

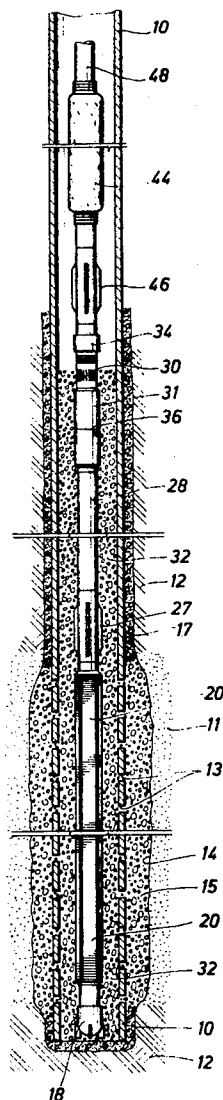
[72] Inventors **Harold C. Block;**
Theodore W. Munhausen, both of Houston,
Tex.
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 [73] Assignee **The Layne & Bowler Company**
Houston, Tex.

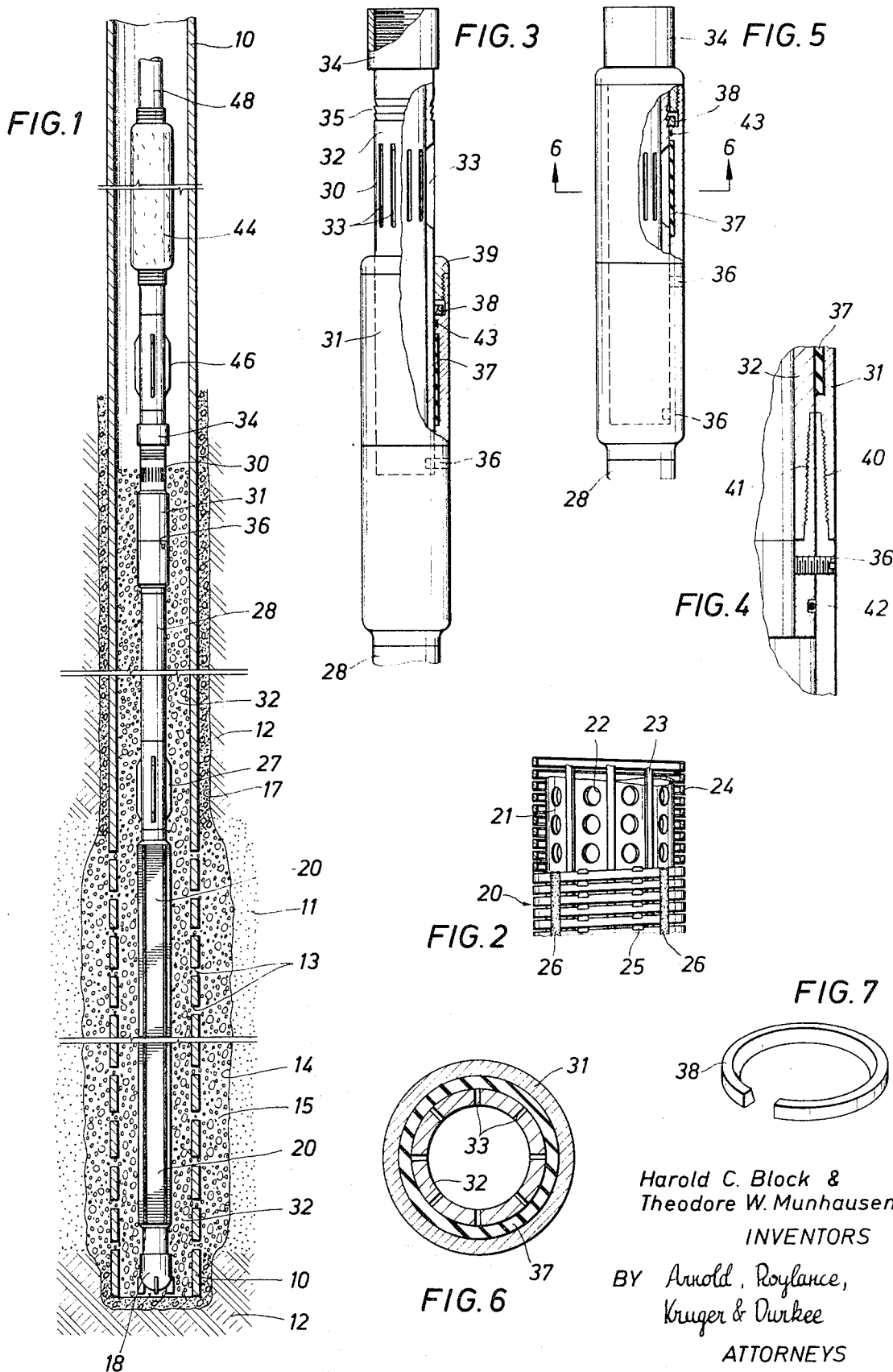
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Primary Examiner—David H. Brown
Attorney—Arnold, White & Durkee

[54] **METHOD OF GRAVEL PACKING OF WELL USING**
SEALABLE INDICATOR ABOVE WELL SCREEN
 8 Claims, 7 Drawing Figs.
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 [50] Field of Search..... 166/278, 51

ABSTRACT: An indicator screen for a well completion setting is adapted to be sealed off after gravel packing of the well. Sealing is by a sleeve which slides over the indicator screen upon shearing a pin which holds the sleeve spaced from the screen. An inset resilient sleeve aids in maintaining the seal, as does a pair of annular seals above and below the screen. A snap ring fastener secures the assembly in the sealed condition.





Harold C. Block &
Theodore W. Munhausen
INVENTORS
BY Arnold, Roylance,
Kruger & Durkee
ATTORNEYS

METHOD OF GRAVEL PACKING OF WELL USING SEALABLE INDICATOR ABOVE WELL SCREEN

Gravel packing in the completion of oil wells has long been used where the well is brought in at a sand formation. This method consists of placing a bed of gravel at the location where oil to be produced enters from the surrounding formations, usually the gravel being placed in the well by circulating gravel with a carrier fluid down into the annulus between the well casing and a tubing string while withdrawing the carrier fluid from the tubing. A well screen is ordinarily positioned at the bottom of the tubing string.

The benefits to be gained from gravel packing are now widely recognized; the gravel reduces the infiltration of sand into the petroleum being produced, since the sand is entrapped in the interstices of the gravel resulting in a graded filter. The velocity of flow through the gravel is low and controlled, assuring separation of sand from the oil. The producing formation is thus protected and supported from erosion during many years of production of the well.

A well is usually gravel packed not only in the cavity surrounding the well screen in the producing formation, but also a considerable distance uphole from the screen to assure that all cavities will be filled with gravel upon any settling which occurs in initial production, as well as to provide a reserve of gravel to fill voids occurring upon slight production of sand from the formation. Since the volume of the cavity adjacent the producing formation can be only very roughly calculated, the quantity of gravel necessary to pack the well to the desired level is not known, and so the point at which to terminate the gravel packing operation is indeterminable. To this end, a so-called "tell-tale" or indicator screen is located at the desired upper level of the gravel, and the time at which the packed gravel passes the indicator screen is detected by observing the pressure of the circulating carrier fluid at the well head. When the telltale screen is covered, the pressure needed to force the gravel and carrier fluid down through the annulus will sharply increase because of the resistance of the path which the fluid must now travel. This technique has proved quite effective, but results in an exposed opening in the tubing string above the producing formation, leaving the possibility that later production will occur through the indicator screen, or providing a shunt for well pressure or suction.

It is therefore the principal feature of this invention to provide well completion apparatus for gravel packing of wells wherein an indicator or telltale screen is used which is adapted to be sealed off upon completion of the well. Another feature is the provision of a sealable indicator screen for use in gravel packing of wells, with the sealing mechanism being operable from the well head without withdrawing the tubing string.

In accordance with one exemplar embodiment of this invention, seal-off apparatus for an indicator screen is provided in the form of a sleeve which is held in a position spaced from the screen by a shear pin until the gravel packing operation is completed up to the desired level. Then, the pin is sheared by allowing the weight of the tubing string to bear upon the completion setting, and the sleeve slides up over the indicator screen and is locked in place by a snap ring fastener. An inset resilient sleeve composed of Teflon or the like aids in sealing off the indicator screen. Also a pair of annular seals of the O-ring type, positioned above and below the screen when the sleeve is in the sealed position, provide additional sealing.

Novel features which are believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as further features and advantages thereof, may best be understood by reference to the following detailed description of particular embodiments, when read in conjunction with the accompanying drawing, wherein:

FIG. 1 is an elevation view in section of an oil well completion arrangement in a producing formation, including seal-off apparatus for an indicator screen according to the invention;

FIG. 2 is a detail view, partly in section and partly broken away, of a well screen which may be used in the well completion setting of FIG. 1;

FIG. 3 is an enlarged detail view of a portion of the completion setting of FIG. 1 including the indicator screen and its sealing means, in an open or nonsealed condition;

FIG. 4 is an enlarged detail view in section of a portion of the apparatus of FIG. 3 surrounding the shear pin;

FIG. 5 is an elevation view of the apparatus of FIG. 3 in the closed or sealed condition;

FIG. 6 is a sectional view of the apparatus of FIG. 5, taken along the line 6-6; and

FIG. 7 is a pictorial view of a snap ring used in the upper end of the sealing sleeve in the apparatus of FIGS. 3 and 5.

The drawings as described above and referred to in the following detailed description, are considered a part of the specification and are incorporated herein. It will be noted that like parts appearing in various views of the drawing will bear like reference numerals.

With reference to FIG. 1, a completion setting arrangement for an oil well or the like is illustrated which may utilize the indicator screen assembly according to the invention. A length of well casing 10 is shown extending through a producing formation 11 which would in this instance ordinarily exhibit a sandlike consistency. The producing formation 11 is a layer of oil bearing sand interposed between nonproducing strata 12, ordinarily rock. In the producing formation, the well casing 10 is gun perforated to provide holes 13 through which the petroleum, or other product being produced, would be admitted into the well casing. The perforations 13 are created by known techniques, such as shaped charges. In a typical example, perhaps 10 half-inch holes per foot of casing would be provided. After perforation, a cavity 14 extending back a few inches beyond the casing 10 would be produced by backwashing the perforations, using large volumes of water or oil. This is accomplished before the producing screen and packer setting shown in the casing in FIG. 1 has been inserted, but instead a bare wash pipe is used. Batches of gravel are pumped down the wash pipe while water returns back up the hole through the annulus between the wash pipe and the casing 10. In this manner the cavity 14 and the casing 10 itself are filled with gravel up to the top of the perforations. The size gravel used would depend upon the character of the producing formation 11, and the expected production volume, well pressure, etc. Typically, gravel which is screened to a selected range of perhaps 30 to 40 mills, or perhaps 60 to 80 mills, would be used. The gravel pack would not extend up outside the casing past the perforations, it being noted that a surrounding layer of cement 16 is in place in the well bore 17. The cement is added after the casing 10 is in place, but before the perforations 13 are formed.

In order to provide room for inserting the production screen, the gravel 15 which at this point fills the inside of the well casing 10, as well as the cavity 14, must be removed. This is accomplished by inserting open end tubing into the well and pumping water down the tubing and back out through the annulus, flushing out gravel within the casing but leaving that which is outside the casing in the cavity 14 substantially intact. The same wash pipe may be used for this purpose as was used to gravel pack.

The well completion setting is now lowered into the hole as seen in FIG. 1. This assembly includes at its lowermost tip a set shoe 18 which functions in this case merely as a plug for the end of the production screen, and as a support or foot. Above the set shoe is the production screen 20 which may comprise a 30-foot joint, or shorter or longer length, of a wire wound welded screen such as that disclosed in U.S. Pat. No. 1,878,432 issued Sept. 20, 1932 to J.P. Whann, and assigned to the assignee of the present invention, Layne & Bowler Company.

One type of well screen which may be used as the production screen 20 is illustrated in FIG. 2. This screen consists of a length of pipe 21 having holes or slots 22 drilled or cut therein. Ribs 23 are positioned around the pipe 21 and keystone shaped wire 24 is wound over the ribs to provide a wire helix. Lugs 25 are formed in the wire as it is wound, these lugs func-

tioning to maintain the desired spacing between courses of the wound wire helix. Longitudinal weld beads 26 are drawn along the outer surface of the wire helix, functioning to hold the assembly together. The spacing between courses of the helix, as defined by the lugs 25, is selected according to the size gravel used, whereby only oil reaches the interior of the pipe 21 by passing between the wires 24 and through the holes 22.

Above the production screen 20 in the fitting of FIG. 1, a centering guide 27 may be used, it being understood that the ribs on this guide would extend out almost to the well casing 10. The centering guide merely functions to assure that the setting does not lie against one wall of the casing. Above the centering guide is a joint of blank tubing 28 which may be, typically, from perhaps 20 to 100 or more feet in length.

According to the invention, an indicator or so-called "telltale" screen 30 is positioned above the blank tubing 28. A seal off assembly including a sleeve 31 is provided adjacent the telltale screen. The function of the telltale screen may be understood by reviewing the procedure for gravel packing the interior of the well casing.

After reverse circulation using open end tubing to remove gravel in the casing, and then removal of the tubing, the assembly of FIG. 1 as thus far described is lowered to the position indicated. Next, gravel along with water or oil is flowed down the annulus between the tubing and the casing to cause the annulus or space 32 between the setting assembly and the casing 10 to be gradually filled with gravel. The production screen 20 will of course filter out the gravel from the mixture of water and gravel, or oil and gravel, so that only the liquid will be returned through the pipe 21 and the remainder of the hollow tubing extending back up to the well head. The back pressure on the liquid-gravel being pumped into the annulus at the well head will be dependent of course upon the depth of the well, the diameters of the casing and tubing, the liquid used, and other fixed factors, but in addition will be dependent upon the length of the production screen 20 which is gravel packed and how much is left above the gravel so far deposited in the annulus 32. When the annulus 32 is gravel packed all the way to the top of the production screen 20, i.e., up level with the uppermost perforation 13 in FIG. 1, there will be a significant increase in the pressure on the annulus at the well head because the liquid will then necessarily traverse a portion of the packed gravel before reaching the production screen for unimpeded flow through the tubing back up to the well head. Upon the occurrence of this pressure increase, it will be known that gravel packing of the area of production is completed, but the gravel packing operation is continued for a considerable length of time to pack a length of the casing 10 above the producing formation 11 in order to provide a reserve of gravel to assure that voids will be filled with gravel and production of oil will be avoided directly from the sandy formation 11 to the screen 20 without passing through gravel.

The gravel pack is thus continued above the upper level of the perforations for the length of the blank tubing 28. The telltale screen 30 is positioned at the level where it is desired to terminate the gravel pack. When this level is reached, there will be another sharp increase in the pressure at the well head, because in the interval while the gravel is being deposited in the annulus from the top of the production screen to the level of the telltale screen 30, liquid could pass through the holes in the telltale screen 30 without being impeded by the packed gravel. But when the holes in the telltale screen are covered, all liquid must pass through gravel before returning up the tubing, resulting in the necessity for higher pressure at the well head to force liquid through such paths. Thus, the gravel pack operation would be terminated upon the occurrence of this second sharp pressure increase.

The telltale screen 30 functions only as an indicator of the level of the gravel pack during the packing operation, and thereafter has no function. Indeed, the presence of the screen uphole from the producing area is considered undesirable in some wells, and can actually be detrimental. It is for this reason that the seal-off arrangement of the invention is necessary.

With reference to FIG. 3, it may be noted that the telltale screen comprises a length of tubing 32 having a plurality of longitudinal slots 33 formed therein. The slots would be of width smaller than the minimum gravel size being used, and the slots may be formed by saw blade-type cutters. The number of slots 33 used would depend upon the width of slot needed, and also upon the pressure to be used, thus upon the depth of the well. The number of slots must be large enough so that there will be substantial flow of liquid through the telltale screen while the gravel pack operation is depositing gravel below the telltale screen so that the change in pressure when gravel level passes the top of the telltale screen will be quite noticeable; but yet, flow through the telltale screen must be much less than that through the production screen so that the first pressure drop when the gravel pack passes the top of the production screen will also be quite noticeable. Also, it may be noted that horizontal slots 33 rather than longitudinal slots may be employed, or a segment of well screen as in FIG. 2 may be inserted here if a fairly open or low pressure screen is needed.

At the upper end of the tubing 32 in the indicator screen assembly is an internally threaded collar 34 which is merely used to attach the indicator screen assembly to the remainder of the completion setting. Below the collar is a plurality of notches or grooves 35 functioning to lock the sleeve 31 in place after completion of the well as will be explained. The sleeve 31 is held in the position shown in FIG. 3, with the slots or screen 33 exposed, by a shear pin 36 extending through the sleeve 31 and the lower end of the tube 32. Positioned in a recess in the inner face of the sleeve 31 is a resilient sleeve 37 composed of a plastic material such as Teflon which will function to assure that the slots 33 are sealed off when the sleeve 31 has been moved up to the sealing position. A snap ring 38 is fitted in a recess in the inside diameter of the collar 31 and held in place by a threaded collar 39 at the top of the sleeve. The snap ring is undersized to assure engagement with the notches 35 when the sleeve is moved up. The lower end of the sleeve 31 is necked down and is connected to the upper end of the blank tubing 28 by a suitable threaded connection.

Referring to FIG. 4, a detail view of the collar 31 and tube 32 is shown in the vicinity of the shear pin 36. The shear pin is threaded to engage a threaded bore extending through both the collar and tube from outside to inside surfaces. The shear pin would be composed of a frangible or shearable material such as a brittle plastic or metal, the size and material being selected to withstand considerable compression and tension as might be applied to the tubing string when setting the completion assembly, but the pin 36 is adapted to shear when a major portion of the weight of the tubing string is allowed to bear upon the completion setting. The outer collar or sleeve 31 is seen to be constructed of two parts fitted to one another at a threaded joint 40, while the tube 32 is likewise fitted at a threaded joint 41 to a lower portion of the tube. An O-ring 42 is positioned in a recess in the lower end of the tube 32 to bear on the inside diameter of the lower portion of the sleeve 31 to aid in sealing. In like manner, another O-ring seal 43 is provided at the upper end of the collar 31. The slots 33 are thus doubly sealed by the plastic sleeve 37 as well as by O-rings above and below the slots when in the sealed position.

Referring to FIG. 5, the seal-off indicator screen assembly is shown in the sealed position. The pin 36 has been sheared, permitting the sleeve 31 to move upward until the upper end engages the lower side of the collar 34. In this position the snap ring 38 will compress into one of the grooves 35 so that the sleeve 31 cannot thereafter be lowered on the tube 32. In this position the plastic sleeve 37 surrounds the slots 33, effectively sealing the telltale screen and preventing leakage of oil from the annulus into the tubing at this point. A cross sectional view of the sealed screen is seen in FIG. 6 where it is noted that the sleeve 37 surrounds the tube 32 and engages all of the slots 33. The shape of the snap ring 38 is seen in FIG. 7, it being noted that the snap ring is undersized, i.e., its inside diameter is less than the outside diameter of the tubing 32, and the snap ring includes a gap to permit the ring to expand and contract.

Ordinarily the completion setting in a well which is gravel picked will include a packer 44 which may be of the collapsible canvas tube type disclosed in U.S. Pat. No. 2,734,493 issued Feb. 21, 1956 to T.W. Munhausen. The upper end of the indicator screen assembly would be connected to the lower end of the packer assembly by means which may include a length of blank pipe and another centering guide 46. The upper end of the collapsible packer is connected by tubing 48 to a conventional setting tool, stuffing box, etc., which would be used for operating the setting mechanism, as well as to the tubing string extending uphole. It may be noted that the seal off operation for the assembly of FIGS. 3 and 5, requiring an application of compression along the tubing string by allowing the weight of the tubing string to rest on the setting, may be accomplished at the same time that the collapsible packer 44 is collapsed to the seal position.

The indicator screen assembly has been described in the context of use with gun perforated casing in the producing formation, but it is understood that the device may also be used in well completions wherein an under-reamed open hole is created below the casing, this completion being well known in the art. Also, where using the perforated casing as described, the setting may be placed by the wash down technique rather than by removing gravel using reverse circulation with open ended tubing.

While the invention has been described with reference to particular embodiments, it is understood that this description is not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as other embodiments of the invention, may be apparent to persons skilled in the art upon reference to this description. It is therefore contemplated that the appended claims will cover any such modifications or embodiments as fall within the true scope of the invention.

What I claim is:

1. In a method of completing a well of the type provided with an elongated tubular screen located in the producing formation of the well and connected to the well head by a tubing string, and provided with indicator aperture means in the tubing string above the tubular screen, the steps of:

circulating gravel and a carrier liquid into the well through the annulus between the walls of the well and the tubing string to pack gravel in the well cavity, the carrier liquid being withdrawn from the tubing string after filtering through the tubular screen,

detecting pressure applied to the carrier liquid and gravel to circulate it into the well,

terminating the circulation of carrier liquid and gravel upon an increase in the pressure needed to circulate the liquid and gravel,

and applying to the tubing string an altered condition to cause sealing of the indicator aperture means to prevent

entry of liquid into the tubing string at said aperture means thereafter.

2. In a method according to claim 1, the step of applying an altered condition to the tubing string comprises permitting at least a portion of the weight of the tubing string to bear upon the completion setting to cause fracturing of a shearable pin which holds portions of the tubing string in axially spaced condition.

3. In a method according to claim 1, the step of collapsing a packer in the annulus between the tubing string and the well casing above the indicator aperture means, such step not occurring prior to sealing the indicator aperture means.

4. In a method according to claim 3, the packer being collapsed by applying compression to the tubing string by permitting at least a part of the weight of the string to bear upon the completion setting.

5. In a method according to claim 1, the step including sealing the indicator aperture means comprising applying vertical compression to the tubing string to cause sliding of a portion of the tubing string relative to a surrounding collar portion thereof adjacent the indicator aperture means.

6. In a method according to claim 5, the step of applying compression comprising permitting at least a portion of the weight of the tubing string to rest on the completion setting.

7. In a method according to claim 6, the step of sealing including fracturing a shearable pin which holds portions of the tubing string adjacent the indicator aperture means in an axially spaced condition.

8. In a method or completing a well of the type provided with an elongated tubular screen located in the producing formation of the well and connected to the well head by a tubing string, and provided with indicator aperture means in the tubing string spaced substantially above the tubular screen, the steps of:

circulating gravel and a carrier liquid into the well through the annulus between the walls of the well and the tubing string to pack gravel in the well cavity between the tubular screen and a perforated casing, the carrier liquid being withdrawn from the tubing string after filtering through the tubular screen and the indicator operative means, detecting pressure applied to the carrier liquid and gravel to circulate it into the well,

terminating the circulation of carrier liquid and gravel upon an increase in the pressure needed to circulate the liquid and gravel, this increase in pressure occurring when the gravel reaches the indicator aperture means, a prior pressure increase having occurred when the gravel reached the top of the tubular screen,

and applying to the tubing string an altered condition to cause sealing of the indicator aperture means to prevent entry of liquid into the tubing string at said aperture means thereafter.