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(54) Title: WELL TOOL ASSEMBLIES WITH QUICK CONNECTORS AND SHOCK MITIGATING CAPABILITIES

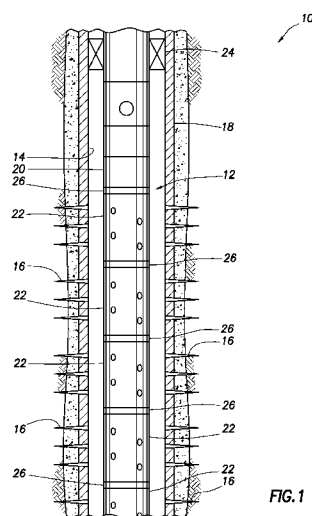


FIG. 1

(57) Abstract: A method can include interconnecting a well tool in a well tool assembly with a shock mitigating connection, the interconnecting being performed without threading, and positioning the well tool assembly in a wellbore. A well perforating assembly can include at least two perforating devices, a detonation train extending through the perforating devices, and a shock absorber positioned between the perforating devices. A method of assembling a perforating assembly can include, prior to installing the perforating assembly in a wellbore, pushing one perforating device connector into another perforating device connector without threading the connectors together, thereby: a) preventing disconnection of the connectors and b) making a connection in a detonation train. A well system can include a perforating assembly including multiple perforating guns and multiple shock absorbers. Each shock absorber may be interconnected between at least two of the perforating guns.



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WELL TOOL ASSEMBLIES WITH QUICK CONNECTORS AND SHOCK MITIGATING CAPABILITIES

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TECHNICAL FIELD

The present disclosure relates generally to equipment utilized and operations performed in conjunction with subterranean wells and, in an embodiment described herein, more particularly provides a well tool assembly with quick
15 connectors and shock mitigating capabilities.

BACKGROUND

Shock absorbers have been used in the past in attempts to prevent damage to well equipment resulting from firing
20 perforating guns and other events. In some situations, a shock absorber is interconnected between a perforating assembly and the well equipment (such as, a packer, gravel packing equipment, instruments, etc.) to be protected from shock loads.

25 However, testing has revealed that such shock loads are transmitted in a very short amount of time (e.g., ~10-30 milliseconds), and conventional shock absorbers are either too rigid to react adequately to the shock, or too compliant to absorb the shock. Therefore, it will be appreciated that

improvements are needed in the art of mitigating shock for well assemblies.

Improvements are also needed in the art of connecting well tool assemblies. Such improvements could reduce the amount of time needed to connect perforating devices or other well tools, and could prevent damage to connectors used to connect well tools.

SUMMARY

In carrying out the principles of the present disclosure, systems and methods are provided which bring improvements to the art. One example is described below in which multiple shock absorbers are interconnected in a perforating assembly. Another example is described below in which connections are made between well tools without threading.

A method described below can include interconnecting a well tool in a well tool assembly with a shock mitigating connection, the interconnecting being performed without threading, and positioning the well tool assembly in a wellbore. The method may be used for well perforating assemblies, or for other types of well tool assemblies.

In one aspect, a well perforating assembly is disclosed. The perforating assembly can include at least two perforating devices, a detonation train extending through the perforating devices, and a shock absorber positioned between the perforating devices.

In another aspect, a method of assembling a perforating assembly is described below. The method can include, prior to installing the perforating assembly in a wellbore, pushing one perforating device connector into another

perforating device connector without threading the connectors together, thereby: a) preventing disconnection of the connectors and b) making a connection in a detonation train.

5 In yet another aspect, a well system is provided which can include a perforating assembly including multiple perforating guns and multiple shock absorbers. Each shock absorber is interconnected between at least two of the perforating guns.

10 These and other features, advantages and benefits will become apparent to one of ordinary skill in the art upon careful consideration of the detailed description of representative embodiments of the disclosure hereinbelow and the accompanying drawings, in which similar elements are
15 indicated in the various figures using the same reference numbers.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a representative partially cross-sectional
20 view of a well system and associated method which can embody principles of the present disclosure.

FIG. 2 is an enlarged scale representative partially cross-sectional view of a prior art perforating assembly.

FIG. 3 is a representative cross-sectional view of a
25 perforating assembly which can embody principles of this disclosure.

FIG. 4 is a further enlarged scale cross-sectional view of detail 4 in FIG. 3.

FIG. 5 is a still further enlarged scale cross-
30 sectional view of detail 5 in FIG. 4.

FIG. 6 is a representative partially cross-sectional view of another configuration of the well system and method.

DETAILED DESCRIPTION

5 Representatively illustrated in FIG. 1 is a well system 10 and associated method which can embody principles of the present disclosure. In the system 10, a perforating assembly 12 is positioned in a wellbore 14 for forming perforations 16 through casing 18 lining the wellbore.

10 The perforating assembly 12 can include any number of perforating devices, such as a firing head 20 and perforating guns 22. The firing head 20 fires the perforating guns 22 in response to a particular stimulus (e.g., pressure levels, pressure pulses, a telemetry signal,
15 a bar dropped through a tubular string to the firing head, etc.). Any type of firing head, and any type of perforating guns, may be used in the perforating assembly 12 in keeping with the principles of this disclosure.

 Although only one firing head 20 connected above the
20 perforating guns 22 is depicted in FIG. 1, it will be appreciated that any number or position of firing head(s) may be used, as desired. For example, the firing head 20 could be connected at a lower end of the perforating assembly 12, multiple firing heads could be used, a separate
25 firing head could be used for each perforating gun, etc.

 In the system 10, it is desired to prevent unsettling or otherwise damaging a packer 24 set in the casing 18 above the perforating guns 22. The packer 24 is used herein as one example of a type of well equipment which can be protected
30 using the principles of this disclosure, but it should be clearly understood that any other types of well equipment

(e.g., anchors, hangers, instruments, other perforating devices, etc.) may be protected in other examples.

In one unique feature of the well system 10, a shock absorbing connection 26 is disposed between each adjacent pair of the perforating guns 22, and a shock absorbing connection is also disposed between the firing head 20 and the uppermost perforating gun. The connections 26 also allow the perforating devices (firing head 20 and perforating guns 22) to be quickly assembled to each other prior to installing the perforating assembly 12 in the wellbore 14.

Although a connection 26 is depicted in FIG. 1 between each adjacent pair of the perforating guns 22, it will be appreciated that the connections could be otherwise positioned. In other examples, some adjacent pairs of perforating guns 22 may not have the connections 26 between them. Thus, it is not necessary for each adjacent pair of perforating guns 22 to have one of the connections 26 between them, nor is it necessary for one of the connections 26 to be positioned between the firing head 20 and the adjacent perforating gun 22.

By interconnecting multiple shock absorbing connections 26 in the perforating assembly 12, each connection only has to absorb shock generated due to firing of the adjacent perforating device(s), and accumulation of the shock loads along the perforating assembly is prevented, or at least beneficially mitigated. Greater or fewer numbers of the connections 26 may be used in the perforating assembly 12 as needed to achieve a desired level of shock mitigation.

Referring additionally now to FIG. 2, a partially cross-sectional view of a prior art perforating assembly 28 is representatively illustrated. The perforating assembly 28 includes the perforating guns 22, with each perforating gun

including perforating charges 30, a charge carrier 32 and detonating cord 34 in a generally tubular gun body 36.

However, instead of the shock absorbing connections 26 used in the system 10, the perforating assembly 28 of FIG. 2 includes a rigid, threaded connection 38 between the
5 perforating guns 22. Specifically, a connector 40 having opposing externally-threaded ends is threaded into one perforating gun 22, and another connector 42 having opposing externally- and internally-threaded ends is threaded into
10 another perforating gun 22.

When the connectors 40, 42 are threaded together, the rigid, threaded connection 38 is made. The connection 38 has no shock absorbing capability, and threading the connectors 40, 42 to each other can be difficult when the guns 22 are
15 long and/or heavy, sometimes resulting in damage to threads on the connectors.

The improved connection 26 used in the system 10 is representatively illustrated in FIG. 3. The connection 26 may be used between perforating guns 22, between a
20 perforating gun and the firing head 20, or between any other well tools or equipment. The connection 26 may also be used in perforating assemblies other than the perforating assembly 12, and in well systems other than the well system 10, in keeping with the principles of this disclosure.

25 The connection 26 includes a connector 44 which is attached to a perforating device (such as a perforating gun or firing head, not shown), and another connector 46 which is depicted in FIG. 3 as being attached to a perforating gun 22. The connectors 44, 46 may each be attached to the
30 respective perforating guns 22, firing head 20 or other perforating devices or other well tools by threading or any other suitable means.

In one unique feature of the connection 26, the connector 44 can be inserted and pushed into the other connector 46 without threading. Once connected in this manner, an engagement device 48 prevents disconnection of the connectors 44, 46.

The engagement device 48 permits the connector 44 to displace in one direction longitudinally toward the other connector 46, but prevents the connector 44 from displacing in the opposite longitudinal direction relative to the connector 46. Thus, the connection 26 can be longitudinally compressed, but the device 48 prevents the connection from being elongated longitudinally.

One benefit of this arrangement is that the perforating devices or other well tools attached to the connectors 44, 46 can be quickly and conveniently connected to each other, without any need for threading the connector 44 into the other connector 46. Another benefit of this arrangement is that detonation transfer components (such as, detonation boosters 56 attached at ends of the detonating cords 34) are brought into close proximity to each other when the connector 44 is pushed into the other connector 46. In this manner, a connection is made in a detonation train 54 (including the detonating cord 34, boosters 56, etc.) which extends through the connection 26.

Another unique feature of the connection 26 is that it includes shock absorbers 50, 52 disposed between the connectors 44, 46. The shock absorbers 50, 52 function to absorb shock loads which would otherwise be transmitted through the connection 26.

The shock absorbers 50, 52 are preferably made of a material which can deform appropriately to absorb the shock loads resulting from firing of the perforating devices. Some

acceptable materials for the shock absorbers 50, 52 can include brass, aluminum, rubber, foamed materials, or any other shock absorbing materials.

5 The shock absorbers 50, 52 may be annular-shaped as depicted in FIG. 3, or they could have any other shapes, such as round, square, T- or I-shaped cross-sections, etc. The size, shape, material and/or other characteristics of the shock absorbers 50, 52 may be customized for their placement in the perforating assembly 12, position in the
10 well, size and length of the adjacent perforating devices or other well tools, etc.

Although two shock absorbers 50, 52 are illustrated in the connection 26 example of FIG. 3, in other examples different numbers of shock absorbers (including one) may be
15 used. In addition, although in FIG. 3 the detonation train 54 is depicted as extending through the shock absorbers 50, 52, such an arrangement is not necessary in keeping with the principles of this disclosure.

Since the connection 26 allows for longitudinal
20 compression of the connectors 44, 46, when a compressive shock load is transmitted to the connection, the connectors will compress somewhat, with the shock absorbers 50, 52 thereby absorbing the compressive shock load. In this manner, transmission of the shock load across the connection
25 26 is prevented, or is at least significantly mitigated.

Referring additionally now to FIG. 4, an enlarged scale cross-sectional view of the engagement device 48 is representatively illustrated. As depicted in FIG. 4, the engagement device 48 comprises a segmented or longitudinally
30 split sleeve 58 having a series of relatively coarse pitch ramp-type profiles 60 on an exterior thereof, and a series of relatively fine pitch profiles 62 on an interior thereof.

The profiles 60, 62 may be formed as threads on the engagement device 48, with the respective connectors 46, 44 having complementarily shaped profiles formed thereon. For example, the profiles 60 could be formed as 45-degree
5 buttress threads, and the profiles 62 could be formed as a "phonograph" finish (very fine grooves).

However, it should be understood that, preferably, the connectors 44, 46 are not threaded to each other with the engagement device 48. Instead, the connector 44 is
10 preferably pushed into the connector 46 (without rotating or threading either connector), and the engagement device 48 prevents the connector 44 from being withdrawn from the connector 46.

In the example of FIG. 4, this result is accomplished
15 due to the ramped interface between the profiles 60 and the connector 46, and gripping of the connector 44 by the profiles 62. A further enlarged scale view of this engagement between the connectors 44, 46 and the device 48 is representatively illustrated in FIG. 5.

20 If a tensile load is applied across the connection 26, the profiles 62 will grip the outer surface of the connector 44, so that the sleeve 58 attempts to displace with the connector 44. However, the ramps of the profiles 60, in engagement with the connector 46, prevent downward (as
25 viewed in FIG. 5) displacement of the connector 44 and sleeve 58, and cause the sleeve to be compressed radially inward.

The inward compression of the sleeve 58 causes the profiles 62 to more securely grip the outer surface of the
30 connector 44. The sleeve 58 can be formed with a C-shaped lateral cross-section, so that it can be readily deformed inward. The sleeve 58 can also be deformed radially outward,

if desired, so that it no longer grips the outer surface of the connector 44, thereby allowing the connector 44 to be withdrawn from the connector 46, for example, to disassemble the perforating assembly 12 after firing, after a misfire,
5 etc.

Although the connection 26 is described above as having multiple benefits (e.g., speed of connecting, lack of threading connectors 44, 46 to each other, shock absorbing capability, detonation train 54 connecting, etc.), it is not
10 necessary for all of the above-described benefits to be incorporated into a single connection embodying principles of this disclosure. The connection 26 could include one of the above-described benefits, any subset of those benefits, and/or other benefits.

15 Referring additionally now to FIG. 6, another configuration of the well system 10 is representatively illustrated. In this configuration, the connections 26 are used to prevent or mitigate shock being transmitted to various well tools 64a-c interconnected in a well tool
20 assembly 66 positioned in the wellbore 14.

In this example, the well tool 64a comprises an instrument carrier (containing, for example, one or more pressure and/or temperature sensors, etc.), the well tool 64b comprises a fluid sampler (e.g., with chambers therein
25 for containing selectively filled fluid samples), and the well tool 64c comprises an electronics module (e.g., used for receiving, storing and/or transmitting data, commands, etc., measuring parameters, etc.). However, it should be clearly understood that these are merely examples of well
30 tools which can benefit from the principles of this disclosure, and any type of well tool may be used in the assembly 66 in keeping with those principles.

It is not necessary for the assembly 66 to include multiple well tools. Instead, a single well tool may benefit from use of the connections 26.

5 It is not necessary for the connections 26 to be used on both ends of each of the well tools 64a-c as depicted in FIG. 6. Instead, a connection 26 may be used on only one end of a well tool, or in positions other than the ends of a well tool.

10 In the example of FIG. 6, the connections 26 prevent or mitigate shock being transmitted to the well tools 64a-c interconnected in the assembly 66, and also allow the well tools to be interconnected in the assembly quickly and without threading. Note that the firing head 20, perforating guns 22 and packer 24 described above are also examples of
15 well tools which can benefit from use of the connection 26.

It may now be fully appreciated that the above disclosure provides several advancements to the art. The connection 26 depicted in FIGS. 1 & 3-6 allows for shock loads to be absorbed or at least mitigated between
20 perforating devices or other well tools, and allows perforating devices and other well tools to be connected to each other quickly and without threading.

A method described above can include interconnecting a well tool 64a-c in a well tool assembly 66 with a shock
25 mitigating connection 26, the interconnecting being performed without threading, and positioning the well tool assembly 66 in a wellbore 14.

The connection 26 may comprise at least one shock absorber 50, 52 positioned between connectors 44, 46. The
30 connection 26 may comprise a sleeve 58 having relatively coarse pitch profiles 60 on one side, and the sleeve 58

having relatively fine pitch profiles 62 on an opposite side.

Interconnecting can include pushing one connector 44 into another connector 46 without threading the connectors 44, 46 together, thereby preventing disconnection of the connectors 44, 46. An engagement device 48 may permit relative displacement between the connectors 44, 46 in one longitudinal direction, but prevent relative displacement between the connectors 44, 46 in an opposite longitudinal direction.

The well tool may be one or more of a perforating gun 22, a firing head 20, a packer 24, an instrument carrier 64a, a fluid sampler 64b and an electronics module 64c.

A well perforating assembly 12 described above can include at least two perforating devices (such as firing head 20, perforating gun 22, etc.), a detonation train 54 extending through the perforating devices 20, 22, and a shock absorber 50, 52 positioned between the perforating devices 20, 22.

The shock absorber 50, 52 preferably absorbs longitudinally directed shock generated by firing at least one of the perforating devices 20, 22.

The detonation train 54 may extend longitudinally through the shock absorber 50, 52.

The perforating devices may comprise perforating guns 22. The perforating devices may comprise a perforating gun 22 and a firing head 20.

The assembly 12 can include a connection 26 between the perforating devices 20, 22. An engagement device 48 of the connection 26 may permit longitudinal compression of the connection 26, but prevent elongation of the connection 26.

The connection 26 can comprise connectors 44, 46 attached to the respective perforating devices. The engagement device 48 may permit relative displacement between the connectors 44, 46 in one longitudinal direction, but prevent relative displacement between the connectors 44, 46 in an opposite longitudinal direction.

The connectors 44, 46 are preferably connected to each other without threading together the connectors 44, 46. The detonation train 54 may extend through the connectors 44, 46.

Also described above is a method of assembling a perforating assembly 12. The method can include, prior to installing the perforating assembly 12 in a wellbore 14, pushing one perforating device connector 44 into another perforating device connector 46 without threading the connectors 44, 46 together, thereby: a) preventing disconnection of the connectors 44, 46 and b) making a connection in a detonation train 54.

The method can also include positioning a shock absorber 50, 52 between the connectors 44, 46. The shock absorber 50, 52 may absorb longitudinally directed shock generated by firing at least one perforating device 20, 22. The detonation train 54 may extend longitudinally through the shock absorber 50, 52.

Each, or at least one, of the perforating device connectors 44, 46 may be attached to a perforating gun 22. At least one of the perforating device connectors 44, 46 may be attached to a firing head 20.

The above disclosure also provides to the art a well system 10. The well system 10 can comprise a perforating assembly 12 including multiple perforating guns 22 and multiple shock absorbers 50, 52.

Each shock absorber 50, 52 may be interconnected between at least two of the perforating guns 22. Each shock absorber 50, 52 preferably mitigates transmission of shock from one connector 44 to another 46, the connectors being
5 longitudinally compressible but prevented from elongating. A detonation train 54 may extend through the shock absorbers 50, 52.

It is to be understood that the various embodiments of the present disclosure described herein may be utilized in
10 various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of the present disclosure. The embodiments are described merely as examples of useful applications of the principles of the disclosure,
15 which is not limited to any specific details of these embodiments.

In the above description of the representative embodiments of the disclosure, directional terms, such as "above," "below," "upper," "lower," etc., are used merely
20 for convenience in referring to the accompanying drawings.

Of course, a person skilled in the art would, upon a careful consideration of the above description of representative embodiments of the disclosure, readily appreciate that many modifications, additions,
25 substitutions, deletions, and other changes may be made to the specific embodiments, and such changes are contemplated by the principles of the present disclosure. Accordingly, the foregoing detailed description is to be clearly understood as being given by way of illustration and example
30 only, the spirit and scope of the present invention being limited solely by the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A method, comprising:

interconnecting a well tool in a well tool assembly
5 with a shock mitigating connection, the interconnecting
being performed without threading; and

positioning the well tool assembly in a wellbore.

2. The method of claim 1, wherein the connection
10 comprises at least one shock absorber positioned between
connectors.

3. The method of claim 1, wherein the connection
comprises a sleeve having relatively coarse pitch profiles
15 on one side, and the sleeve having relatively fine pitch
profiles on an opposite side.

4. The method of claim 1, wherein interconnecting
comprises pushing one connector into another connector
20 without threading the connectors together, thereby
preventing disconnection of the connectors.

5. The method of claim 4, wherein an engagement
device permits relative displacement between the connectors
25 in one longitudinal direction, but prevents relative
displacement between the connectors in an opposite
longitudinal direction.

6. The method of claim 1, wherein the well tool is selected from a group comprising: a perforating gun, a firing head, a packer, an instrument carrier, a fluid sampler and an electronics module.

7. A well perforating assembly, comprising:
at least two perforating devices;
a detonation train extending through the perforating
5 devices; and
a shock absorber positioned between the perforating
devices.

8. The assembly of claim 7, wherein the shock
10 absorber absorbs longitudinally directed shock generated by
firing at least one of the perforating devices.

9. The assembly of claim 7, wherein the detonation
train extends longitudinally through the shock absorber.
15

10. The assembly of claim 7, wherein the perforating
devices comprise perforating guns.

11. The assembly of claim 7, wherein the perforating
20 devices comprise a perforating gun and a firing head.

12. The assembly of claim 7, further comprising a
connection between the perforating devices, and wherein an
engagement device of the connection permits longitudinal
25 compression of the connection, but prevents elongation of
the connection.

13. The assembly of claim 12, wherein the connection
comprises connectors attached to the respective perforating

devices, and wherein the engagement device permits relative displacement between the connectors in one longitudinal direction, but prevents relative displacement between the connectors in an opposite longitudinal direction.

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14. The assembly of claim 13, wherein the connectors are connected to each other without threading together the connectors.

10

15. The assembly of claim 13, wherein the detonation train extends through the connectors.

16. A method of assembling a perforating assembly, the method comprising:

5 prior to installing the perforating assembly in a wellbore, pushing one perforating device connector into another perforating device connector without threading the connectors together, thereby: a) preventing disconnection of the connectors and b) making a connection in a detonation train.

10

17. The method of claim 16, further comprising positioning a shock absorber between the connectors.

15 18. The method of claim 17, wherein the shock absorber absorbs longitudinally directed shock generated by firing at least one perforating device.

19. The method of claim 17, wherein the detonation train extends longitudinally through the shock absorber.

20

20. The method of claim 16, wherein each of the perforating device connectors is attached to a perforating gun.

25 21. The method of claim 16, wherein at least one of the perforating device connectors is attached to a perforating gun.

22. The method of claim 16, wherein at least one of the perforating device connectors is attached to a firing head.

- 5 23. The method of claim 16, wherein an engagement device permits relative displacement between the connectors in one longitudinal direction, but prevents relative displacement between the connectors in an opposite longitudinal direction.

24. A well system, comprising:

a perforating assembly including multiple perforating
guns and multiple shock absorbers, and wherein each shock
5 absorber is interconnected between at least two of the
perforating guns.

25. The well system of claim 24, wherein each shock
absorber mitigates transmission of shock from one connector
10 to another, the connectors being longitudinally compressible
but prevented from elongating.

26. The well system of claim 24, wherein a detonation
train extends through the shock absorbers.

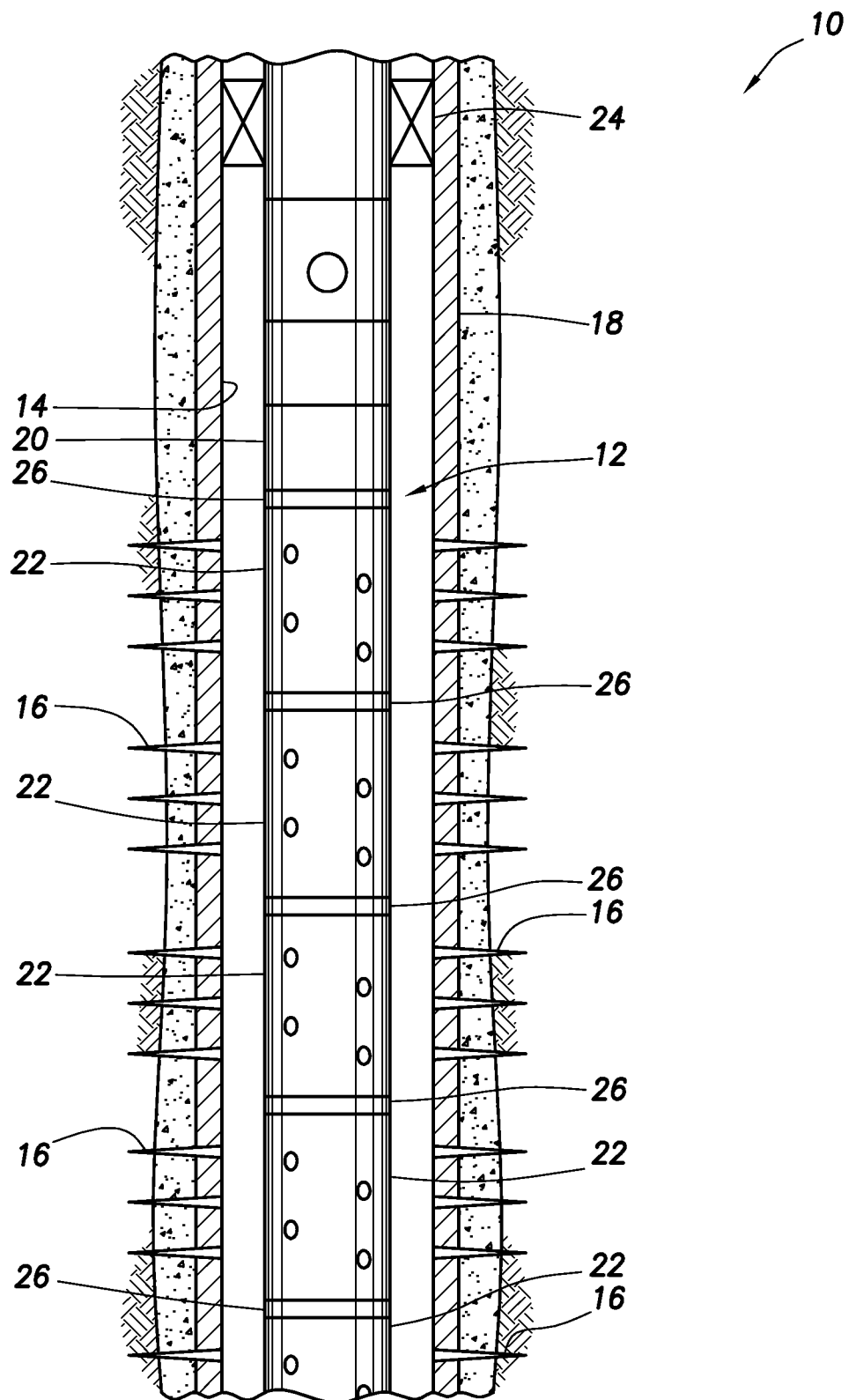
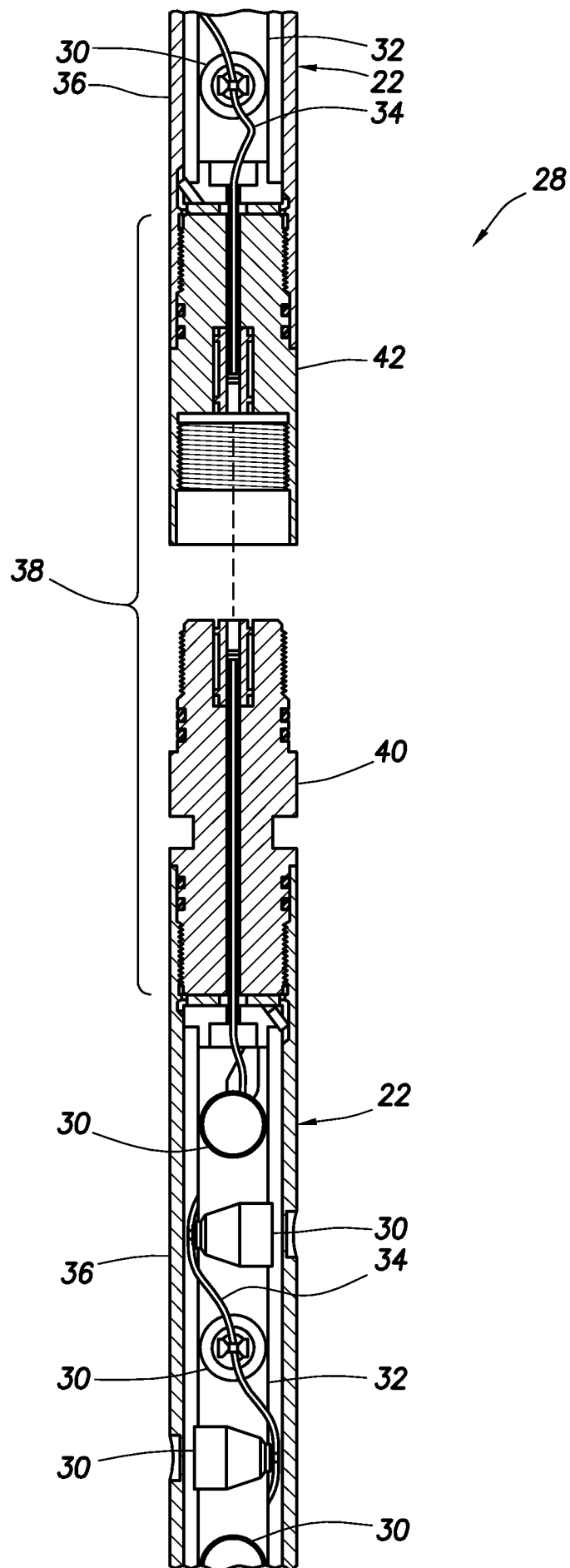


FIG. 1

FIG.2
(PRIOR ART)



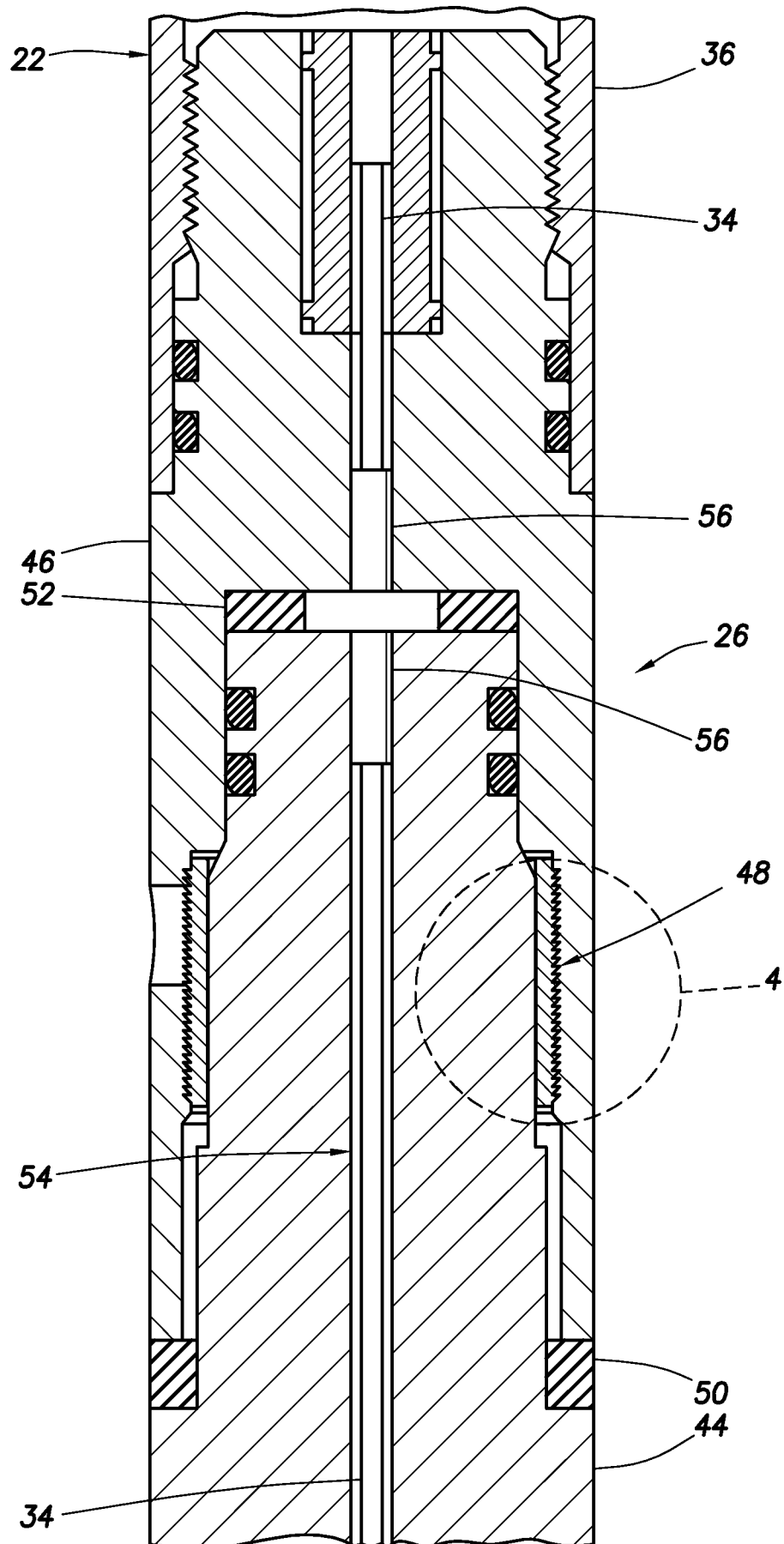


FIG.3

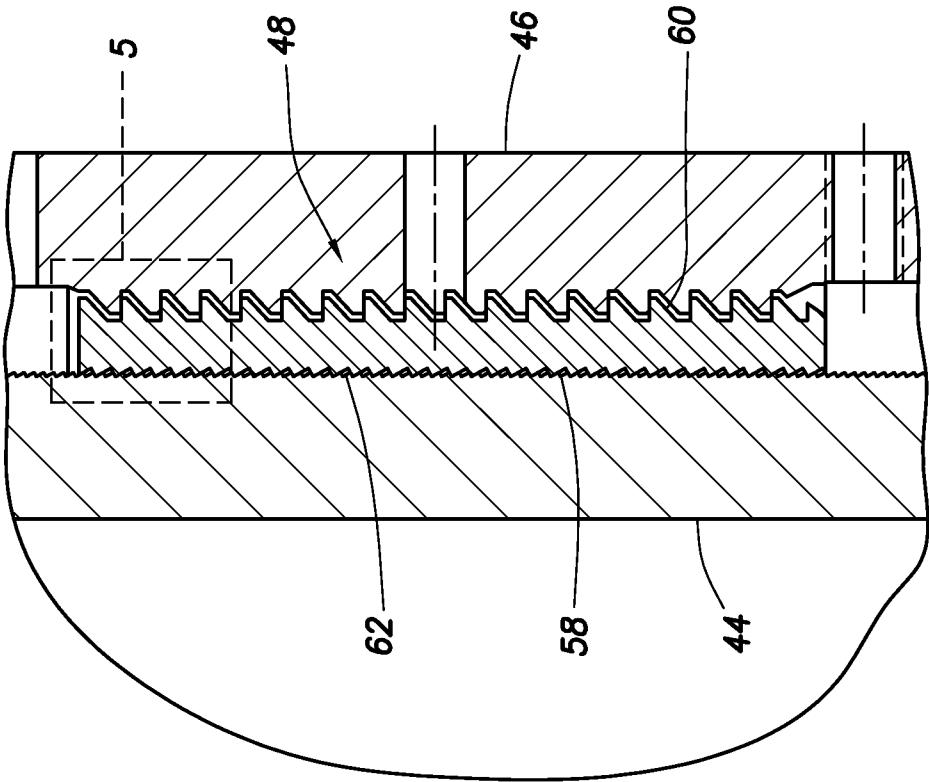


FIG. 4

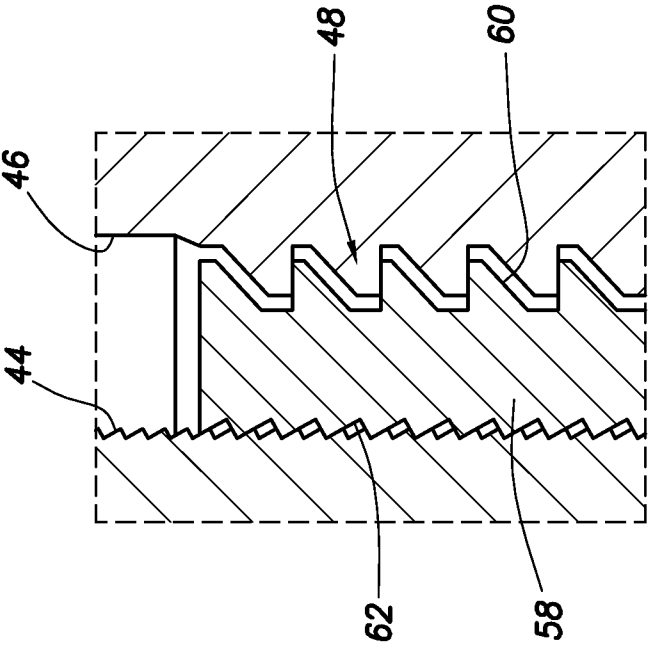


FIG. 5

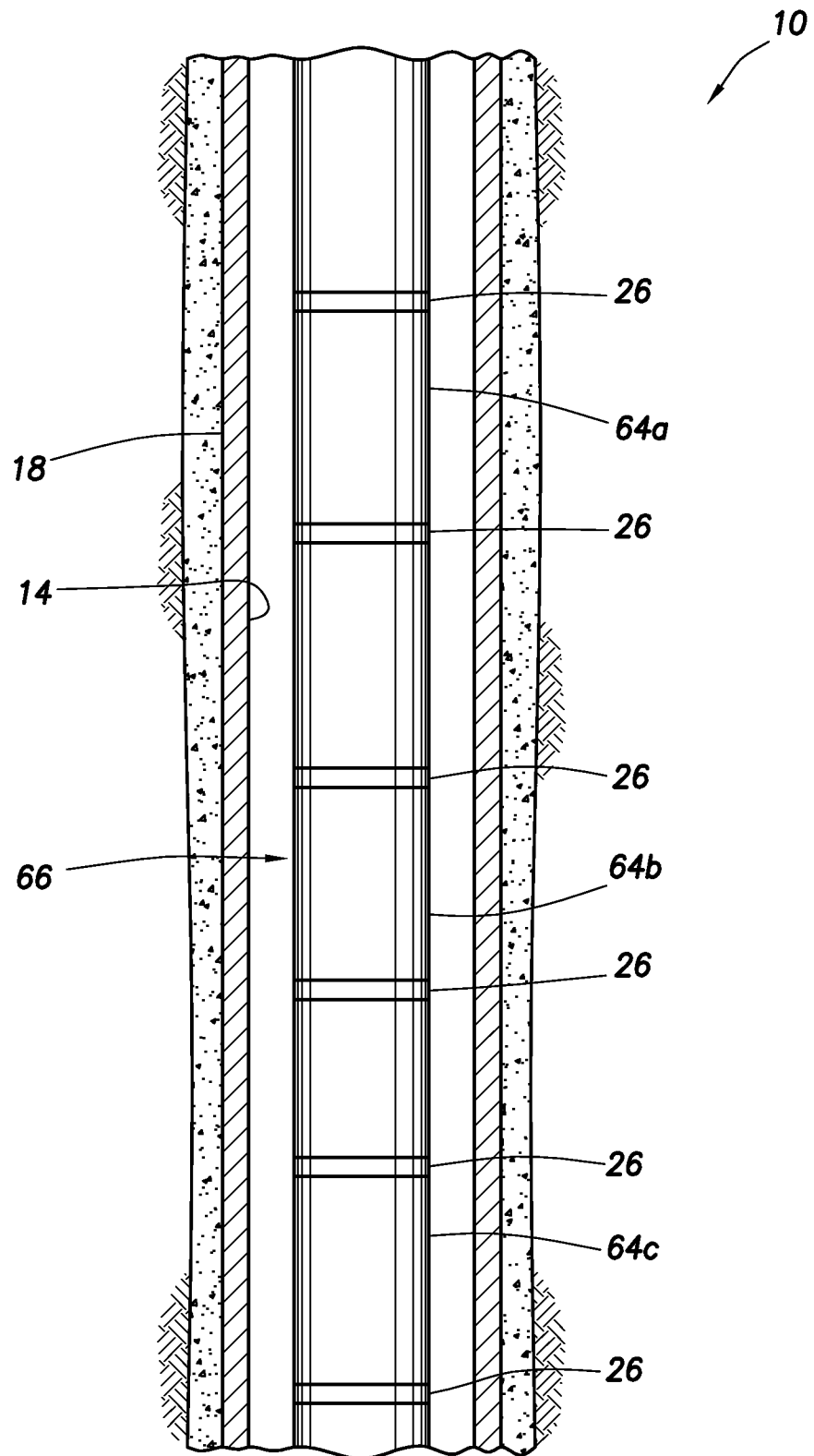


FIG. 6

A. CLASSIFICATION OF SUBJECT MATTER**E21B 43/116(2006.01)i, E21B 43/119(2006.01)i, E21B 28/00(2006.01)i, E21B 7/24(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B 43/116; E21B 17/07; E21B 43/117; F16F 7/12; E21B 28/00; E21B 17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: shock, mitigating, absorber, perforating

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004-0140090 A1 (GUY HARVEY MASON et al.) 22 July 2004 See abstract, paragraph 0028, 0041 and figures 2, 4	1,2,4,6
X	US 05131470 A (MISZEWSKI; ANTONI K. L. et al.) 21 July 1992 See abstract, column 4 and figures 2a,5a	7-11
A	US 2003-0089497 A1 (FLINT R. GEORGE et al.) 15 May 2003 See abstract, paragraph 0026, claims 1-50 and figure 2	1-26
A	US 2010-0147519 A1 (GOODMAN KENNETH) 17 June 2010 See abstract, paragraph 0012, claims 1-20 and figure 1	1-26



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004-0140090 A1	22.07.2004	FR 2824373 A1	08.11.2002
		FR 2824373 B1	10.02.2006
		GB 0110905 D0	27.06.2001
		GB 0210306 D0	12.06.2002
		GB 2375125 A	06.11.2002
		GB 2375125 B	09.04.2003
		US 7044219 B2	16.05.2006
		WO 02-090715 A1	14.11.2002
US 05131470 A	21.07.1992	EP 0488875 A2	03.06.1992
		EP 0488875 A3	31.03.1993
		EP 0488875 B1	08.01.1997
US 2003-0089497 A1	15.05.2003	US 6708761 B2	23.03.2004
US 2010-0147519 A1	17.06.2010	WO 2010-074902 A1	01.07.2010