wherein, in addition to means for venting the packer-inflating fluid, other means are provided whereby the

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tool may be isolated from the supply of pressurized fluid when it is desired to effect the removal of the tool.

A further object of the invention is to provide a tool such as that heretofore described wherein a portion of the tool including actuating components may be selectively disengaged from a portion of the tool carrying an elastic packer.

A final object of the invention is to provide a method and apparatus which materially facilitates, simplifies, and improves the reliability of fluid-injecting operations such as grouting.

In accomplishing the foregoing objectives, a method for operating a tool for discharging fluid is envisioned, which method entails the following steps:

First, the tool is inserted into a passage;

Second, pressurized fluid is supplied to a portion of the tool to cause the tool to become engaged with the passage, with this engagement being dependent upon the maintenance of fluid pressure within the tool;

Third, fluid is flowed out of the tool while a predetermined pressure differential is maintained between the tool interior and exterior so as to maintain the tool in engagement with the aforesaid passage; and

Fourth, the portion of the tool to which pressurized fluid was supplied is placed out of fluid communication with the supply of pressurized fluid so that the tool becomes disengaged from the passage and pressurized fluid within the tool is allowed to vent into the passage.

The apparatus of this invention to be employed in injecting fluid includes laterally distensible and contractable packer means. First valve means are provided through which pressurized fluid may be directed to pass from the interior of the tool to the packer means so as to effect the lateral distension of this packer means. Valve operating means, responsive to fluid pressure within the tool, are provided for operating the valve means to direct pressurized fluid to the packer means. Second valve means are provided through which pressurized fluid, serving to distend the packer means, may be vented so as to allow contraction of the packer means. Third valve means adapted to allow a flow of pressurized fluid out of the tool are provided. This third valve means opens in response to the attainment of a predetermined fluid pressure within the tool and is positioned on the tool so that it may be in fluid communication with pressurized fluid which serves to distend the packer means carried by the tool.

Broader aspects of the invention involve unique methods and apparatus for effecting the setting and releasing of an elastic packer.

In a preferred packer setting technique, a first fluid is directed through a passageway and restricted opening means branching therefrom to an elastic packer to effect its expansion. The viscosity of this first fluid remains substantially constant with the passage of time. A second fluid is thereafter directed through the passageway and allowed to issue from the tool. The viscosity of the second fluid, which may comprise a grouting fluid, increases with the passage of time. Thereafter fluid pressure within the passageway is reduced so that the first fluid may vent by initially returning into the passageway through the restricted opening means to allow the contraction of the elastic packer.

Another broad aspect of the invention, involving the setting and releasing of an elastic packer, entails a method and apparatus wherein pressurized fluid is directed to an elastic packer to effect its expansion, with the maintenance of this expansion being dependent upon the maintenance of fluid pressure. After fluid within the tool and in fluid communication with the expanded packer has attained a predetermined fluid pressure, this fluid is allowed to issue from the tool.

Consistent with the foregoing broad aspects of the invention, the preferred apparatus embodiment is characterized by a unique combination of a valving sleeve, ported mandrels, and an elastic-sleeve packer.

In describing the invention, reference will be made to preferred apparatus and method embodiments which will be described with reference to the accompanying drawings. In these drawings:

FIGURE 1 is a schematic, elevational view of the exterior of a preferred embodiment of a grouting tool illustrating the positional relationships of major tool components and these components as they are arranged while the tool is being positioned within a passage;

FIGURE 2 is an enlarged, sectional, and elevational view of a circulating valve portion of the tool shown in FIGURE 1;

FIGURE 3 is an enlarged, sectional, and elevational view of a safety joint which may be included in the tool shown in FIGURE 1;

FIGURE 4 is an enlarged, sectional, and elevational view of a packer portion of the tool shown in FIGURE 1;

FIGURE 5 illustrates the exterior arrangement of components of the FIGURE 1 tool when the elastic packer carried by this tool has been laterally expanded into engagement with passage wall portions;

FIGURE 6 provides an illustration of the circulating valve components of the tool shown in FIGURE 2, with such components being arranged to effect the inflation of the tool packer;

FIGURE 7 provides an illustration of the arrangement of tool packer components shown in FIGURE 4 when these components have been manipulated to effect the inflation of a packer sleeve;

FIGURE 8 is a sectional view of the tool packer components as they are arranged after the inflation of the packer sleeve and disposed for the injection of fluid such as grouting material into a passage below the inflated packer sleeve;

FIGURE 9 is a schematic and elevational view of the upper portion of the tool shown in FIGURE 1 in combination with a valve mechanism which may be incorporated in the conduit supporting the tool in relatively close proximity to the tool; and

FIGURE 10 provides a fragmentary, enlarged and partially sectional view of the valve mechanism shown in FIGURE 9.

As shown in FIGURE 1, the grouting tool embodiment of the present invention comprises a tool 1 adapted to be supported on the end of a conduit or pipe string 3 and inserted into an opening or passage 2. As will be appreciated, passage 2 may comprise a bored hole, a fissure in a subterranean formation, an opening in a ground surface or other mass, etc. Pressurized fluid may be supplied to the conduit string 3 for transmission to the tool 1 by conventional fluid pump means not shown.

The principal components of the tool 1, as schematically shown in FIGURE 1, include a circulating valve 4, a packer 5, and a check valve 6. The tool may also include a conventional safety joint 7.

While the tool components are shown in separated positions in FIGURES 2, 3 and 4, it will be appreciated that the components shown in these figures are joined along the connecting lines *a-a* and *b-b* according to the manner in which these connecting lines are shown in each of these views. Connecting lines *a-a* and *b-b* are also illustrated in FIGURES 6, 7 and 8 with reference to the components of the packer portion of the tool when the packer is in its expanded condition.

FIGURES 1 and 2 illustrate the structural details and relative positioning of the components of the circulating valve 4 when the tool 1 is initially positioned within the passage 2.

Circulating valve 4, as shown in FIGURE 2, includes a first mandrel portion 8 which is connected to an externally threaded end 3a of the conduit string 3 by a coupling collar 9. Coupling collar 9 may be internally threaded

at each end so as to threadably connect the externally threaded end 3a of the conduit string with an externally threaded end 10 of the mandrel portion 8.

Circulating valve 4 further includes sleeve means 11 which may be composite in character and include threadably interconnected and generally tubular sections 11a, 11b and 11c.

Sleeve means 11 is telescopically and reciprocally mounted upon mandrel portion 8, with the maximum limits of such reciprocation being established by annular mandrel abutments 12 and 13 which are adapted to respectively engage annular sleeve abutments 14 and 15. Abutments 12 and 13 are defined by a radially enlarged portion 16 of the mandrel portion 8.

As illustrated, enlarged mandrel portion 16 extends radially into an annular recess 17 which extends generally radially outwardly and longitudinally of the interior of the sleeve means 11. Enlarged mandrel portion 16, with the cooperation of sealing means such as a conventional O-ring 18, is sealingly and telescopically engaged with the wall of the recess 17.

Mandrel portion 8 includes a first fluid passage 19 which is in fluid communication with the interior of the conduit string 3 and a second fluid passage 20. As shown, fluid passage 20 is disposed between fluid passage 19 and the packer portion 5 of the tool 1. Passages 19 and 20 are separated by a plugged mandrel portion or barrier 21.

A series of axially spaced ports are incorporated in the first or upper mandrel portion 8.

One such group of ports, i.e., first port means 22, comprises at least one, and preferably two or more, ports as shown which extend radially through the wall of mandrel portion 8 and are in fluid communication with the passage 19 and the recess 17.

Second port means 23, which includes at least one and preferably two or more radially extending ports intersecting the wall of mandrel portion 8, are also in fluid communication with the first passage 19. As shown in FIGURE 2, second port means 23 are located between radial mandrel enlargement 16 and barrier 21.

Third port means 24 are disposed on the side of barrier 21 opposite to that where second port means 23 are located. Port means 24 includes at least one and preferably two or more radially extending ports which intersect the mandrel portion 8 so as to be in fluid communication with the passage 20.

Fourth port means 25, incorporated in mandrel portion 8, comprise at least one and preferably two or more radially extending ports which intersect mandrel portion 8, and are in fluid communication with passage 20. Fourth port means 25 are located so as to lie between third port means 24 and the lower end of the mandrel portion 8 when the apparatus is viewed as shown in FIGURE 1.

Fifth port means 26 are incorporated in the sleeve means 11. As shown in FIGURE 2, port means 26 comprises at least one and preferably two or more radially extending ports which pass through the wall of lower sleeve portion 11c so as to provide fluid communication between the interior and exterior of this sleeve portion.

In order to insure and maintain proper rotary alignment between the port means 25 and 26, a semi-cylindrical portion 11a of the sleeve means 11 may be provided which extends toward the coupling member 4. A similar semi-cylindrical portion 9a of the coupling member 9 projects toward the sleeve means 11 and is diametrically displaced from the position of the sleeve portion 11e as shown in FIGURES 1 and 2. As will be appreciated, the illustrated overlapping relationship of the sleeve portion 11a and coupling portion 9a provides a rotationally abutting relationship between the projection 11a and 9a which limits relative rotation of sleeve means 11 on the mandrel portion 8.

As will be appreciated, the length of the projecting portions 11a and 9a may be such as to exceed the extent of

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maximum reciprocation of the enlarged portion 16 in the annular sleeve recess 17 so that the free ends of the projections 11a and 9a will respectively engage the connecting member 4 and sleeve means 11 so as to limit the extent of upward telescoping movement of the sleeve means 11 over the mandrel portion 8.

With the arrangement of components shown in FIGURE 2, it will be appreciated that pressurized fluid introduced into passage 19 through conduit string 3 will pass through port means 22 and apply fluid pressure against the annular surface 15 and thus tend to move the sleeve means 11 toward the conduit string 3. With the components positioned as shown in FIGURE 2, before fluid pressure has been applied, a collar portion 11d of the sleeve means 11 cooperates with the outer periphery of the mandrel portion 8 so as to isolate the second port means 23 from the third port means 24. In this position of the tool components, the fourth port means 25 is axially aligned with the fifth port means 26 so that fluid communication is established between the tool exterior and the passage 20.

The abutting relationship between surface 15 of enlarged portion 16 of mandrel 8 and annular surface 13 of sleeve means 8 may be employed to effect the proper axial alignment of the port means 25 and 26.

As will be appreciated, when pressurized fluid is introduced into the passage 19, and the sleeve means 11 moves toward the conduit string 3 in response to the application of fluid pressure to the annular surface 15, the collar 11d will move toward the conduit string 3 so as to uncover the second port means 23. In this manner, the second port means 23 and the third port means 25 will be placed in fluid communication by way of an annular recessed portion 27 formed in the sleeve portion 11b. In this upward position of the sleeve means 11, the fifth port means 26 will have been displaced toward the conduit string 3 so as to be isolated from the fourth port means 25.

The positioning of the components of circulating valve 4, with the sleeve means 11 telescoped over the mandrel portion 8 toward the conduit string 3, is illustrated in FIGURE 6 and will be subsequently described with reference to the overall mode of operation of the tool 1.

Appropriate sealing relationships between the components of the circulating valve 4 may be achieved through conventional means such as the O-rings 28, 29, 30, 31, and 32 shown in FIGURE 2.

Structural details of the packer 5 are illustrated in FIGURE 4. As there shown, packer 5 includes a second mandrel portion 33 upon which is coaxially supported a laterally distensible and contractable, elastic packer 34. Packer 34 may comprise a generally tubular or cylindrical sleeve of elastomeric material, such as rubber. Preferably resilient reinforcing elements are embedded within the sleeve 34. Such reinforcing elements may comprise strands of nylon 35, schematically shown in FIGURE 4, which extend generally longitudinally of the sleeve 34. Such strands 35 may be biased or inclined with respect to the longitudinal or axial direction of the sleeve 34.

Sleeve 34 may be secured on the second mandrel portion 33 at each end 34a and 34b by sleeve connecting member 36 and 37. As shown in FIGURE 4, connecting member 36 includes an annular recess 38 adapted to receive one end 34a of the sleeve 34, while connecting portion 37 includes a similar recess 39 adapted to receive and secure the end 34b of the sleeve 34. The sleeve ends 34a and 34b may be bonded to the recessed portions 38 and 39 and the portions of mandrel 33 immediately adjacent these recesses by any of several conventional bonding techniques. For example, where the sleeve 34 is fabricated of rubber, a conventional adhesive employed for securing rubber to metallic surfaces may be employed to effect this bonding. Several, well-known, artificial resin type adhesives are commercially available for this purpose.

Second mandrel portion 33 includes an axially extending, third fluid passage 40 which is disposed beneath the

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second passage 20 of the first mandrel portion 8 when the tool is assembled and positioned as shown in FIGURE 1. As will be apparent from the drawings, passage 40 is in fluid communication with passage 20 by way of the interior of sleeve means 11.

Sixth port means 41 are included in second mandrel portion 33. Port means 41 may comprise at least one or preferably, as shown, a plurality of ports or relatively restricted openings which extend radially through the wall of mandrel portion 33 so as to provide fluid communication between the passage 40 and the interior of the packer sleeve 34. As will be appreciated when fluid is supplied to the third passage 40, fluid pressure will be transmitted through the port means 41 to act upon the packer 34 to effect its lateral distension or expansion.

As shown in FIGURES 1, 3 and 4, circulating valve 4 may be connected to packer 5 by a conventional safety joint 7. Safety joint 7, as illustrated in FIGURE 3, may comprise a connecting member 42 having an internally threaded recess 42a threadably engaged with a threaded end 11c of sleeve means 11. Safety joint 7 may further include a connecting member 43 having an externally threaded end 43a adapted to be threadably engaged with an internally threaded end 36a of connecting member 36, which member 36 defines an extension of second mandrel portion 33.

Coupling members 42 and 43 are threadably interconnected by a left-hand threaded joint which may comprise a threaded female portion 44 carried by coupling member 43 and a male threaded portion 45 carried by a coupling member 42. Bearing in mind that the remainder of the threaded joints in the conduit string 3 and throughout the tool 1 would be of conventional or right-hand threaded character, the left-hand threaded connection between coupling members 42 and 43 would enable the tool to be selectively separated at the safety joint by merely imparting clockwise rotation to the conduit string 3. With the mode of operation and structure of such a safety joint being conventional and well understood in the art, further description of this component, which may be incorporated in the tool, is not necessary.

A schematic representation of a representative type of check valve structure which may be incorporated in check valve portion 6 of tool 1 is illustrated in FIGURE 4. As there shown, check valve 6 may include a piston-type, valving member 46 which is secured within a valve housing 47 by a coil type of compression spring 48. Compression spring 48 exerts a predetermined biasing force upwardly on a collar portion 46a of the valve 46 so as to hold the valve 46 closed until a predetermined fluid pressure has been attained within the passage 40 which communicates with the interior of the piston 46 as shown.

When a predetermined fluid pressure is attained within the passage 40, such that a biasing force is exerted on the piston 46 sufficient to overcome the predetermined biasing strength of the coil spring 48, the piston 46 is displaced outwardly of the housing 47 so as to uncover one or more piston ports 46b and allow a flow of material out of the passage 40.

With the check valve 6 being supported upon the coupling member 37, which defines an extension of the second mandrel portion 33, it will be appreciated that fluid is thus allowed to issue from the tool 1, with the packer unit 5 being located between the point of fluid issuance and the conduit string 3.

Under certain circumstances it may be desired to incorporate a valve mechanism in the conduit string 3 for the purpose of venting excessively high fluid pressure from the interior of the conduit string 3 to the exterior of this string. A valve 49, which may be employed for this purpose, is schematically illustrated in FIGURES 9 and 10.

As shown schematically in FIGURES 9 and 10, valve 49 may include a generally cylindrical sleeve unit 50 which is telescopically mounted upon a portion of conduit

string 3 below an abutment or collar 51. One or more radially extending ports 52 may be provided in the wall of conduit string 3, below abutment 51, in the manner generally shown in FIGURE 10. Sleeve 50, which is reciprocally mounted upon the conduit string 3 between movement limiting abutments 51 and 53, is adapted to be frictionally engaged with the wall of the passage 2 by means such as a plurality of outwardly flexed leaf springs 54.

As will be appreciated, while the tool 1 is being inserted into the passage 2, the leaf springs 54 will frictionally engage the wall of the passage 2 so as to bias the sleeve 50 generally toward the abutment 51. With the sleeve 50 in engagement with the abutment 51, this sleeve will cover and thus seal the ports 52. By exerting a pull on the conduit string 3 away from the site of the tool 1, the string 3 will be moved upwardly with respect to the sleeve 50, which sleeve is restrained against movement by frictional engagement of the springs 54 with the wall of the passage 2. Such an upward movement of the conduit string 3 will thus be effective to cause the sleeve 50 to uncover the ports 52 and allow pressurized fluid within the string 3 to vent into passage 2 exteriorly of the conduit string 3.

The manner in which the tool heretofore described may be employed for injecting fluid, such as grouting fluid, into a formation will now be described with reference to FIGURES 1 through 10.

After the tool has been inserted into the passage 2 in the position shown in FIGURE 1, the tool components will be in the positions illustrated in FIGURES 2, 3 and 4. When pressurized fluid is passed through the conduit means 3 to the first passage 19, the sleeve means 11, carrying the packer unit 5, will telescope over the mandrel portion 8 toward the conduit string 3 so that the tool components assume the positions shown in FIGURES 5, 6 and 7. In this disposition, the sleeve means 11 will have been moved toward the conduit string 3 in response to fluid pressure passing through the port means 22 and acting on the reaction surface, i.e., piston means 15. With the sleeve means 11 thus positioned in the upper or raised position as shown in FIGURE 6, the port means 23 and 24, functioning in combination with annular recess 27 and collar portion 11d as a first valve means, will place passages 19 and 20 in fluid communication. Fluid will then flow from the first passage 19, around the barrier 21, and into the second passage 20. Owing to the relative displacement of the ports 25 and 26, which subsequently function as a second or venting valve means, a flow of fluids from the passage 20 to the exterior of the sleeve means 11 will be prevented. Thus, fluid entering the passage 20 will pass into the third passage 40 of the mandrel portion 33. Fluid entering the mandrel portion 33 will pass through the relatively restricted openings or port means 41 and act upon the interior of the packer sleeve 34. Packer sleeve 34 will thus expand or distend laterally outwardly to assume the position shown in FIGURE 7 where the packer engages the wall of the passage 2.

In order to effect the expansion of the packer sleeve 34, it is desirable to employ an actuating fluid, the viscosity of which remains substantially constant with the passage of time. Such a setting fluid may comprise, for example, water. By using such a packer-setting fluid, the packer cavity 55 will be filled with a liquid and subsequently be readily vented through the restricted openings comprising the port means 41.

After the packer sleeve 34 has been expanded and set, grouting material may be flowed through the conduit string 3 so as to flow through the tool 1 and act upon the piston 46 within third valve means, i.e., check valve 6. When a predetermined fluid pressure has been created within the passage 40, sufficient to overcome the valve closing, biasing force provided by the coil spring 48, the

valve 46 will open so as to allow the discharge of grouting fluid through the ports 46b, as shown in FIGURE 8. As will be appreciated, the spring loaded check valve 46 will insure the maintenance of a predetermined biasing or packer setting force on the packer sleeve 34. The predetermined pressure differential thus created between the tool exterior below the packer sleeve 34 and the tool interior will serve to discourage the leakage of grouting fluid around the set packer sleeve 34 and serve to prevent upward displacement of the set tool in response to grouting fluid pressure acting on the lower end of the packer.

While a variety of grouting fluids may be successfully employed with this tool, a representative grouting fluid comprises a catalyzed aqueous mixture of acrylamide and N,N'-methylenebisacrylamide which gels rapidly at ordinary concentrations and temperatures.

After a grouting operation has been completed, the supply of grouting fluid to the tool 1 may be interrupted and an upward force exerted on the conduit string 3. This upward force will tend to move the first, or upper, mandrel portion 8 away from the site of the set tool 1 so as to return the tool components to the positions shown in FIGURES 1 and 2. In this position the port means 23 and 24 will have been restored to their mutually isolated relationship so as to have separated the packer portion of the tool from the supply of pressurized fluid. In addition, the ports 25 and 26 will have been realigned so as to reestablish fluid communication between the passage 40 and the exterior of the sleeve means 11. Due to this reestablished communication, packer inflating fluid in the space 55 between the interior of the sleeve 34 and the exterior of the mandrel portion 33 will be vented or returned to the passage 40. This venting permits the collapse of the sleeve 34 and the withdrawal of the entire tool 1 in response to continued upward movement of the conduit string 3. As will be appreciated, this collapse of the packer and withdrawal of the tool is materially facilitated by the ease with which the relatively low viscosity packer inflating fluid is vented through the restricted opening or port means 41 and out of the tool through the sleeve ports 26.

In certain instances it may be desirable to allow the tool to remain in place while at least initial setting of a grouting fluid is accomplished. Where grouting fluids such as the gelling fluid previously described are employed, the increased viscosity of the fluid which may remain within the interior of the tool 1 would not ordinarily materially impede or prevent the collapse of the packer 34 when the removal of the tool 1 is attempted. However, if desired, after sufficient grouting fluid has been injected into a formation, the tool may again be filled with substantially constant viscosity fluid so as to more positively insure the ready venting of the packer chamber 50.

In the event that the collapse of the packer 34 should prove unduly difficult, as for example due to a cave-in of the passage 2, the circulating valve portion of the tool 1 may be retrieved by exerting a clockwise torque on the string 3 so as to separate the circulating valve 4 from the set packer portion of the tool.

Where the tool 1 is employed on a conduit string of such length that an inordinately high fluid pressure is imposed in the tool interior as a result, for example, of the hydrostatic head of fluid contained within the string 3, it may be desirable to vent the string 3 above the tool 1. This may be accomplished by employing and operating fourth valve means such as the valve 49. With the valve 49 incorporated in the conduit string 3 immediately above or in close proximity to the tool 1, an upward pull on the string 3 will be effective to uncover the ports 52 and thus allow the venting of the string above the tool. This will prevent the imposing of undue fluid pressure on the annular reaction surface 15 which might tend to restore the sleeve means 11 to the packer setting position shown in

FIGURE 6, even though a tool withdrawing force was being exerted on the conduit string 3.

In describing the structure and operation of a preferred embodiment of the invention, the several advantages attributable to the invention have been made apparent. As shown, the setting of the tool may be readily accomplished merely by supplying pressurized fluid to the tool, while the tool may be released from its set position merely in response to a tool withdrawing force being exerted upon the tool-supporting conduit string.

Through the use of the check valve at the end of the conduit string, in combination with the elastic packer sleeve, a predetermined packer setting or holding force is maintained at all times.

In employing a substantially constant viscosity, packer setting fluid, maximum ease of tool release or unsetting is made possible.

Through the use of the safety joint, separation of the valving portion of the tool from the packer portion of the tool is made feasible so that the valve may be retrieved, even though the packer portion of the tool be left in place in a passage.

The incorporation of a circulating or venting valve above the tool enables pressure within the tool supporting conduit to be conveniently vented to facilitate the release of the set tool.

Particular advantages result from the concept of isolating the packer portion of the tool from the supply of pressurized fluid and also venting the packer portion of the tool so as to doubly facilitate the collapse of the packer to allow the withdrawal of a tool.

Additional and substantial advantages reside in the rugged and structurally simple character of the tool which facilitates the ease and reliability of tool setting and removing and improves the overall efficiency of the grouting operation.

While the invention has been described with reference to a preferred embodiment, it will be apparent to those skilled in the art that additions, deletions, modifications and substitutions may be made with respect to the structure of the disclosed apparatus components and operating methods. Clearly, the invention is not limited to the specific structural embodiment shown nor to the use of the specific tool setting fluid and grouting fluid described.

The overall scope of the invention is set forth in the appended claims.

What is claimed is:

1. A tool for injecting fluid into material, said tool comprising:

laterally distensible and contractable packer means carried by said tool;

first valve means through which pressurized fluid may be directed to pass from the interior of said tool to said packer means to effect lateral distension of said packer means;

valve operating means comprising piston means connected with said first valve means and responsive to fluid pressure within said tool for operating said first valve means to direct said pressurized fluid to said packer means;

second valve means connected and operable simultaneously with said first valve means and through which pressurized fluid serving to distend said packer means may be vented so as to allow contraction of said packer means, said second valve means being operable to effect said venting when said first valve means is closed; and

third valve means adapted to allow a flow of pressurized fluid out of said tool and into said material in response to the attainment of a predetermined fluid pressure within said tool, said third valve means being adapted to be in fluid communication with pressurized fluid serving to distend said packer means.

2. A tool as described in claim 1 in combination with fourth valve means mounted upon conduit means supply-

ing pressurized fluid to said tool, said fourth valve means being selectively operable to establish fluid communication between the interior and exterior of said conduit means, said fourth valve means comprising abutment means on the outer periphery of said conduit means, radially extending port means intersecting said conduit means, sleeve means slidably mounted on the exterior of said conduit means and adapted to close said port means when disposed in radial alignment therewith, and spring means mounted on said sleeve means and adapted to engage an opening in said material into which said tool is injected.

3. A tool as described in claim 1 wherein said tool includes:

conduit means adapted to supply pressurized fluid to said tool;

a first mandrel portion adjacent said conduit means;

a second mandrel portion disposed with the first mandrel portion between it and said conduit means;

sleeve means reciprocally carried by said first mandrel portion and supporting said piston means of said valve operating means; and

selectively releasable coupling means between said sleeve means and said second mandrel portion whereby said sleeve means, said first mandrel portion, and said conduit means may be selectively detached from said second mandrel portion;

said second mandrel portion including thereon said packer means.

4. A grouting tool adapted to be supported upon conduit means for supplying pressurized fluid, said grouting tool comprising:

a first mandrel portion, one end of which is adapted to be connected with said conduit means;

a second mandrel portion disposed with the first mandrel portion located between it and said conduit means;

first passage means in said first mandrel portion in fluid communication with the interior of said conduit means;

second passage means in said first mandrel portion and located between said first passage means and said second mandrel portion;

barrier means between said first and second passage means;

third passage means in said second mandrel portion in fluid communication with said second passage means; sleeve means mounted for axial reciprocation on said first mandrel portion;

generally annular surface means extending transversely outwardly from an intermediate portion of an inner wall of said sleeve means;

an annular recess in said inner wall of said sleeve means;

first port means in said first mandrel portion in communication with said first passage means for directing pressurized fluid from said first passage means to said annular surface means;

a radially enlarged portion of said first mandrel portion, said radially enlarged portion being located between said first port means and one end of said annular sleeve recess and extending laterally into said annular recess in sealing and telescoping relationship therewith;

second port means in said first mandrel portion in fluid communication with said first passage means, said second port means being located between said radially enlarged portion of said first mandrel portion and said barrier means;

third port means in said first mandrel portion in fluid communication with said second passage means;

a collar portion of said sleeve means adapted to close said second port means when said sleeve means is telescopically moved on said first mandrel portion toward said second mandrel portion and adapted to

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uncover said second port means and place said second and third port means in fluid communication when said sleeve means is telescoped over said first mandrel portion toward said conduit means;

fourth port means in said first mandrel portion in fluid communication with said second passage means, said fourth port means being located between said third port means and said third fluid passage means;

fifth port means in said sleeve means in fluid communication with the exterior of said tool;

said fourth and said fifth port means being mutually sealed from each other by a portion of said sleeve means when said sleeve means is telescoped over said first mandrel portion toward said conduit means and being adapted to be placed in fluid communication when said sleeve means is telescoped over said first mandrel portion toward said second mandrel portion;

elastic packer means carried on the outer periphery of said second mandrel portion;

sixth port means in said second mandrel portion providing fluid communication between said third passage means and the interior of said packer means; and

check valve means carried by said second mandrel portion, said check valve means being adapted to open in response to the attainment of a predetermined fluid pressure within said third passage means and to allow a flow of fluid to the exterior of said tool, with said packer means being disposed between said exterior flow and said conduit means;

said sleeve means being adapted to move toward said conduit means so as to place said second and third port means in fluid communication in response to the supplying of pressurized fluid to said first passage means; and

said sleeve means being adapted to assume a position so as to seal said second port means from said third port means and to place said fourth and fifth port means in fluid communication in response to movement of said conduit means away from the site of said tool.

5. A tool as described in claim 4 in combination with valve means in said conduit means, said valve means being selectively operable to establish fluid communication between the interior and exterior of said conduit means.

6. A tool as described in claim 4 including selectively releasable coupling means between said sleeve means and said second mandrel portion.

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7. A tool as described in claim 4 wherein said packer means comprises a cylindrical sleeve of elastomeric material in which resilient reinforcing elements are imbedded.

8. A tool as described in claim 4 including abutment means adapted to limit rotation of said sleeve means relative to said first mandrel portion.

9. A tool for injecting fluid into material, said tool comprising:

laterally distensible and contractable packer means;

means for directing pressurized fluid to said packer means to cause its lateral distension, with the maintenance of said distension being dependent upon the maintenance of fluid pressure against said packer means;

valve means adapted to allow a flow of pressurized fluid out of said tool in response to the attainment of a predetermined fluid pressure within said tool, said valve means being adapted to be in fluid communication with pressurized fluid serving to distend said packer means;

conduit means adapted to supply pressurized fluid to said tool; and

sleeve valve means selectively operable to establish fluid communication between the interior and exterior of said conduit means, said sleeve valve means including,

abutment means on the outer periphery of said conduit means,

radially extending port means intersecting said conduit means;

sleeve means slidably mounted on the exterior of said conduit means and adapted to close said port means when disposed in radial alignment therewith, and

spring means mounted on said sleeve means and adapted to engage the wall of an opening in said material into which said tool is inserted.

References Cited by the Examiner

UNITED STATES PATENTS

2,058,688	10/1936	Halliburton	166—27
2,196,658	4/1940	Burt	166—187
2,399,125	4/1946	Lehnhard	166—187

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