United States Patent

[11] 3,601,192

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Continuation-in-part of application Ser. No. 789,652, Dec. 26, 1968, now abandoned, which is a continuation-in-part of application Ser. No. 367,473, May 14, 1964, now abandoned.

[54] WELDED WELL STRAINER
2 Claims, 6 Drawing Figs.

[52] U.S. Cl. 166/232
[51] Int. Cl. E03b 3/18
[50] Field of Search 166/15–19, 56, 227–236, 278

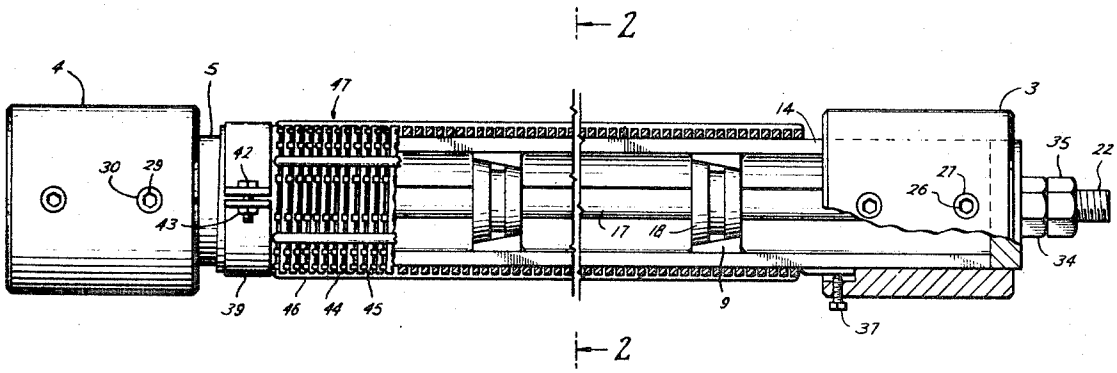
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ABSTRACT: A wound wire well strainer having an elongate hollow cylindrical screen of helical wire windings axially spaced from one another by separating lugs formed therein and disposed in circumferentially spaced longitudinal rows, the windings being secured to one another by elongate weld beads disposed longitudinally between rows of lugs along the outer surfaces of the windings without protruding beyond the inner surfaces thereof such that the structural integrity of the screen is maintained in situ without a perforated central pipe or interior protrusions. One end of the screen is disposed within an annular recess in a tubular end fitting adaptable to couple the screen to a tubing string, and the screen is secured to the fitting by external and internal annular weld beads. Apparatus for and a method of making such a well strainer are also disclosed.



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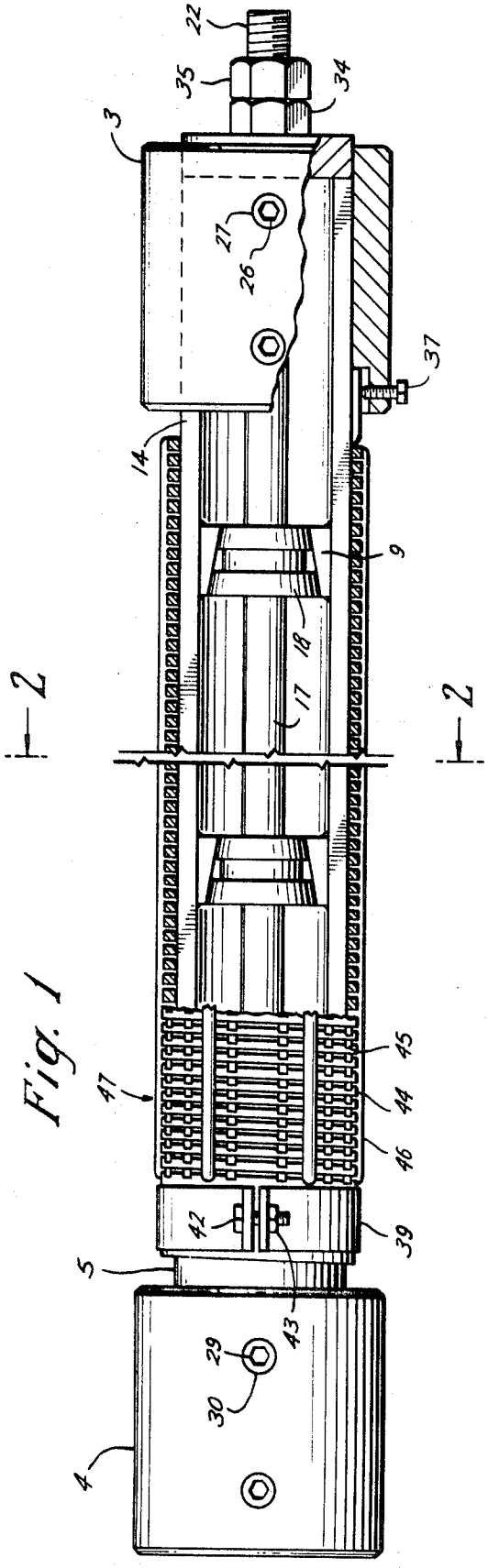


Fig. 1

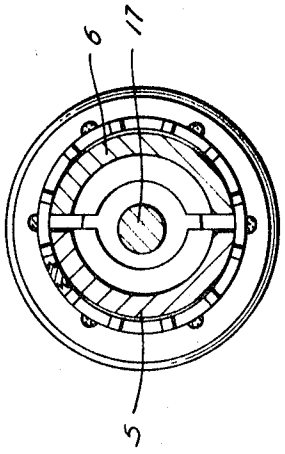


Fig. 3

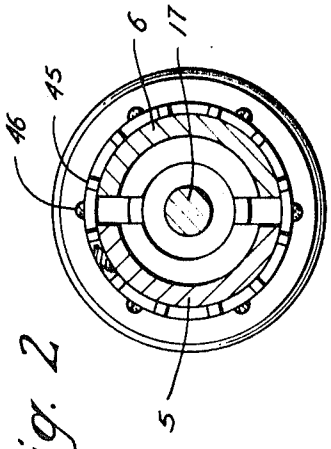


Fig. 2

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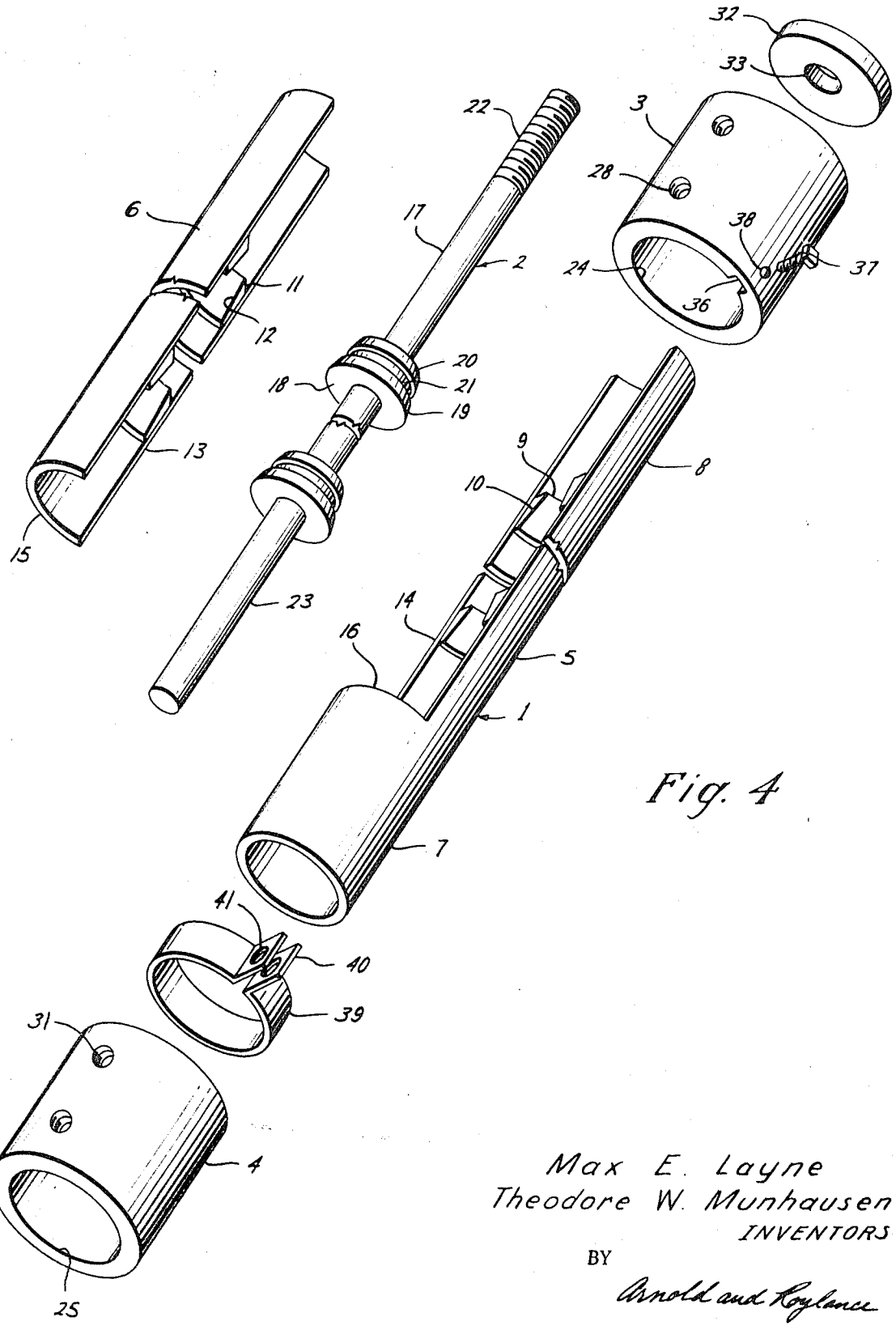


Fig. 4

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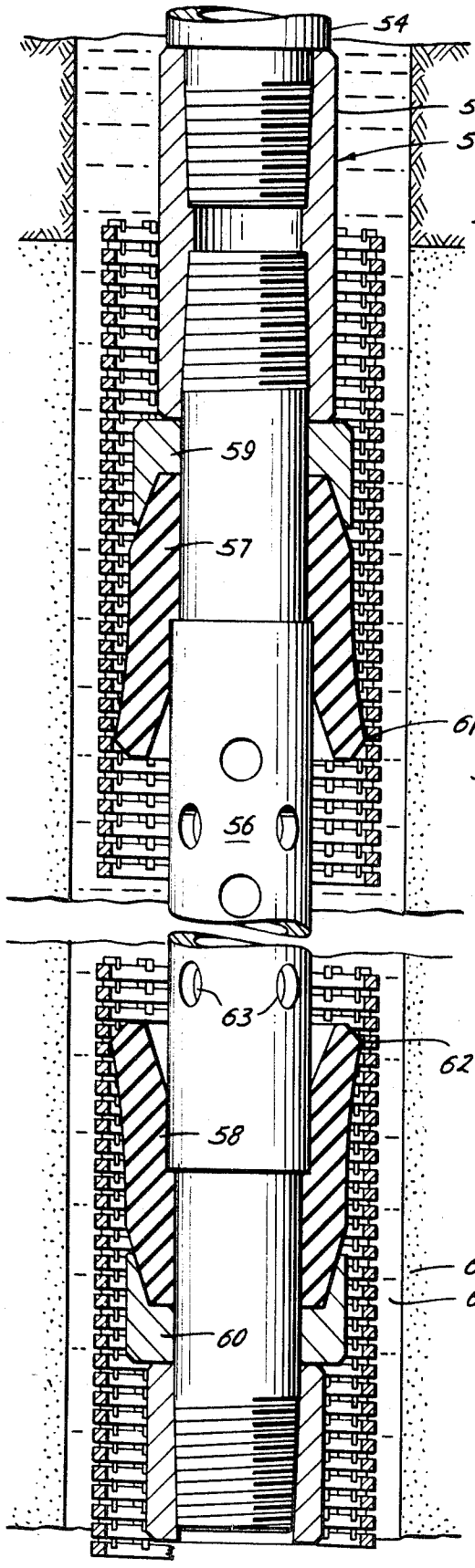
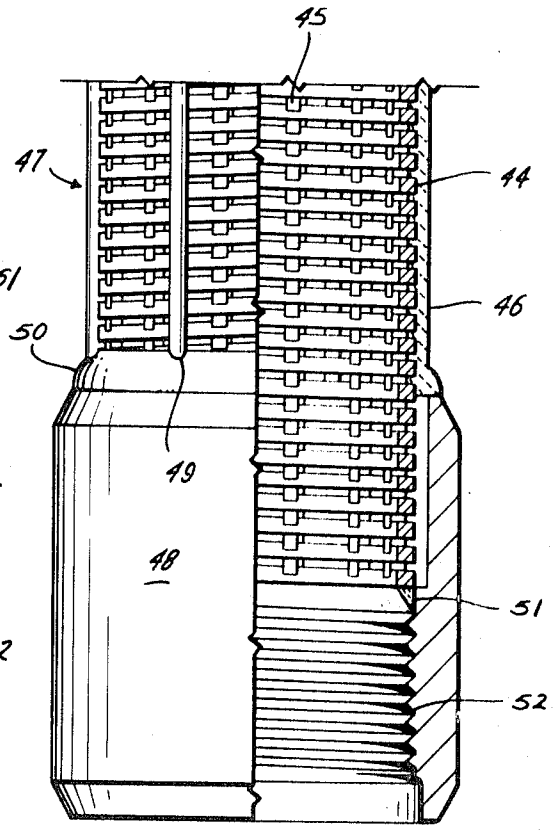


Fig. 6

Fig. 5



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WELDED WELL STRAINER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuing application from application Ser. No. 789,652, filed Dec. 26, 1968, now abandoned, which was a continuing application from application Ser. No. 367,473 filed May 14, 1964, now abandoned.

BACKGROUND OF THE INVENTION

Commonly a well is completed with a string of casing pipe secured in the well bore and having a screen or strainer at the lower end thereof positioned within the formation from which oil, water, gas production, or the like, is to be obtained. Although the nomenclature is not consistent throughout the industry, in the specification and claims of this patent, the term "screen" denotes the body of the pipe comprising the openings and the term "strainer" denotes the screen plus the associated hardware to make up a complete assembly ready for attachment to the casing pipe. The strainer may be a single length of screen pipe (in the industry usually called a "joint" of screen pipe) perhaps 30 feet long, or it may comprise six or eight or more joints of screen pipe each of 30-foot length.

The producing formation is often quite sandy, resulting in unconsolidated sand particles tending to flow to the screen and clog its openings. Particles of sand and the like that are small enough to pass through the openings in the screen are produced with the production fluid or gas, often cutting elbows, valve seats, etc. along the internal surface of the production string, as well as contaminating the fluid or gas produced.

To greatly reduce undesired contaminates, it is common practice in many producing formations to surround the screen with a pack of gravel to fill the space between the screen and the natural-producing formation. By proper selection of gravel particle size much straining action can be built into the gravel pack, thereby reducing screen clogging and the production of sand with the production of oil, water, gas or the like.

It is also common practice during the drilling and completion of wells and the setting of the gravel pack to use drilling mud of a heavy viscous and colloidal nature. Since this mud also tends to contaminate the production fluid or gas, it is desirable to remove such mud from the gravel pack and its environs before commencement of production. A flushing operation is performed to accomplish this desired cleansing.

A full understanding of certain features in well strainers, and the problems in their manufacture, commands a familiarity with this flushing operation.

A flushing tool, one example of which **53** is illustrated inside a well strainer screen **47** in FIG. **6**, is lowered into the well on the lower end of a string of pipe or tubing **54** used as a flushing string assembly until it reaches the bottom of the screen **47**.

The flushing tool **54** comprises a length of pipe **56** perhaps two to four feet or so in length and having perforations **63** therein through which flushing fluid may pass outwardly when it is pumped down the string of pipe carrying the flushing tool.

On each side of the perforation, there is fitted a swab cup, **57** and **58**, facing each other and adapted slidingly to engage the interior of the well screen, and to expand outwardly in response to pressure between the swab cups from fluid discharge through the perforations so as to sealingly engage the screen interior.

In the common flushing operation, such a flushing tool **53** on the lower end of a string of pipe **54** is located at the lower end of the screen **47** situated in the producing formation **64** in the well bore, and a flushing fluid, commonly water, is pumped down the interior of the pipe **54** and out the perforations **63**, being confined by the swab cups **57** and **58** to pass through the screen into the gravel pack **65** and on occasion into the adjacent formation. Circular of the flushing water is completed through the gravel pack **65** to a level above the upper swab cup **57**, then back through the screen **47** into the annulus between the screen **47** and the pipe **54**, and upward for conduct to the surface in the annulus between the pipe **54** and the casing, which in this example it is assumed extends to the surface from above the screen **47**.

After a period of time sufficient to wash the lowermost location, the flushing tool **53** is raised upward slowly, so that the outward flow of flushing water is moved upward to an area where before the flushing water was moving into the annulus between the screen **47** and the pipe **54** and this area is washed as before. The flushing tool **53** is again moved upward, while flushing water continues to flow, until the entire length of the screen has been washed. The flushing tool **53** may be raised and lowered as many times as desired in continuance of the flushing action until satisfactorily clean water is being returned to the surface.

To obtain satisfactory flushing, a good seal must be achieved between the swab cups and the inside surface of the screen and there must be good flow characteristics of the water in the return path. Projections from the strainer wall protruding into the center bore will prevent an effective seal. Also, a strainer of different internal diameter from the well pipe will prevent good flow characteristics of the water in the return path, as well as requiring the swab cups to either expand or contract in the strainer from their condition while in the well pipe through which they are lowered and removed.

The majority of prior art structures are typified by U. S. Pat. Nos., Johnson 2,046,459, Harmon 2,323,713, and Westphal 1,546,528. Johnson shows the strainer screen formed by a perforated section of pipe wrapped with wire. The reduced internal diameter of the strainer with respect to the attached well pipe and the double thickness of pipe wherein particles are easily trapped are undesirable characteristics of the Johnson-type structure.

Harmon shows a single thickness of strainer material made from wrapped wire, but the angle irons left on the inside of the structure form internal projections and make effective flushing extremely difficult because of the poor seat for the swab cups.

Westphal's structure is incapable of fabrication with close control of tolerances in other than short lengths. Westphal requires the exceedingly expensive procedure of cutting out the entirety of all of the space-forming inlet area permitting the fluid to pass through the resulting screen. The cost of doing that cutting, particularly in the case of stainless steel and other hard metal screens, is absolutely prohibitive and totally forbids the use of the screen of the type disclosed in Westphal. In the well business today most screen is made in 30- to 33-foot lengths to eliminate the problem of having to secure screen sections together as by welding or otherwise, and in such lengths the practical impossibility of cutting the openings as in Westphal to close tolerances is readily apparent.

SUMMARY OF THE INVENTION

Briefly, in accordance with one embodiment of the present invention, there is provided, for use in a borehole containing a tubing string, a wound wire well strainer in which a helical tubular wire screen, having closely spaced windings axially separated by lugs and secured to one another by at least one weld bead longitudinally disposed along the outer surface of the screen, is connected to a tubular end fitting adaptable for connection with the tubing string by a concentric annular weld bead in an annular recess in the end fitting. Desirably, the inside diameter of the screen is substantially the same as that of the tubing string.

In accordance with the subject matter of copending application Ser. No. 591,460, filed Nov. 2, 1966, now U.S. Pat. No. 3,489,185.

An expansible mandrel having a smooth external surface is used for establishing a form about which the metal wire is wound to form the screen. Unlike the prior art structure exemplified in Harmon U.S. Pat. No. 2,323,713, the invention utilizes tapered surfaces as the expanding force so as to achieve

uniform expansion. Also, the complete absence of projections affixed to the inside surface of the screen eliminates the possibility of the mandrel sections binding when the mandrel is collapsed.

Because the end product of this invention is different from those in the prior art, methods and apparatuses used heretofore have also been found to be quite dissimilar.

Therefore, described herein is an illustrated embodiment of a well strainer and the method of manufacturing the illustrated embodiment comprising:

expanding an adjustable collapsible mandrel to an outside diameter equal to the inside diameter, which will be smooth without inwardly protruding ribs or the like, of the screen to be produced;

deforming metal wire from which the screen is to be formed at spaced intervals and precisely sizing such deformation so as to provide lugs of precise dimension protruding from the sides thereof;

clamping one end of such wire to the mandrel;

wrapping the wire helically around the periphery of the mandrel so that each succeeding convolution of the wire is adjacent the preceding convolution except as held apart by the preformed lugs of precise dimension;

clamping the second end of the wire at a distance, which may be any desired distance without restriction by the practicalities of this manufacturing method, along the mandrel from the first end of the wire, thereby determining the total length of the screen;

welding beads mostly externally of the internal diameter of the screen to bond together successive convolutions of wire without bonding the wire to the mandrel;

then collapsing the mandrel to allow the screen to be removed therefrom;

all whereby a screen of any desired length may be economically made with precise control of the screen openings down to fine tolerances and with a smooth interior screen surface facilitating easy and good flushing operations.

BRIEF DESCRIPTION OF THE DRAWINGS

More particular description of the invention may be had by reference to the embodiment thereof which is illustrated in the appended drawings, which form a part of this specification. It is to be noted however, that the appended drawings illustrate only a typical embodiment of the invention and therefore are not to be considered limiting of its scope for the invention will admit to other equally effective embodiments.

In the drawings:

FIG. 1 is a plan view with some parts broken away of a well strainer being constructed in accordance with this invention;

FIG. 2 is a transverse section taken substantially along the line 2–2 of FIG. 1 of the mandrel radially expanded;

FIG. 3 is a transverse section of the same view shown in fIG. 2 with the mandrel partly radially collapsed;

FIG. 4 is an exploded perspective view of the apparatus used to form the well strainer;

FIG. 5 is an enlarged view of one end of the well strainer and adjoining connector half in vertical section and half in side elevation; and

FIG. 6 is a vertical section of the well strainer during flushing operation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the drawings, reference numerals have been employed to indicate parts as follows:

1. mandrel
2. rod assembly
3. limiting collar
4. limiting collar
5. lower section
6. upper section
7. cylinder end
8. extending end
9. flanges
10. truncated conical surfaces
11. flanges
12. truncated conical surfaces
13. edge
14. edge
15. edge
16. edge
17. rod
18. conical rod collar
19. conical edge
20. conical edge
21. recess
22. threaded rod end
23. unthreaded rod end
24. inside surface of collar
25. inside surface of collar
26. machine screw
27. washer
28. hole
29. machine screw
30. washer
31. hole
32. washer
33. hole
34. nut
35. locknut
36. recess
37. holding pin
38. hole
39. wire clamp
40. flanges
41. holes
42. clamp bolt
43. clamp nut
44. metal wire
45. lugs
46. weld beads
47. well strainer screen
48. connector
49. groove
50. external connector weld bead
51. internal connector weld bead
52. internal connector threads
53. flushing tool
54. flushing string assembly
55. connector
56. perforate flushing string section
57. swab cup
58. swab cup
59. swab cup holder
60. swab cup holder
61. outer edge of cup
62. outer edge of cup
63. perforations
64. producing formation
65. gravel pack

Referring to the drawings, and first to FIGS. 1 and 4, it is seen that the apparatus used for forming the screen of the well strainer comprises principally a mandrel 1, rod assembly 2 and limiting collars 3 and 4. Mandrel 1 comprises two parts, a lower section 5 and upper section 6. Sections 5 and 6 are arbitrarily referred to herein as "lower" and "upper" to correspond with their positions in FIG. 4; therefore, this designation is not intended to mean that in use section 5 is always in the lower position and section 6 is always in the upper position.

The lower section 5 forms a complete cylinder at one end 7. Extending from the cylinder end of the lower section is an extending end 8, which is at least as long as the well strainer screen to be formed. A transverse section of end 8 reveals the partial shell of a cylinder describing an arc somewhat less than 180°, on the order of 170°.

Rigidly affixed internally in this open or cutout extending end 8 is a series of flanges 9 spaced at even distances. Each of

these flanges forms one-half of a truncated conical surface with its internal surface 10.

The upper section 6 of mandrel 1 is similar in shape to the extending end 8 of the lower section 5, i.e., a transverse section forms an arc of slightly less than 180°, (on the order of approximately 170°) with the section being at least as long as the well strainer screen to be formed. Rigidly affixed to the inside surface of the upper section 6 are a series of flanges 11 similar to flanges 9 in that they have internal truncated conical surfaces 12.

Upper section end 6 compliments the extending end 8 so that when the mandrel 1 is in use, edge 13 of the upper section is aligned opposite edge 14 of the lower section and edge 15 of the upper section is aligned opposite edge 16 of the lower section. When sections 5 and 6 of the mandrel are aligned in this position, flanges 9 and 11 internal to the two sections, are diametrically opposed to form approximately continuous surfaces, only separated by the distance which edge 13 is separated from edge 14, as best shown in FIG. 2.

Rod assembly 2, in operation located within the mandrel to expand it and hold it in expanded condition, comprises a rod 17 and a series of conical rod collars 18, there being a rod collar 18 corresponding to each pair of flanges 9 and 11. The external surface of each collar 18 describes a conical slope of essentially the same angle described by the internal surfaces of flanges 9 and 11. It will be seen that preferably only conical edges 19 and 20 come into mating contact with the surfaces of the flanges, there being a recess 21 to minimize friction and sticking between the surfaces. Rod 17 is threaded on the end nearest the smallest diameter of the conical collars at threaded end 22. As will be explained, the operation of the rod assembly 17 does not require that the opposite end 23 be threaded.

Limiting collars 3 and 4 constitute means for determining the inside diameter of the well strainer screen to be formed by their internal diameters. That is, the surfaces 24 and 25 describe cylinders having the same diameter as the internal diameter of the well strainer to be formed. Collar 3 is held to mandrel 1 via machine screws inserted through washers 27 and tightened into internally threaded holes 28, and in a similar manner, limiting collar 4 is held to the mandrel via machine screws 29 inserted through washers 30 and tightened into holes 31.

Washer 32, having a central hole 33 that slips over threaded end 22 on rod 17, presses and holds section 6 into correct longitudinal relationship with respect to section 5. Washer 32 is held in position by nut 34 and locknut 35 screwed onto threaded end 22. The outside diameter of washer 32 is small enough to slip inside of surface 24 of collar 3.

A recess 36 on the inside surface 24 of collar 3 accommodates the lead end of the metal wire to be used for forming the well strainer screen. This lead end is held in place via holding pin 37 screwed into threaded hole 38 in collar 3, which opens into recess 36, thereby constituting means for holding the lead end of the wire. Retaining wire clamp 39 is positioned between collars 3 and 4 and around mandrel 1 at a location along the mandrel that determines the length of the well strainer screen to be formed. That is, the distance between wire clamp 39 and collar 3 determines the length of the screen. After the wire used for forming the screen is completely wrapped, clamp 39 is squeezed together at flanges 40, thereby constituting means for holding the trailing end of the wire. A clamp bolt 42, inserted through holes 41, is secured by clamp nut 43 for this purpose.

In readying the mandrel so that it is in condition for forming screen 47, the lower section 5 of the mandrel is placed so that the open or cutout portion of extending end 8 is facing upward. Rod 17 is inserted by placing nonthreaded end 23 into cylindrical end 7 of section 5 and resting conical rod collars 18 on their corresponding flanges 9 located in the mandrel section. The rod is then moved longitudinally slightly in the direction of its nonthreaded end.

Upper section 6 is then placed in position over the rod assembly so that the edges 13 rest on edges 14 and edge 15 is in contact with edge 16. The flanges 11 in upper section 6 are now exactly positioned over flanges 9 in lower section 5 to form evenly aligned, continuous flange surfaces for contact with the conical collars on rod 17.

Collars 3 and 4 are placed over the mandrel so that they are positioned at the respective opposite ends of upper section 6, which now forms the expansible and collapsible section of the mandrel. For convenience of assembly, collar 3 is positioned preferably to slightly overhang the end of the mandrel by an amount slightly less than the thickness of washer 32. Washer 32 is then placed over rod 17 and into collar 3 so as to abut the end of section 6 and section 5. Nut 34 and locknut 35 are then screwed loosely onto threaded end 22 of rod 17 to hold washers 32 loosely in position.

Rod 17 is pushed in the direction of its threaded end to radially expand the upper section 6 away from lower section 5, as best shown in FIG. 2. Because the longitudinal movement of rod 17 tends to cause section 5 to slip longitudinal with respect to section 6, it may be necessary to apply a little longitudinal restraining pressure to washer 32 to keep section 6 aligned properly with respect to section 5.

When section 5 is properly expanded to its limit as determined by collars 3 and 4, nut 34 is tightened into fast holding position; locknut 35 is tightened against nut 34 to secure it in position; and machine screws 26 and 29 in collars 3 and 4 are tightened to hold these collars firmly in position.

The wire selected for forming the well strainer screen is normally stainless steel or other hard metal capable of forming a rigid section. The wire is squeezed or pinched together by stamping small segments at predetermined intervals to form lugs. In the wrapped condition, these wire lugs provide the necessary spacing between consecutive convolutions to allow proper straining action to occur. Typically, the lugs are stamped to space the wires apart by an amount almost equal to the diameter of the wires. In the referenced drawings, it will be seen that lugs 45 have been pinched in metal wire 44 at an interval spacing to form 12 lug groups about the periphery of the wire screen.

To form the screen, the entire assembly is placed on a machine capable of rotating it about its center, longitudinal axis, typically an engine lathe, and the lead end of the prepared metal wire 44 is inserted in recess 36 of collar 3 and held in position by holding pin 37 screwed into the threads of hole 38.

The assembly is then rotated to allow the metal wire to be wrapped helically about the circumference of the mandrel. About 40 to 80 pounds of tension is normally used on the wire as it is guided longitudinally along the mandrel in the wrapping operation.

Consecutive convolutions are spaced as close to one another as the spacing lugs will allow, the tension on the wire and the surface of the mandrel being inherent factors that cause the lugs to align themselves parallel to the longitudinal axis of the screen.

When the desired length of well strainer screen has been prepared, clamp 39 is positioned to receive the trailing end of metal wire 44 and tightened about this end by clamp bolt 42 and clamp nut 43.

An automatic welding machine, any of the types well known in the art, is moved into position opposite one end of the wire helix that has been formed by the metal wire. The depth of the weld is adjusted to be approximately one-half of the diameter of the metal screen, which is sufficient to create a sturdy bond between the consecutive convolutions of wire but not so deep as to weld the metal wire to the mandrel.

In accordance with ordinary good welding practice, such as welding in the presence of an inert gas, the machine is moved along the surface of the screen to form weld beads. In the embodiment of the invention shown in the referenced drawings, six weld beads are illustrated, although it will be understood that any practical number is suitable.

As illustrated in the drawings, the longitudinal weld beads **46** are positioned between the rows of lugs **45**. The weld beads do not overlie rows of lugs. Upon cooling of the weld bead in manufacture, the bead is not subjected to tensile stress caused by the lugs holding the wires apart.

It has been found that continuous bead rows the full length of the well screen are quite satisfactory. However, it is possible to use a series of partial or staggered bead rows forming an even pattern about the well screen to accomplish comparable results.

To remove the well screen from the mandrel, collars **3** and **4** are removed by loosening machine screws **26** and **29** and holding pin **37**. Wire clamp **39** is then released by loosening clamp bolt **42** and sliding wire clamp **39** along the mandrel away from the screen. Locknut **35** and nut **34** are then unscrewed from threaded end **22** of rod **17**. Rod assembly **2** is loosened by pulling longitudinally in the direction of unthreaded end **23**.

This allows upper section **6** of the mandrel to collapse toward the lower section **5**, as shown in FIG. **3**, so that the well strainer is easily removed by slipping it from the end of the mandrel.

Well strainer screen **47** which has been formed is attached to a connector to make an operable assembly, female connector **48** being shown in FIG. **5** for this purpose. Connector **48** is channeled with grooves **49** to guide the connector onto the end of the well screen, there being a corresponding groove **49** for each weld bead **46**. An external connector weld bead **50** secures the connector to the outside of the screen and an internal connector weld bead **51** connects the screen to the inside of the connector. In practice, only external connector weld bead **50** or internal connector weld bead **51** should be sufficient.

The connector is threaded with threads **52** to facilitate connecting with a well pipe or closed stub.

A male connector, rather than the female connector **48** illustrated, may be used for a specific installation. When used, a male connector is attached by abutting the connector to the end of the well strainer screen and welding a single external bead, similar to weld bead **50**, to bond the screen to the connector.

The well strainer is shown being used in the flushing operation in FIG. **6**. Flushing tool **53** is shown lowered into a segment of the well strainer by means of a flushing string assembly **54** attached to the flushing tool by connector **55**. Flushing tool **53** comprises primarily a perforate flushing string section **56** and facing swab cups **57** and **58**. Cup holders **59** and **60** attach the swab cups to the body of flushing tool **53**.

The outer edges **61** and **62** of swab cups **57** and **58** effectively block off an area in the channel annulus between the inside of well strainer screen **47** and the outside of perforate flushing string section **56**. This means that fluid material flowing in the channel annulus cannot freely flow from the isolated area to the remainder of the annulus without first flowing out through grooved opening **49** to the outside of the screen and back in again after bypassing the swab cups.

To flush with flushing tool **53**, fresh water supplied from the flushing string assembly flows out through perforations **63** into the isolated section of the well strainer channel between the swab cups. If the slitted passageways in the screen are clogged, pressure will build up on the channel until it becomes enough to flush out the clogging material.

The return path for the slushing water is above and around cup **57**, in through the inlet passageways in the wall of screen **47**, and up the channel between the inside of the strainer (and higher up, the inside of the well casing) and the outside of flushing string assembly **54** to the surface of the well.

For a normal well where the contents of the well are pumped only from a single stratum, the well strainer is attached to the well pipe and lowered into the well to the lowest operating depth; the flushing tool is lowered to its fullest extent within the strainer; fresh water is flushed down the flushing tool until clear water is returned up the well pipe; then the flushing tool is raised to the next higher position in the strainer and the process repeated until the entire area of the strainer has been flushed.

If reflushing or partial reflushing is desired, flushing string assembly **54** can be easily lowered to the desired extent and the operation repeated.

It has been mentioned that the length of well strainers in common use today is in the neighborhood of 30feet. Should a longer well strainer be required for a specific application, sections can be easily joined together via their connectors.

In some well applications, it is desired to draw from two different stratum depths, for instance, from 30feet and from 60feet with no desire to draw from the well between these two depths. In this event, one well strainer is lowered to the 60 position, a plain well pipe is connected in the area where there is no desire to flush, and a second strainer is connected at the 30-foot location. Flushing is performed as with a normal well installation except there is no need to flush in the area of the plain pipe.

Notice particularly that since the internal diameter of the strainer and the well pipe in accordance with this invention are constant throughout, the cup of the flushing tool assembly is easily moved the entire length without materially expanding and contracting. Also, since there are no internal projections from the screen forming the well strainer, leakage within the channel from the isolated passage is held to a minimum.

While only a single embodiment of the invention has been described, it is obvious that numerous changes can be made with out departing from the scope of the invention. For example, it has already been suggested that a male connector can be used instead of the female connector illustrated in FIG. **5**. It was also noted that welds beads of various configuration can be used to bond the consecutive convolutions of the wire screen together.

Also, another method which might be used for setting the limit of radial expansion of the mandrel prior to the wrapping process is through the placement of longitudinal stops critically positioned for arresting the movement of the rod when the mandrel has expanded by the proper radial amount.

WHAT WE CLAIM IS:

1. A well strainer for use in a borehole containing a tubing string, said strainer comprising

a wire helix having a plurality of closely spaced-apart winding defining the inner and outer surfaces of a hollow tubular structure,

a plurality of lugs located at intervals along said wire in said helix for separating said windings without protruding inwardly of said hollow tubular structure,

at least one weld bead disposed longitudinally along said outer surface and spaced externally from said inner surface of said tubular structure defined by said windings to interconnect said winding one to another,

a tubular end fitting having one end adapted for interconnection in said tubing string,

an annular weld bead concentrically connecting the other end of said end fitting to one end of said wire helix,

said tubular end fitting being also provided with an annular internal recess adjacent said other end thereof, and

said annular weld bead being mounted in said annular recess in said end fitting.

2. The well strainer described in claim **1**, wherein the inner surface of said hollow tubular structure defined by said windings of said wire helix has a diameter substantially the same as the inside diameter of said tubing string in said borehole.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,601,192 Dated August 24, 1971

Inventor(s) Max E. Layne and Theodore W. Munhausen

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 73, "Circular" should be changed to --Circulation--.

Column 2, lines 70-71 should be changed to --3,489,185, an expansible mandrel having a smooth external surface is--.

Column 8, lines 11 and 16, "30feet" should be changed to --30 feet--;

line 17, "60feet" should be changed to --60 feet--;

line 18, after "60" the word --foot-- should be inserted;

line 36, "welds" should be changed to --weld--; and

line 48, "winding" should be changed to --windings--.

Signed and sealed this 14th day of March 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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