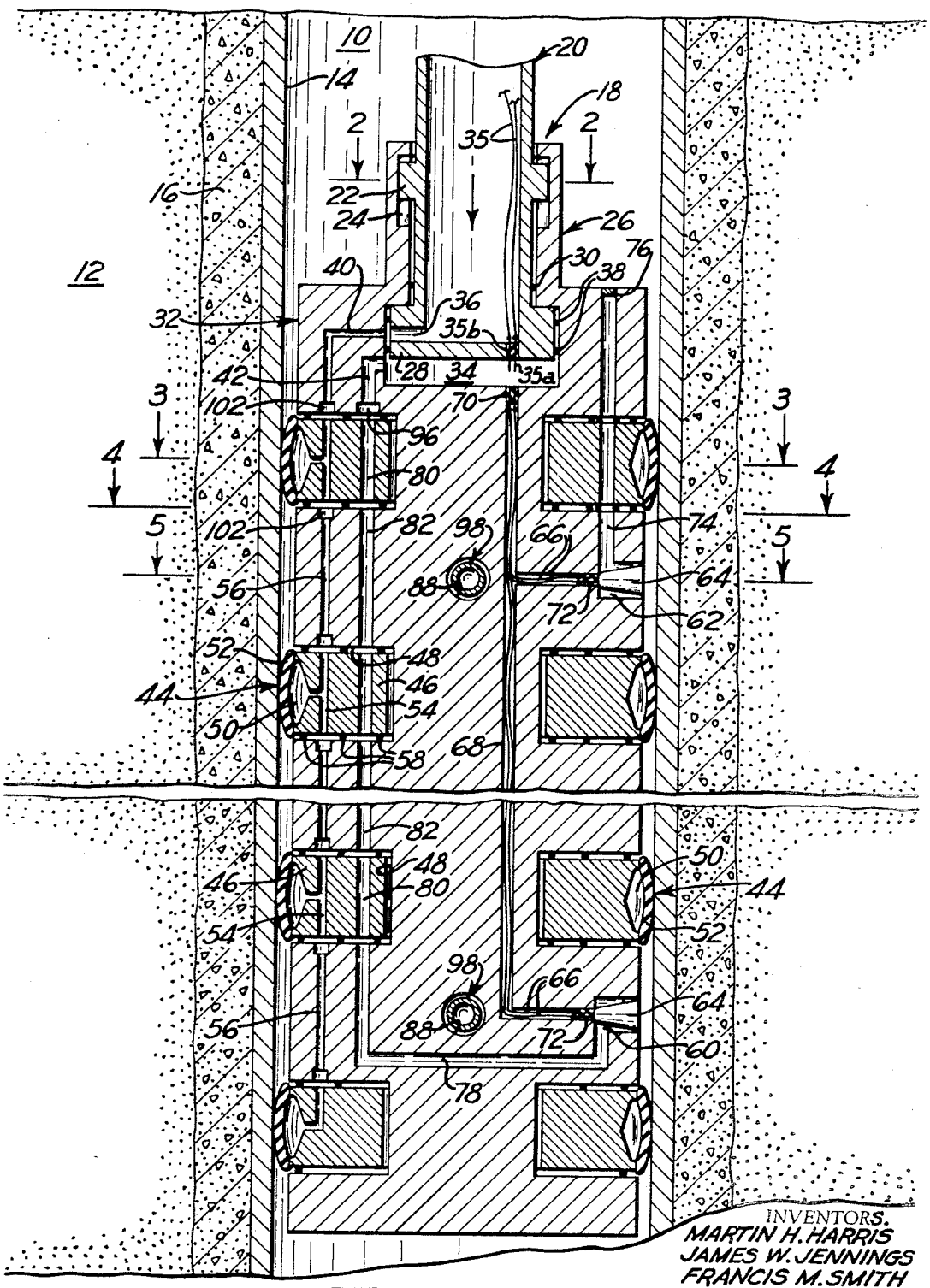
June 3, 1969 M. H. HARRIS ETAL 3,447,607

METHOD FOR SAND CONTROL IN WELLS

Filed March 10, 1967 Sheet 1 of 4



INVENTORS.
MARTIN H. HARRIS
JAMES W. JENNINGS
FRANCIS M. SMITH

Fig. 1

METHOD FOR SAND CONTROL IN WELLS

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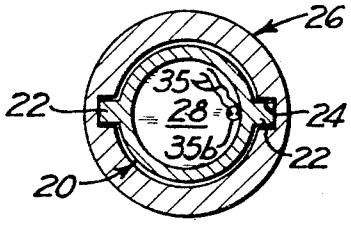


Fig. 2

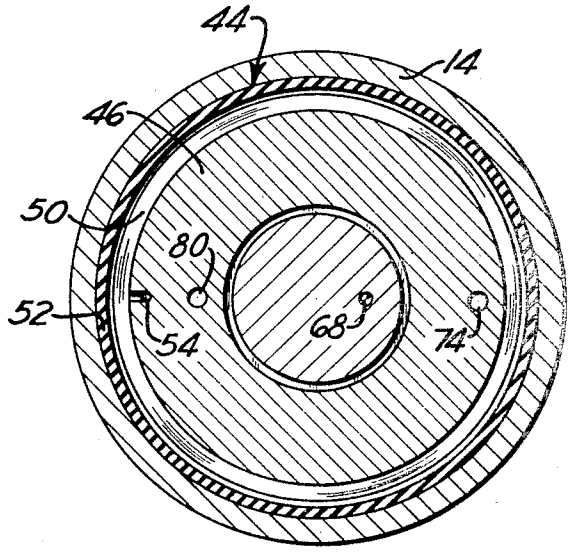


Fig. 3

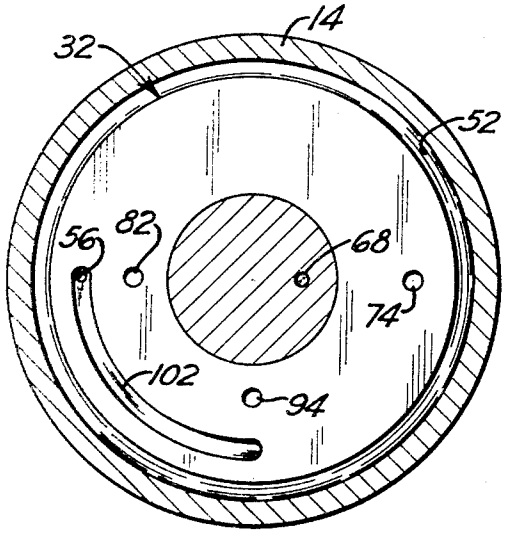


Fig. 4

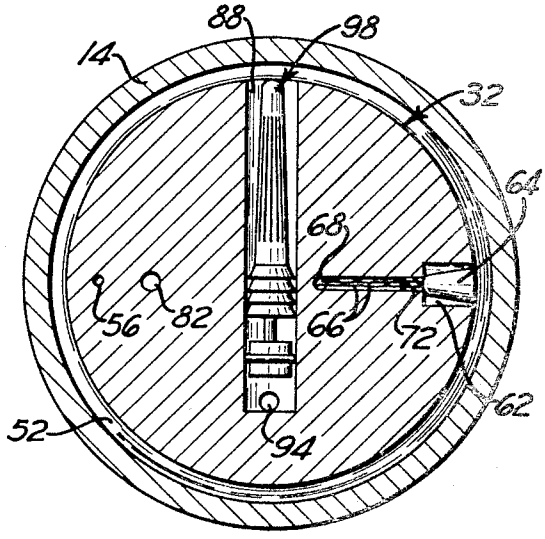


Fig. 5

INVENTORS.
MARTIN H. HARRIS
JAMES W. JENNINGS
FRANCIS M. SMITH

June 3, 1969 M. H. HARRIS ETAL 3,447,607

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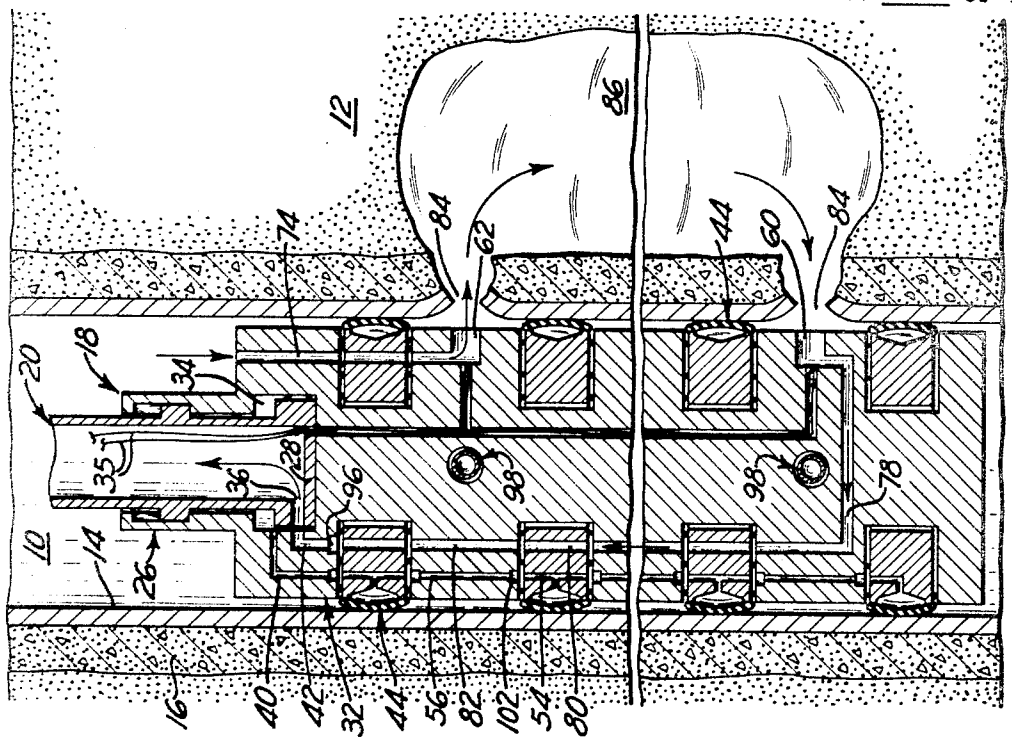


Fig. 7

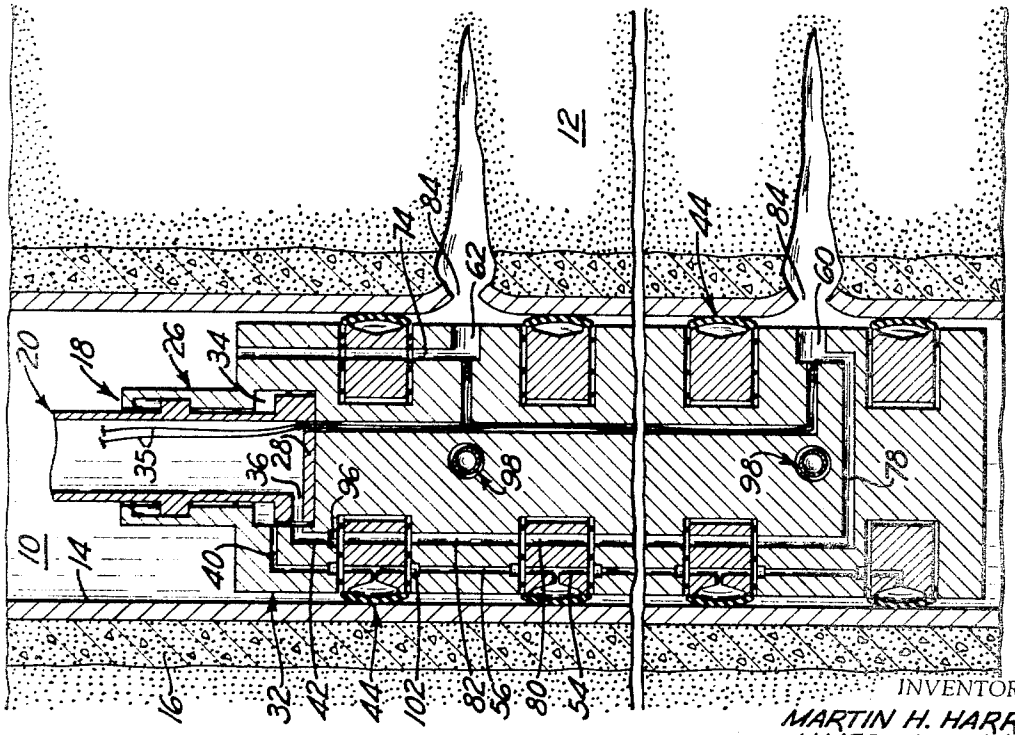


Fig. 6

INVENTORS.
MARTIN H. HARRIS
JAMES W. JENNINGS
FRANCIS M. SMITH

June 3, 1969 M. H. HARRIS ETAL 3,447,607

METHOD FOR SAND CONTROL IN WELLS

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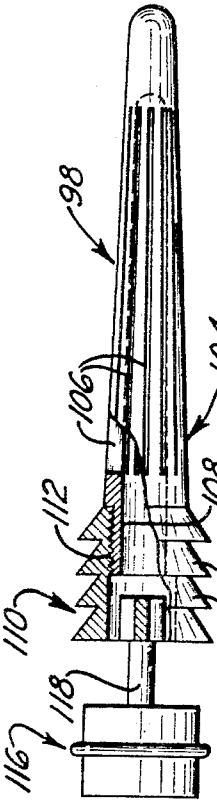


Fig. 9

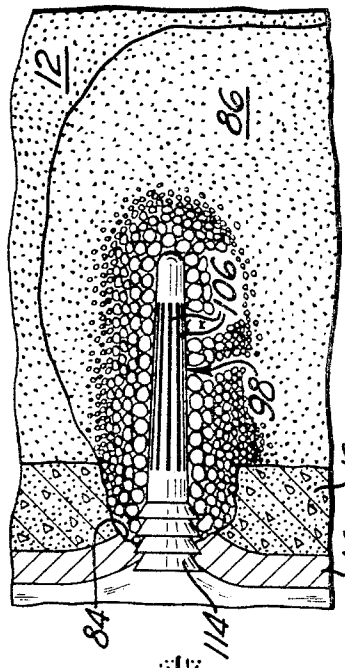


Fig. 10

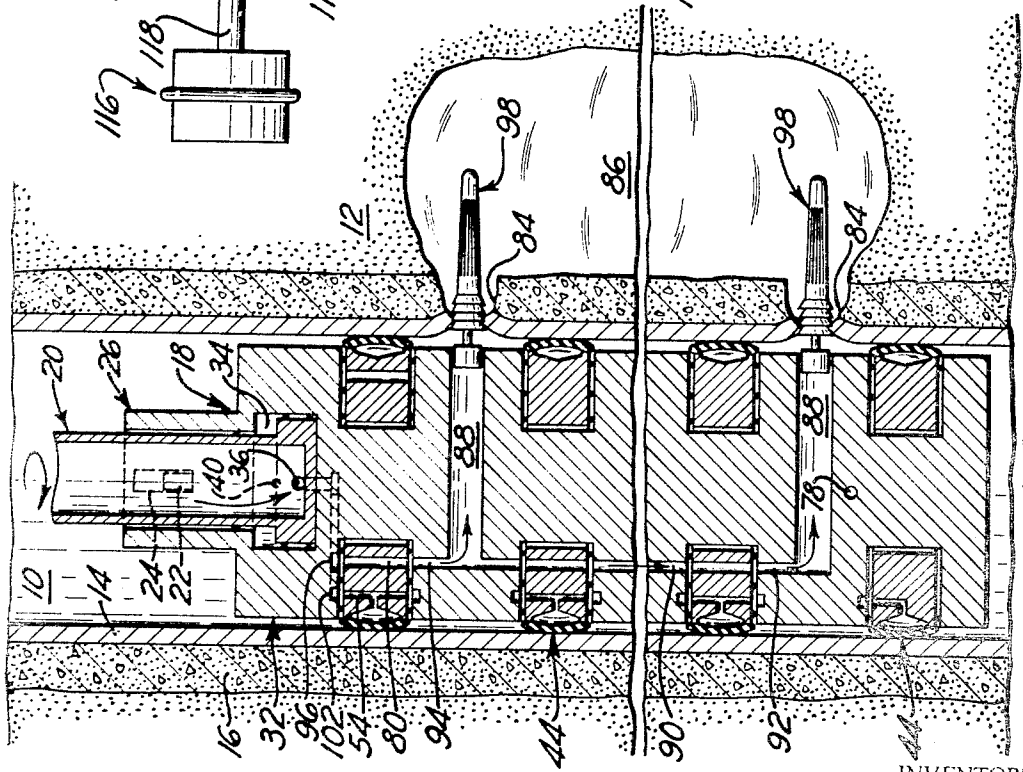


Fig. 8

INVENTORS.
MARTIN H. HARRIS
JAMES W. JENNINGS
FRANCIS M. SMITH

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METHOD FOR SAND CONTROL IN WELLS

Martin H. Harris, Pittsburgh, Francis M. Smith, Gibsonia, and James W. Jennings, Verona, Pa., assignors to Gulf Research & Development Company, Pittsburgh, Pa., a corporation of Delaware

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Int. Cl. E21b *43/04*

U.S. Cl. 166—278 2 Claims

ABSTRACT OF THE DISCLOSURE

A special tool is lowered into a well and two vertically spaced perforations are created. A volume of formation outside the casing is washed out between the perforations, the tool is rotated, and filter plugs are hydraulically pushed into the perforations and locked into place. The tool is removed and the well is produced to pack a zone of high permeability sand around the filter plugs.

When a well is in contact with a hydrocarbon bearing layer in the earth which is composed in large part of loose sand, there are a number of production problems which must be solved. The usual procedure of producing from such a layer is to set a casing in the well which is secured in place by means of a cement sheath between the outside of the casing and the formation. The casing and the cement sheath are then perforated to provide openings through which the oil and gas flows into the inside of the casing and up to the surface. If no control means are provided, the loose sand will flow through the perforations and either block them up or fill the inside of the casing, or otherwise interfere with or stop production.

Various kinds of filter spikes or plugs may be inserted through the perforations to prevent the entry of sand and the like into the inside of the casing. However, this tends to create a zone of low permeability around the spike due to compaction of the formation, crushed sand and the like immediately around the spike.

The present invention comprises a method which comprises the use of a special tool which when lowered into the well down to the cased and cemented producing zone produces a pair of vertically spaced perforations, creates a hollow cavity or void in the formation between the perforations, inserts filter spikes into the perforations and into the void in the formation created previously, and then creates a zone of high permeability around the filter spikes by producing the well. The production of the well permits a small amount of small sand particles to pass through the filter spike. These smaller particles, if they were permitted to pack around the filter spike would foul it. During a short production time, larger sand particles will bridge around the openings in the filter spike. The larger particles create relatively large spaces between them, which create the zone of high permeability. The smaller particles will bridge on the larger particles as the pack builds outwardly from the spike into the void.

The invention solves another problem present in prior methods and apparatuses concerning the use of filter spikes. The problem involves the proper alignment of the filter spike before it is inserted into the perforation. Misalignment of the spike and perforation when inserting will cause damage to either or both of the spike and the perforation which will result in the failure of the spike to seal properly in the perforation causing leakage around the spike into the casing. The present invention solves this problem by providing a tool which does not move axially in the well between the steps of perforating and inserting of the filter plugs, so that proper alignment of the plugs and openings is assured.

In the accompanying drawing forming a part of this disclosure: FIG. 1 is a cross-sectional view through a part of a well in the earth with the tool of the invention in place for the first step in the method; FIGS. 2, 3, 4 and 5 are cross-sectional views taken on lines 2—2, 3—3, 4—4, and 5—5 respectively of FIG. 1; FIGS. 6, 7, and 8 are figures similar to FIG. 1 showing succeeding steps in method; FIG. 9 is a view of a filter spike; and FIG. 10 is a partial view of the built up pack on the filter spike.

Referring now in detail to the drawing, **10** designates a well traversing an oil bearing layer **12**. Well **10** has been completed through layer **12** by means of a casing **14** which is secured in position by a cement sheath **16** between the casing and the formation.

A tool **18** embodying the invention is located in well **10** adjacent layer **12**. Tool **18** is supported on the lower end of a length of well tubing **20** which has its lower end specially fabricated for cooperation with tool **18**, and which may be joined at its upper end to the usual well tubing in any conventional manner, not shown. In spaced relation above its lower end, tubing **20** is provided with a pair of opposed ears **22** which are axially and slidably received within a pair of blind slots **24** formed in the upper neck **26** of tool **18**. Thus, tubing **20** is constrained to axial motion with respect to neck **26** of tool **18** with limits defined by the ends of blind slots **24**. The interaction of ears **22** and slots **24** permits rotation of tubing **20** to be transmitted to the remainder of tool **18** by neck **26**, for a reason explained below.

The lower end of tubing **20** is sealed shut by means of a bottom plate portion **28**. Sealing means **30**, such as O rings, slidably seal the interface between the outside of the lower end of tubing **20** and the inside of neck **26**. Tool **18** comprises a main body portion **32** formed with a chamber **34** spaced below neck **26**. Bottom plate **28** is slidably received within chamber **34** and is constrained to motion within said chamber by interaction of the upper face of bottom plate **28** and the lower end of neck **26**. A pair of electrical wires **35** extend through the length of tubing **20** from the surface, and terminate in a pair of plugs **35***a* which are sealed into bottom plate **28** by any suitable sealing means **35***b*. Bottom plate **28** is formed with a radial opening **36**. A pair of O rings **38** gird bottom plate **28** above and below opening **36** to form a fluid tight seal between said opening and the openings with which opening **36** communicates.

Body portion **32** is formed with an opening **40** and an opening **42** spaced below opening **40**. As can be seen from comparison of FIGS. 1 and 6, opening **36** communicates with opening **40** in the upper position of bottom plate **28** in chamber **34**, and communicates with opening **42** in the lower position thereof.

Means are provided to seal tool **18** at a selected position axially in the well. To this end, a plurality of packer ring assemblies **44** are provided in body portion **32** of tool **18**. All the packer ring assemblies are similar, and each comprises a metal ring **46** which is rotatably and sealably received within a suitable opening **48** formed in body portion **32**. Each ring **46** is formed with a fluid receiving pocket **50** on its outer cylindrical face which encircles the ring. An inflatable packer **52**, of any suitable type, is joined to the edges of the outer face of each ring so that a pressurized fluid supplied to pocket **50** will force packer **52** into contact with casing **14** to hold tool **18** in position. Means are provided to supply a pressurized fluid to pockets **50**, and to hold the packers **52** under pressure until the entire well treatment is completed. To this end, each ring **46** is provided with an axial passageway **54** including a connecting passageway to pocket **50**. The bot-

tom passageway dead ends at its pocket **50**. The uppermost passageway **54** is in communication with the lower end of passageway **40**. Body portion **32** is formed with a plurality of passageways **56** which interconnect the passageways **54** of the packer rings.

The tool is set in the casing as follows: It is lowered on tubing **20** to the desired level, and pressurized fluid, which may be oil, water, or other suitable fluid is supplied down the tubing and passes through passageways **36**, **40**, **54** and **56** to fill the pockets **50** and inflate the packers. Tubing **20** is then dropped within neck **26**, but the packers remain inflated because of sealing means **38**.

Means are provided to permit rotation of body portion **32** with respect to packer ring assemblies **44**, which are fixed with respect to the casing, and to maintain communication between the axial passageways described above, and the second set of axial passageways to be described hereinafter. To this end, each interface between a radially disposed face of a packer ring **46** and the opposed radially disposed face of an opening **48** is provided with suitable sealing means such as O rings, which define discrete annular spaces between themselves.

Means are provided to create two vertically spaced openings through the casing **14**, cement sheath **16**, and into formation **12**. To this end, body portion **32** is formed with a lower perforator receiving chamber **60** and an upper perforator receiving chamber **62**. Chamber **60** is spaced between the lower two packer assemblies **44** and the upper chamber **62** is spaced between the upper two packer assemblies **44**. Mounted in each chamber **60** and **62** is a shaped charged perforator **64** of usual construction. Means are provided to fire charges **64** from the surface. Each charge **64** has a pair of detonating wires **66** which are connected to wires **35** via plugs **35***a*. Tool body **32** is formed with suitable small openings **68** through which wires **66** pass and which terminate in a plug **70** which cooperates with plugs **35***a* when the well tubing **20** is dropped to the lower position,to set the circuit up for firing from the surface. Suitable fluid tight seals **72** are at the ends of openings **68** to permit passage of the wires therethrough. Upper perforator chamber **62** communicates with a passageway **74**, which passes through the uppermost packer ring **46** and up to the top of body portion **32**. The upper end of passageway **74** is sealed by a blow-out disc **76**. When perforator **64** fires, the pressure of the explosion will destroy blow-out disc **76**, opening passageway **74** for a reason appearing below. Chamber **60** communicates with a passageway **78**, which is spaced below the plane of chamber **60**, and which extends across the tool. Means are provided to join opening **36** to the opposite end of passageway **78**. To this end, packer rings **46** are provided with axial passageways **80**, each spaced radially inwardly of the passageway **54** in the ring. The passageways **80** are interconnected to each other and to passageway **78** and opening **36** by means of passageways **82** formed in body portion **32** and spaced inwardly of the passageways **56**.

Means are provided to wash out the formation between the two perforations **84** created by perforators **64**. Upon firing, blow-out disc **76** is removed, the charges and their lead wires forward of the seals **72** are consumed, and a continuous flow passage is created for fluid to perform said washing. Oil, water, or any other suitable fluid may be used for washing. The flow path for the washing fluid is as follows: From suitable pumps on the surface down the annulus between tubing **22** and casing **14**, into passageway **74**, through upper chamber **62**, through upper perforator **84**, through the formation, into lower perforation **84**, through chamber **60**, passageway **78**, passageways **82** and **80**, opening **36**, and back up to the surface through the inside of tubing **20**. The washing continues until a void **86** of sufficient size is created. The operator is able to tell when void **86** is sufficiently large by the volume of formation material collected at the surface.

After void **86** is created, means are provided to insert

filter plugs, of any suitable type, through perforations **84** and into void **86**. To this end, body portion **32** is provided with a pair of filter plug receiving chambers **88** disposed at right angles to passageway **78** and in the planes of chambers **60** and **62**, respectively. Body portion **32** is provided with a passageway **90**, which is at the same radial distance from the center of rotation of the tool as the passageways **80** and **82**, and which interconnects the ends of chambers **88**. The tubing **20** and the body portion **32** has been turned 90° to the right or in the clockwise direction looking down on the tool from above with respect to the packers in FIG. 8. The packer assemblies **44** remain stationary throughout the entire operation, and the plane through the well on which the cross-sectional view of FIG. 8 is taken is the same as that shown in FIG. 1. A passage **92** interconnects the rear end of the lower chamber **88** with the underside of the lowermost of the middle two packer ring assemblies **44**. A passageway **94** interconnects the upper two packer assemblies with the rear end of the upper chamber **88**. The upper end of the passageway **80** in the uppermost packer ring is maintained in communication with opening **42** by means of an arcuate cavity **96** formed in the upper radial face of opening **48** in facing relation to the upper packer ring **46**. Thus, cavity **96** communicates opening **42** with passageway **94**.

Referring to FIG. 5, the filter spike **98** is shown seated in body **32** within its chamber **88**. The cavity **96**, which is arcuate and extends for 90°, serves the purpose of communicating opening **42** with passageway **80** after the tool is turned to the position of FIG. 8. The filter plugs **98** are expelled from the cavities **88** and into perforations **84** by the application of pressurized fluid on passageways **90** and **94**, and cavity **96** as described above and as shown in FIG. 8.

As shown in FIG. 4, the system of passageways which supplies pressurized fluid behind the packers **52** remains in communication with opening **40** even after the tool is turned, by means of cavities **102**, see FIG. 4, which are arcuate for 90°. A cavity **102** is provided in the tool body between each interface of the tool and a packer ring. By means of these cavities **102**, the pressure behind the inflatable packers can be released at the end of the operation as will appear below.

Referring now to FIG. 9, one filter spike or plug **98** is shown in detail. It is to be understood that the spike shown in FIG. 9 is by way of example only, and that any other suitable filter plug could be provided. Filter spike **98** comprises a hollow plug body **104** which may be tapered, and which is provided with a plurality of filter slots **106** which communicate the outside of the plug with the chamber within the plug. The width of slots **106** is determined by the average grain size of the sand involved. As required, because of the nature of the sand, a plurality of openings of other shape or a plurality of short aligned slots could be provided in place of the slots **106** shown. The body **104** may be made of ferrous or nonferrous metals, inert plastics such as nylon, Teflon, or the like, or combinations of these materials. The rear end of body **104** is provided with a threaded connecting portion **108**.

Mounted on threads **108** is a cap member **110** provided with a threaded portion **112** which mates with threads **108** to join the cap to the body. The outside of cap **110** is formed into a plurality of staggered teeth **114**, as shown in FIG. 8, which wedge against the edges of perforations **84** in casing **14** to form a fluid-tight seal. A piston member **116**, which fits snugly within chamber **88** and permits the action of the pressurized fluid in the charge to expel the filter spike, is joined to the rear end of member **110** by means of a shear pin **118**. When the spikes are in place, the tool is removed from the well and the shear pins break off. This is accomplished by raising drill pipe **20** with respect to neck **26** to bring opening **36** into registry with opening **40**, releasing the pressure in

the drill pipe at the surface, which allows the pressurized fluid in pockets **50** to escape through the drill pipe, thus deflating packers **52**. Continued upward pull on tubing **20** will break off the shear pins **118** leaving the filter plugs **98** in place.

The well is then produced, and, as shown in FIG. 10, a zone of high permeability is created immediately around the filter plugs. This zone of high permeability is created because only larger sand particles bridge on the filter slots or openings in the plug at first, and only thereafter do the smaller particles bridge on the larger particles.

The advantages of the invention include the high degree of control of perforating efficiency, and accuracy of placement of the filter plugs in the perforations. Also, damage from cement, mud, crushed sand, and debris from the explosion of the charges, is eliminated because of the washing and circulating through the perforations. Since the well is produced when the filter plug is in a void, the problem of crushed sand clogging the filter plug is completely eliminated. The selective control of the size and type of openings in the filter plug permits the use of a filter specially designed for each type of sand encountered.

While the invention has been described in detail above, it is to be understood that this detailed description is by way of example only, and the protection granted is to be limited only within the spirit of the invention and the scope of the following claims.

We claim:

1. A method of sand control in a cased well comprising the steps of creating a pair of vertically spaced perforations through the casing and into the formation, circulating fluid through the perforations to create a void between the perforations in the formation, inserting a filter spike through each of the perforations and into said void space by applying hydraulic pressure behind each of said filter spikes, and producing the well through said perforations to form a zone of high permeability immediately surrounding said filter spikes.

2. The method of claim **1**, wherein said perforations are created by electrically detonating shaped explosive charges.

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CHARLES E. O'CONNELL, *Primary Examiner.*

I. A. CALVERT, *Assistant Examiner.*

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166—35, 55.1, 100