



No. 11-177813- -00000-0000



Fecha: 2011-12-23 14:56:30 Dep. 2020 DIR.NUEVASCR
Tra. 11 PATENTEIYII Eve: 378 FASENACIONALI
Act. 411 PRESENTACION Folios: 171

Industria y Comercio

SUPERINTENDENCIA

DELEGATURA PROPIEDAD INDUSTRIAL

SOLICITUD DE PATENTE DE INVENCION PCT

EXPEDIENTE No _____

TITULO MODELADO DE IMPACTO PRODUCIDO
POR LA PERFORACIÓN DE UN POZO

CLASIFICACION INTERNACIONAL _____

SOLICITANTE HALLIBURTON ENERGY SERVICES,
INC

DOMICILIO Texas, Estados Unidos de América

APODERADO DARIO CARDENAS NAVAS

BOGOTA D.C. _____

PETITORIO



SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO



No. 11-177813- -00000-0000

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FORMULARIO UNICO DE SOLICITUD DE PATENTE PCT ENTRADA EN FASE NACIONAL

①

SOLICITUD DE:

☒ X

Patente de Invención

☐

Patente de Modelo de Utilidad

☒ X

Capítulo I

☐

Capítulo II

②

SOLICITANTE

Nombre: **HALLIBURTON ENERGY SERVICES, INC**

Dirección: 2601 Beltline Road, Carrollton, Texas 75006,
Estados Unidos de América

Nacionalidad o Domicilio: Texas, Estados Unidos de
América

Lugar de Constitución: Estados Unidos de América

Teléfono: 3137800 Fax: 3122410

E-mail: general@cardenasycardenas.com

IDENTIFICACION

☐ NIT

☐ NIT

☐ Otro

☒ X Otro

Cual
Número

③

REPRESENTANTE
O APODERADO

Nombre: **DARIO CARDENAS NAVAS**

Dirección: Carrera 7 No 71-52 Torre B Piso 9

Teléfono: 313 7800 Fax: 312 3600

E-Mail: general@cardenasycardenas.com

IDENTIFICACION

☒ X NIT

☐ NIT

☐ Otro

☐ Otro

Cual
Número 17066629 TP 1250
BTA C.S.J.

④

INVENTOR(ES)
(72)

Nombre:
1. John Rodgers
2. Marco Serra
3. David Swenson
4. Timothy S. Glenn

Dirección:
1. 1904 Winter Drive Roanoke, Texas 76262, Estados Unidos de América
2. Jaegerstrasse 2 Winterthur 8406, Suiza
3. 2601 Beltline Road, Carrollton, Texas 75006, Estados Unidos de América
4. 1904 Winter Drive, Roanoke, Texas 76262, Estados Unidos de América

Nacionalidad o Domicilio:

1. Estadounidense
2. Italiano
3. Estadounidense
4. Estadounidense

⑤ PCT (86)

Solicitud Internacional No. PCT/US10/61104

Fecha 17.12.2010

Publicación Internacional No.

Fecha

⑥

Título(54): **MODELADO DE IMPACTO PRODUCIDO POR LA PERFORACIÓN DE UN POZO**

⑦

Clasificación Internacional (51):

⑧

Prioridad
SI ☒ X NO ☐

(33) País de Origen

(32) Fecha

(31) N° de Solicitud

US

17.12.2010

PCT/US10/61104

⑨

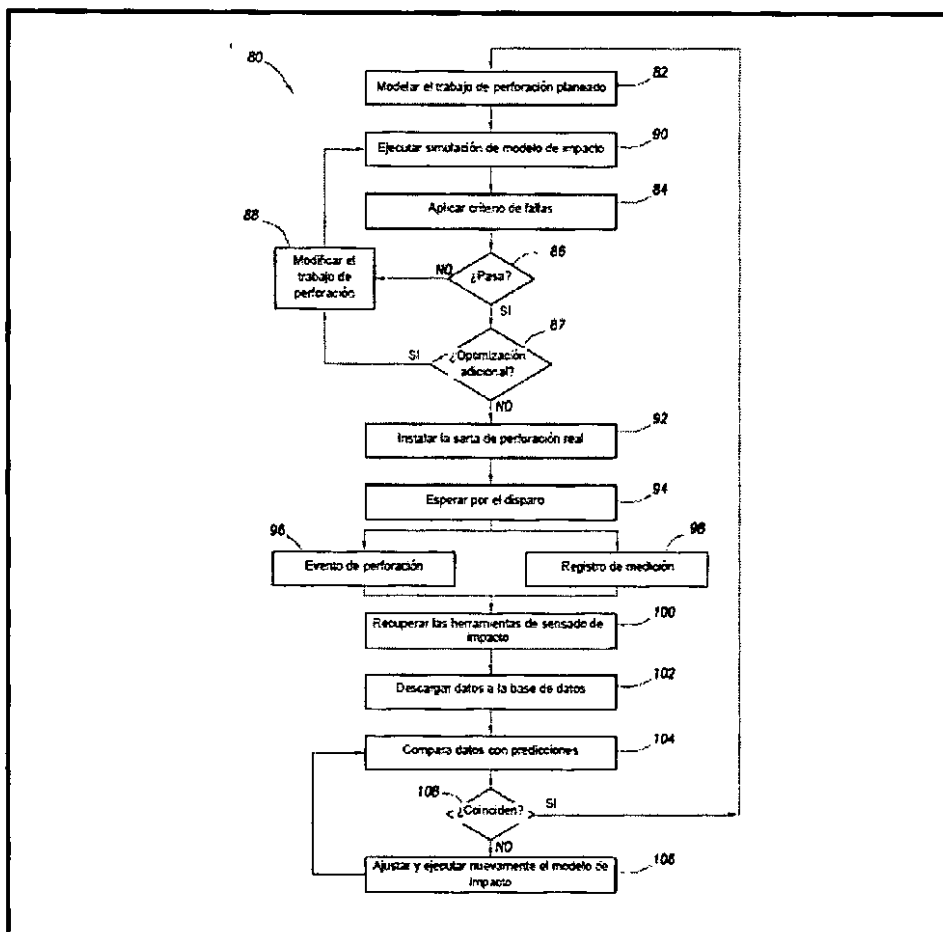
Comprobante de Pago No.: 11-122886

Fecha 19.12.2011

⑩ ANEXOS

- ☒ Comprobante de pago de la tasa de presentación de la solicitud.
- ☐ Documento que acredita la existencia y representación legal cuando el solicitante sea persona jurídica.
- ☒ Poderes, si fuere el caso
- ☒ Documento de cesión del inventor al solicitante o a su causante.
- ☒ Traducción de la solicitud internacional al castellano (Resumen, Resumen, descripción, reivindicaciones, dibujos)
- ☐ Copia del examen preliminar internacional efectuado por la Autoridad Internacional de Examen Preliminar (IPEA)
- ☐ Traducción del examen preliminar internacional efectuado por la IPEA.
- ☐ De ser el caso, copia del contrato de acceso.
- ☐ De ser el caso, documento que acredite la licencia o autorización de uso de conocimientos tradicionales de las comunidades indígenas.
- ☐ De ser el caso, certificado de depósito del material biológico.
- ☐ Arte final 12x12.
- ☐ De ser el caso, información sobre otras solicitudes de patente o títulos obtenidos en el extranjero por el mismo titular o su causante, relacionadas parcial o totalmente con la invención de esta solicitud.
- ☒ Recibo Reivindicaciones adicionales No 11-0099482 /11-0099457
- ☒ Prioridad

11 FIGURA CARACTERISTICA



12

Solicito la Concesión de la patente

NOMBRE: **DARIO CARDENAS NAVAS**

FIRMA:

AG. C.C. 17066629 BTA TP. 1250 CSJ

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO
NIT : 800.176.089-2
- / -

 Industria y Comercio SUPERINTENDENCIA	RECIBO DE CAJA	No. 11 - 122886
		Bogotá D.C., Diciembre 19 de 2011 - 12:22:17

RECIBIDO DE : CARDENAS & CARDENAS ABOGADOS PI LTDA NI 830.083.491

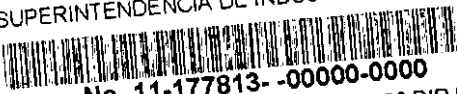
*** Soporte del Pago ***					
TIPO PAGO	BANCO	CUENTA	No. PAGO	FECHA PAGO	VR. PAGO
CONSIGNACION	BANCO DE BOGOTA	062754387	402984842	19/12/2011	10.040.000.00

*** Conceptos Pagados ***			
CANT.	RENTISTICO	CONCEPTO	Vr. UNIDITARIO Vr. CONCEPTO
1	50005-01-01 SOLICITUDES	1 TRAMITES DE SOL. DE PATENTE DE INVENCIÓN	571.000.00 571.000.00
			\$571.000.00

SON: **QUINIENTOS SETENTA Y UN MIL PESOS MONEDA CORRIENTE***

Responsable: 

Recibo de Caja Aplicado al Expediente No. _____

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

No. 11-177813- -00000-0000
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CARDENAS & CARDENAS
ABOGADOS

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO
NIT : 800.176.089-2

	RECIBO DE CAJA	No. 11 - 122887
		Bogotá D.C., Diciembre 19 de 2011 - 12:22:17

RECIBIDO DE : CARDENAS & CARDENAS ABOGADOS PI LTDA NI 830.083.491

*** Soporte del Pago ***					
TIPO PAGO	BANCO	CUENTA	No. PAGO	FECHA PAGO	VR. PAGO
CONSIGNACION	BANCO DE BOGOTA	062754387	402984842	19/12/2011	10.040.000.00

*** Conceptos Pagados ***			
CANT.	RENTISTICO	CONCEPTO	VR. CONCEPTO
1	50005-01-09 OTROS SERVICIOS DE PROPIEDAD INDUSTRIAL	99 OTROS SERVICIOS ADMINISTRATIVOS	405.000.00
			\$405.000.00

SON: **CUATROCIENTOS CINCO MIL PESOS MONEDA CORRIENTE**

Responsable: _____
Recibo de Caja Aplicado al Expediente No. _____

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

No. 11-177813- -00000-0000
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CARDENAS & CARDENAS
ABOGADOS



The State of Texas

Secretary of State

000914

Requested for use in COLOMBIA

Not for use within the United States of America

This Apostille only certifies the signature, the capacity of the signer and the seal or stamp it bears. It does not certify the content of the document for which it was issued.

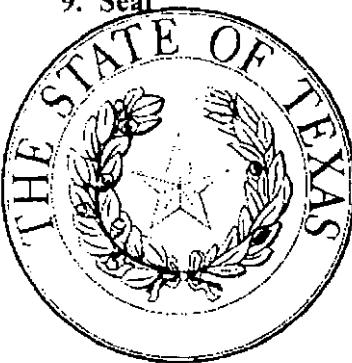
APOSTILLE

(Convention de La Haye du 5 Octobre 1961)

- | | |
|--------------------------------|--|
| 1. Country | United States of America |
| This public document | |
| 2. has been signed by | VALORIE CASEY |
| 3. acting in the capacity of | Notary Public, State of Texas |
| 4. and bears the seal/stamp of | VALORIE CASEY,
Notary Public, State of Texas,
Commission Expires: 10-16-14 |

CERTIFIED

- | | |
|---------------------------------------|--------------------|
| 5. at Austin, Texas | 6. on June 9, 2011 |
| 7. by the Secretary of State of Texas | |
| 8. Certificate No. N-802693 | |
| 9. Seal | 10. Signature: |



Hope Andrade

Hope Andrade
Secretary of State

ST/eg

- Colombia -

POWER OF ATTORNEY

In the city of Houston, Texas on the 31st day of the month of May, two thousand and eleven (2011) before me, Valorie Casey Notary Public, appeared James W. Ferguson of age, and domiciled at Houston, Texas, and stated:

FIRST: That he/she acts in his/her capacity of Senior Vice President & Deputy General Counsel of **HALLIBURTON ENERGY SERVICES, INC.**, legally constituted and in existence in accordance with the laws of the State of Delaware, United States of America and domiciled at 2601 Beltline Road, Carrollton, Texas 75006, United States of America, as evidenced in the documents which I have examined.

SECOND: That in such capacity he/she grants hereby special, ample and sufficient Power of Attorney to DARIO CARDENAS-NAVAS and/or LUZ HELENA ADARVE-GOMEZ and/or EDUARDO CARDENAS-CABALLERO and/or BERNARDO P. CARDENAS-MARTINEZ and/or JUANITA ACOSTA GOMEZ and/or JULY GALINDO QUINTERO, registered lawyers of the firm CARDENAS & CARDENAS-LAWYERS, domiciled at Carrera 7 No. 71-52, Torre B, Piso 9 Bogotá, D.C., Colombia, to carry before the corresponding Colombian national Offices and authorities the proceedings to obtain trademarks, patents, utility models, industrial drawings and designs, deposits of commercial names and ensigns, as well as processing of renewals, assignments, change of name or domicile of the owner, waivers and licenses of the same for which purpose they are empowered to take before said authorities all necessary actions for the indicated purposes; to file applications, statements, claims, formulate descriptions, amendments, oppositions and appeals; pay all taxes and installments and make any other payments determined by law; to receive every document and values issuing the respective discharge; to fulfill any other requirements and take, in general, every measure that they shall deem opportune for the defense and protection of the Industrial Property of the company in the event of infringements, oppositions, proceedings for cancellation or annulment, imposition of fines, passing the antecedents to the courts; they are empowered to appear as plaintiff or defendant before the competent judges, being entitled to transact, submit to arbitration, waive, receive, resign, withdraw, appeal and all other legal powers which may be necessary, and it is hereby declared ever since now valid and good whatever such attorneys do for its benefit, granting them also power to substitute this proxy and if necessary to revoke such substitutions.

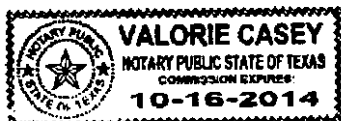
THIRD: That for purposes of articles 597 and 543 of the Colombian code of Commerce the attorneys are empowered to receive service of notice and designate judicial and extrajudicial attorneys.

SIGNED AT Houston, Texas ON May 31, 2011

BY James W. Ferguson

Valorie Casey
NOTARY PUBLIC (Signature)

(Apostille is required)



COPIA D.C.
ESTADO DE TEXAS
16 DIC 2011
ESTADO DE TEXAS
16 DIC 2011
ESTADO DE TEXAS
16 DIC 2011

The undersigned Notary Public certifies that Mr. James W. Ferguson appeared before me and signed the preceding document; that I know him personally and I am certain that he has legal capacity to grant it; that he is Senior Vice President & Deputy General Counsel of **HALLIBURTON ENERGY SERVICES, INC.**, and is consequently authorized to grant such document; that the company is organized under the laws of the State of Delaware, United States of America, and is domiciled 2601 Beltline Road, Carrollton, Texas 75006, United States of America; and that the act for which this document is granted is included among those which constitute the corporate object of said company.

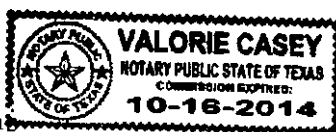
I am certain of all these facts because I have examined the respective documents consisting of certificate of good standing, certificate of incumbency and bylaws of the company all of which I hereby attest.

Valerie Casey

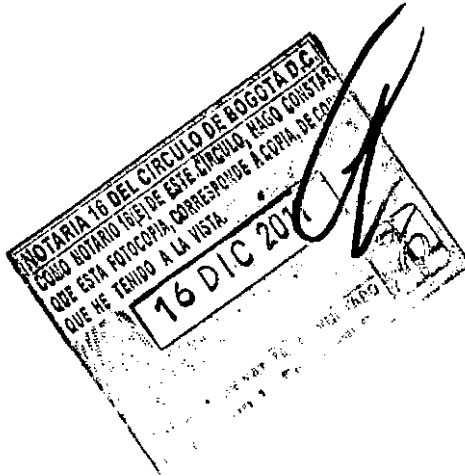
NOTARY PUBLIC (signature)

Issued and signed in Houston, Texas

Dated 5/31/2011



(Apostille is required)



Martha S. Sarmiento S.

MARTHA SOFÍA SARMIENTO SOLANO - TRADUCTORA OFICIAL
Carrera 11D # 124 - 51 Apto. 809 Int. 2 - (571) 2139034 Bogotá - Colombia
E-mail: msarmiento2@yahoo.com

Martha S. Sarmiento S.

Traductora Oficial Juramentada
Resolución No. 835 Minjusticia

TRADUCCIÓN OFICIAL DE LOS SIGUIENTES DOCUMENTOS: APOSTILLA DE LA CONVENCIÓN DE LA HAYA No. N-802693, con fecha del 9 de Junio de 2011, firmada por Hope Andrade - Secretario de Estado. PODER DE ABOGADO otorgado por la Compañía Halliburton Energy Services, Inc., a la Firma de Abogados Cárdenas y Cárdenas, de Bogotá, Colombia, firmado por James W. Ferguson - Vicepresidente Principal y Asesor Legal General Adjunto de dicha compañía, ante Valorie Casey, Notario Público del Estado de Texas, con fecha del 31 de mayo de 2011. CERTIFICACIÓN NOTARIAL expedida y firmada por Valorie Casey, Notario Público del Estado de Texas, con fecha del 31 de mayo de 2011.

Traducción realizada por Martha Sofia Sarmiento Solano, Traductora e intérprete oficial español - inglés - español, nombrada para el cargo mediante Resolución del Ministerio de Justicia, n° 835, del 3 de mayo de 1988.



ESTADO DE TEXAS

SECRETARIO DE ESTADO

Solicitada para uso en COLOMBIA.

No se debe utilizar en los Estados Unidos de América

Esta Apostilla solamente certificar la firma del funcionario, el cargo y el sello o la estampilla que aparecen en el documento. No certifica el contenido del documento para el cual fue emitida.

APOSTILLA

(Convención de La Haya, 5 de octubre de 1961)

País:

Estados Unidos de América

**El presente documento público
ha sido firmado por:**

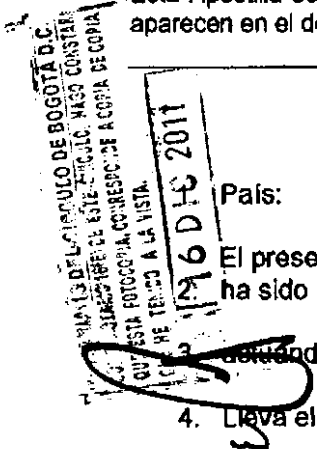
VALORIE CASEY

actuando en calidad de:

Notario Público, Estado de Texas

4. Lleva el sello/ Timbre de:

**VALORIE CASEY
Notario Público, Estado de Texas
Mi Comisión Finaliza el 10-16-14**



MARTHA SOFÍA SARMIENTO SOLANO - TRADUCTORA OFICIAL
Carrera 11D # 124 - 51 Apto. 609 Int. 2 - (571) 2139034 Bogotá - Colombia
E-mail: mssarmiento2@yahoo.com

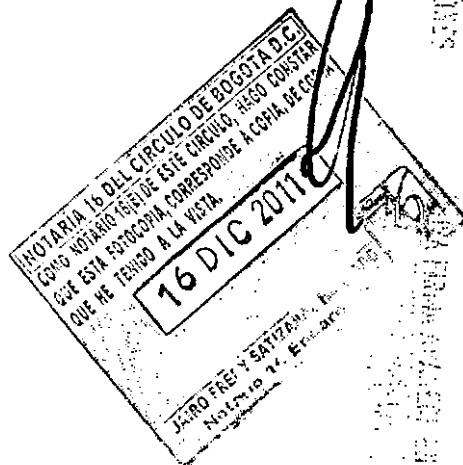
Martha S. Sarmiento S.
Martha S. Sarmiento S.

Traductora Oficial Juramentada
Resolución No. 835 Minjusticia

CERTIFICADO

5. En: **Austin, Texas**
6. El: **9 de junio de 2011**
7. Por: **Secretario de Estado del Estado de Texas**
8. Certificado Número: **N-802693**
9. Lleva Sello /Timbre: **Del Estado de Texas**
10. Firmado por: **Firma Autógrafa
Hope Andrade
Secretario de Estado**

ST/eg



MINISTERIO DE
RELACIONES EXTERIORES
2011 JUL 18 4:00:01
DEPT. DE LEGALIZACIONES
BOGOTA D.C.

6821001
Martha Sarmiento

MARTHA SOFÍA SARMIENTO SOLANO - TRADUCTORA OFICIAL
Carrera 110 # 124 - 51 Apto. 609 Int. 2 - (571) 2139034 Bogotá - Colombia
E-mail: mssarmiento2@yahoo.com

Martha S. Sarmiento
Martha S. Sarmiento S.
Traductora Oficial Jaramentada
Resolución No. 835 Minjusticia

- Colombia -

PODER DE ABOGADO

En la ciudad de Houston, Texas, a los 31 días del mes de mayo del año dos mil once (2011), ante mí, Valorie Casey Notario Público, compareció James W. Ferguson, mayor de edad y con domicilio en Houston, Texas, quien declaró lo siguiente:

PRIMERO: Que él actúa, en su calidad de Vicepresidente Principal y Asesor Legal General Adjunto de **HALLIBURTON ENERGY SERVICES, INC.**, una Compañía legalmente constituida y en existencia de conformidad con las leyes del Estado de Delaware, Estados Unidos de América y cuyo domicilio se encuentra ubicado en el 2601 Beltline Road, Carrollton, Texas 75006, Estados Unidos de América, de acuerdo con lo que se evidencia en los documentos que he examinado.

SEGUNDO: Que haciendo uso de las facultades del cargo arriba mencionado, él/ella otorga Poder de Abogado, especial, amplio y suficiente a **DARÍO CÁRDENAS NAVAS**, y/o a **LUZ HELENA ADARVE GÓMEZ**, y/o a **EDUARDO CÁRDENAS CABALLERO**, y/o a **BERNARDO P. CÁRDENAS MARTÍNEZ**, y/o a **JUANITA ACOSTA GÓMEZ**, y/o a **JULY GALINDO QUINTERO**, abogados registrados, quienes trabajan para la firma **CÁRDENAS & CÁRDENAS ABOGADOS**, con sede en la Carrera 7 No. 71-52, Torre B, Piso 9, en Bogotá, D.C., Colombia, para que gestionen en Colombia ante las Oficinas y Autoridades correspondientes la obtención de registros de marcas comerciales, patentes, modelos de utilidad, diseños y dibujos industriales, depósitos de nombres y enseñas comerciales, como también para el procesamiento de renovaciones, cesiones, cambios de nombre o domicilio del titular, renunciaciones y licencias de lo arriba mencionado, propósitos para los cuales se les otorga poder para que lleven a cabo ante dichas autoridades todas las acciones necesarias para los propósitos indicados, como radicar solicitudes, hacer declaraciones, reclamaciones, formular descripciones, realizar enmiendas o modificaciones, interponer recursos de

Martha S. Sarmiento Solano
Martha S. Sarmiento S.

MARTHA SOFÍA SARMIENTO SOLANO - TRADUCTORA OFICIAL
Carrera 11D # 124 - 51 Apto. 809 Int. 2 - (571) 2139034 Bogotá - Colombia
E-mail: msarmiento2@yahoo.com

Traductora Oficial Juramentada
Resolución No. 835 Minjusticia

oposición y apelaciones; pagar todos los impuestos y cuotas y hacer cualquier otro pago establecido por ley; recibir todos los documentos y dineros y emitir el descargo correspondiente; cumplir con cualquier otro requerimiento y tomar, en general, todas las medidas que consideren apropiadas y oportunas para defender y proteger la Propiedad Industrial de la Compañía en el evento de infracciones, oposiciones, procesos para cancelación o anulación, imposición de sanciones, presentar antecedentes ante las Cortes y Tribunales. Además, quedan facultados para comparecer como demandantes o demandados ante Jueces competentes, también se les da poder para negociar, solicitar arbitraje, ceder, recibir, dimitir, rescindir o desistir, apelar, ratificar y todos los poderes legales adicionales que sean necesarios. También se declara que a partir de ahora todas las acciones que realicen dichos abogados respaldando este Poder de Representación y para beneficio de la Compañía son buenas y válidas. Adicionalmente se les otorga facultades para sustituir este Poder y si es necesario revocar dichas sustituciones.

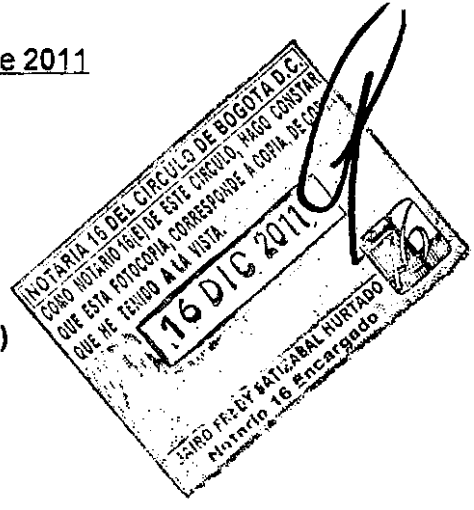
TERCERO: Con el propósito de cumplir con los artículos 597 y 543 del Código Colombiano de Comercio, dichos abogados quedan facultados para recibir notificaciones judiciales y designar abogados judicial y extrajudicialmente.

FIRMADO EN: Houston, Texas El 31 de mayo de 2011

POR: (Firma Autógrafa)
 James W. Ferguson

(Firma Autógrafa)
Notario Público (Firma)

(Requiere de Apostilla)



NOTARIO PÚBLICO ESTADO DE TEXAS	VALORIE CASEY NOTARIO PÚBLICO ESTADO DE TEXAS MI COMISIÓN FINALIZA EL 10-16-2014
------------------------------------	--

MARTHA SOFÍA SARMIENTO SOLANO - TRADUCTORA OFICIAL
Carrera 11D # 124 - 51 Apto. 609 Int. 2 - (571) 2139034 Bogotá - Colombia
E-mail: mssarmiento2@yahoo.com

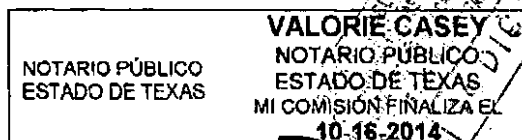
El suscrito Notario Público, certifica que el Señor James W. Ferguson, compareció ante mí y firmó el documento anterior; que lo conozco personalmente y estoy seguro que él tiene la facultad legal para otorgarlo; que él es el Vicepresidente Principal y Asesor Legal General Adjunto de **HALLIBURTON ENERGY SERVICES, INC.**, y por consiguiente está autorizado para expedir y otorgar dicho documento. Que la Compañía está organizada bajo las leyes de Delaware y su domicilio es el 2601 Beltline Road, Carrollton, Texas 75006, Estados Unidos de América. Además certifico que el acto para el cual se expide y otorga este documento está incluido entre los que constituyen el objeto corporativo de la mencionada Compañía.

Tengo la certeza sobre la veracidad de todos estos hechos debido a que examiné los documentos respectivos, que consistieron en el Certificado de Buen Estatus, el Certificado de Responsabilidad y los Estatutos de la Compañía. Doy testimonio de todo lo anterior.

Firma Autógrafa
Notario Público (Firma)

Expedida y firmada en Houston, Texas
Fechada el 5/31/2011

Sello del Notario:



(Requiere de Apostilla)

CERTIFICO QUE ESTA ES UNA TRADUCCIÓN FIEL DEL INGLÉS AL ESPAÑOL DE LOS DOCUMENTOS QUE HE TENIDO A LA VISTA; QUE SOY TRADUCTORA E INTERPRETE OFICIAL ACREDITADA POR RESOLUCIÓN N° 835 DEL 3 DE MAYO DE 1988 DEL MINISTERIO DE JUSTICIA Y QUE ESTOY REGISTRADA ANTE EL MINISTERIO DE RELACIONES EXTERIORES DE COLOMBIA.

Bogotá, 14 de Julio de 2011

Martha S. Sarmiento Solano
Martha S. Sarmiento Solano

Traductora Oficial Juramentada
Resolución No. 835 Minjusticia

APOSTILLE

(Convention de La Haye du 5 octobre 1961)

1 Country: United States of America

This public document

2. has been signed by N. Williams

3. acting in the capacity of Certifying Officer

4. bears the seal/stamp of US Patent and Trademark Office

Certified

5. at Washington, D.C.

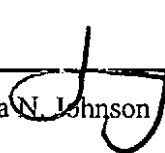
6. the seventeenth of November, 2011

7. by Assistant Authentication Officer, United States Department of State

8. No. 12005861-3

9 Seal/Stamp.

10. Signature:


Sonya N. Johnson

A 7323407



THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

November 07, 2011

THIS IS TO CERTIFY THAT ANNEXED IS A TRUE COPY FROM THE
RECORDS OF THIS OFFICE OF A DOCUMENT RECORDED ON
JANUARY 28, 2011.

By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office


N. WILLIAMS

Certifying Officer



PATENT ASSIGNMENT

Electronic Version v1.1
Stylesheet Version v1.1

SUBMISSION TYPE:	NEW ASSIGNMENT										
NATURE OF CONVEYANCE:	ASSIGNMENT										
CONVEYING PARTY DATA											
<table border="1"><thead><tr><th>Name</th><th>Execution Date</th></tr></thead><tbody><tr><td>John RODGERS</td><td>12/30/2010</td></tr><tr><td>Marco SERRA</td><td>01/14/2011</td></tr><tr><td>David SWENSON</td><td>01/05/2011</td></tr><tr><td>Timothy S. GLENN</td><td>01/10/2011</td></tr></tbody></table>		Name	Execution Date	John RODGERS	12/30/2010	Marco SERRA	01/14/2011	David SWENSON	01/05/2011	Timothy S. GLENN	01/10/2011
Name	Execution Date										
John RODGERS	12/30/2010										
Marco SERRA	01/14/2011										
David SWENSON	01/05/2011										
Timothy S. GLENN	01/10/2011										
RECEIVING PARTY DATA											
<table border="1"><tr><td>Name:</td><td>Halliburton Energy Services, Inc.</td></tr><tr><td>Street Address:</td><td>10200 Bellaire Boulevard</td></tr><tr><td>City:</td><td>Houston</td></tr><tr><td>State/Country:</td><td>TEXAS</td></tr><tr><td>Postal Code:</td><td>77072</td></tr></table>		Name:	Halliburton Energy Services, Inc.	Street Address:	10200 Bellaire Boulevard	City:	Houston	State/Country:	TEXAS	Postal Code:	77072
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PROPERTY NUMBERS Total: 1											
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PCT Number:	US1061104										
CORRESPONDENCE DATA											
Fax Number: (972)516-0608 <i>Correspondence will be sent via US Mail when the fax attempt is unsuccessful.</i>											
Phone: 972-516-0030											
Email: mail@smithipservices.com											
Correspondent Name: SMITH IP SERVICES, P.C.											
Address Line 1: P.O. Box 997											
Address Line 4: Rockwall, TEXAS 75087											
ATTORNEY DOCKET NUMBER:	10-031572U1										
NAME OF SUBMITTER:	Sally Ann Smith										
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PATENT
REEL: 025714 FRAME: 0919

PCT Application
10-031572U1

ASSIGNMENT

In consideration of one dollar (\$1.00), and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, we the undersigned, **John RODGERS, Marco SERRA, David SWENSON, and Timothy S. GLENN** having made an invention in a **"MODELING SHOCK PRODUCED BY WELL PERFORATING"** while in the employ of **HALLIBURTON ENERGY SERVICES, INC.**, a corporation organized and existing under the laws of the State of Delaware, doing business at 10200 Bellaire Boulevard, Houston, Texas 77072, (sometimes hereinafter called **"ASSIGNEE"**), do hereby ASSIGN, SELL and CONVEY to said ASSIGNEE, its successors and assigns, the entire right, title and interest throughout the world in and to:

1. Said invention in a **"MODELING SHOCK PRODUCED BY WELL PERFORATING"**;

2. International Application on said invention, Agent File Reference No. **10-031572U1**, Serial No. **PCT/US10/61104** filed **December 17, 2010**, entitled **"MODELING SHOCK PRODUCED BY WELL PERFORATING"**;

3. All applications for patent or like protection on said invention that have now been or may in the future be made by us or our legal representatives, whether in the United States of America or any other place anywhere in the world;

4. All patents and like protection that have now been or may in the future be granted on said invention to us or our legal representatives, whether in the United States of America or in any other country or place anywhere in the world;

5. All substitutions for and divisions, continuations, continuations-in-part, renewals, reissues, extensions, and the like of said applications and patents and like grants, including without limitations, those obtained or permissible under past, present and future law and statutes;

6. All rights of action on account of past, present and future unauthorized use of said invention for infringement of said patents and like protection;

7. The right to ASSIGNEE to file in its name applications for patents and like protection for said invention in any country or countries foreign to the United States; and

8. All international rights of priority associated with said invention, applications, patents and like protection; and we covenant that we, our heirs, legal representatives, assigns, administrators, and executors will at the

PATENT
REEL: 025714 FRAME: 0920

21

expense of ASSIGNEE, its successors and assigns, execute all papers and perform such other acts as may be reasonably necessary to give ASSIGNEE, its successors and assigns, the full benefit of this Assignment.

EXECUTED at TARRANT County, Texas, on the 30 day
of December, 2011. 2010

John P. Rodgers
John RODGERS

STATE OF Texas §
COUNTY OF TARRANT §

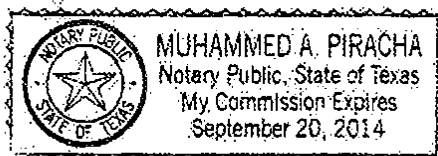
BEFORE ME, the undersigned authority, on this day personally appeared John RODGERS known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he executed the same for the purposes and consideration therein expressed.

GIVEN UNDER MY HAND AND SEAL OF OFFICE, this the
30 day of December, 2011. 2010

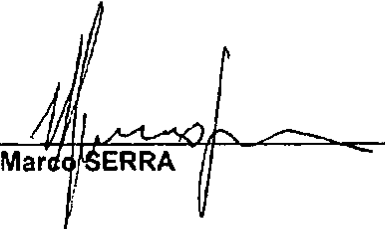
Muhammed A. Piracha
Notary Public

[SEAL]

My Commission Expires:



EXECUTED at WINTERTHUR, Switzerland, on the 14th day of
JANUARY, 2011.


Marco SERRA

ACKNOWLEDGEMENT

BEFORE ME, the undersigned witness, on this day personally
appeared **Marco SERRA**, known to me to be the person whose name is
subscribed to the foregoing instrument, and acknowledged to me that he
executed the same for the purposes and consideration therein expressed, on
this 14th day of JANUARY, 2011.

K. Detener
Witness Signature
KAI DETENER
Witness Name
Edi Meier + Partner AG
Geophysik + Geotechnik
Jägerstrasse 2
8406 Winterthur
Witness Address

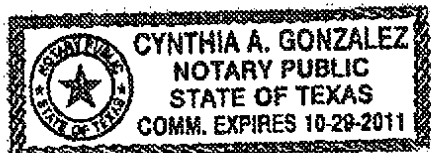
EXECUTED at Dallas County, Texas, on the 5th day
of January, 2011.

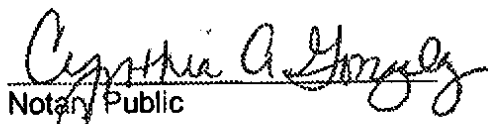

David SWENSON

STATE OF Texas §
COUNTY OF Dallas §

BEFORE ME, the undersigned authority, on this day personally
appeared **David SWENSON** known to me to be the person whose name is
subscribed to the foregoing instrument, and acknowledged to me that he
executed the same for the purposes and consideration therein expressed.

GIVEN UNDER MY HAND AND SEAL OF OFFICE, this the
5th day of January, 2011.




Notary Public

[SEAL]

My Commission Expires: 10-29-2011

PATENT
REEL: 025714 FRAME: 0923

EXECUTED at Middlesex County, ^{TSG}~~Texas~~^{Massachusetts}, on the 10th day of January, 2011.

Timothy S. Glenn
Timothy S. GLENN

STATE OF Massachusetts §
COUNTY OF Middlesex §

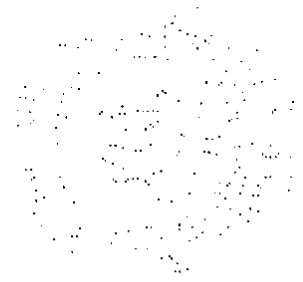
BEFORE ME, the undersigned authority, on this day personally appeared **Timothy S. GLENN** known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he executed the same for the purposes and consideration therein expressed.

GIVEN UNDER MY HAND AND SEAL OF OFFICE, this the 10th day of January, 2011.

Albert A. Ray
Notary Public

[SEAL]

My Commission Expires: 8/11/11



MODELADO DE IMPACTO PRODUCIDO POR LA PERFORACIÓN DE UN POZO

5

CAMPO TÉCNICO

La presente descripción se refiere generalmente a un equipo utilizado y a las operaciones llevadas a cabo junto con un pozo subterráneo y, una modalidad descrita en la presente, más particularmente se proporciona para modelar el
10 impacto producido por la perforación de un pozo.

ANTECEDENTES

Se han intentado modelar los efectos del impacto debido a la perforación. Sería deseable ser capaz de predecir el
15 impacto debido a la perforación, por ejemplo, para evitar el desmontaje de un obturador de producción, para evitar fallas de un cuerpo de cañón de punzado, y para evitar además o al menos reducir, los daños a varios componentes de una sarta de perforación.

Desafortunadamente, los modelos de impacto anteriores no han sido capaces de predecir los efectos de impacto en las direcciones torsional, axial y de flexión, y aplicar estos efectos de impacto a tres estructuras dimensionales, prediciendo de esta manera el esfuerzo particular de los
20 componentes de la sarta de perforación. Un impedimento para el desarrollo de tal modelo de impacto ha sido la carencia de mediciones satisfactorias de las tensiones, cargas, esfuerzos, presiones, y/o aceleraciones, etc., producidas por la perforación. Tales mediciones pueden ser útiles para
25 verificar un modelo de impacto y perfeccionar su salida.
30

Por consiguiente, se apreciará que se necesitan mejoras en la materia. Estas mejoras se pueden usar, por ejemplo, para diseñar nuevos componentes de la sarta de perforación los cuales se configuran apropiadamente para las condiciones que experimentarán en las situaciones de perforación reales, y para evitar daños a cualquier equipo.

SUMARIO

Para llevar a cabo los principios de la presente descripción, se proporciona un método el cual trae mejoras en la materia de predecir el impacto producido por la perforación de un pozo. Un ejemplo se describe a continuación en el cual el método se usa para ajustar las predicciones hechas por un modelo de impacto, para hacer las predicciones más precisas. Otro ejemplo se describe a continuación en el cual el modelo de impacto se usa para optimizar un diseño de una sarta de perforación.

Un método para utilizar un modelo de impacto para la predicción de los efectos de perforación se proporciona mediante la descripción siguiente. En un ejemplo, el método puede incluir registrar las mediciones de los efectos de perforación en una sarta de perforación real en un agujero de pozo; ajustar el modelo de impacto de manera que las predicciones de la salida de los efectos de perforación del modelo de impacto coincidan sustancialmente con las mediciones de los efectos de perforación; y provocar que el modelo de impacto ajustado prediga los efectos de perforación para una sarta de perforación propuesta.

A continuación también se describe un método de predicción de los efectos de perforación en una sarta de perforación en un agujero de pozo. El método puede incluir entrar un modelo de pozo tridimensional y un modelo tridimensional de la sarta de perforación en un modelo de

impacto; y provocar que el modelo de impacto prediga los efectos de perforación en la sarta de perforación.

Estas y otras características, ventajas y beneficios serán evidentes para un experto en la materia después de una cuidadosa consideración de la descripción detallada de
 5 de las modalidades representativas descritas aquí y los dibujos acompañantes, en los cuales se indican los elementos similares en las figuras usando los mismos números de referencia.

10

BREVE DESCRIPCIÓN DE LOS DIBUJOS

La FIG. 1 es una vista en sección transversal esquemática parcial de un sistema de pozo y método asociado que incorpora principios de la presente descripción.

15 Las FIGS. 2-5 son vistas esquemáticas de una herramienta de sensado de impacto la cual se puede usar en el sistema y método de la FIG. 1.

Las FIGS. 6-8 son vistas esquemáticas de otra configuración de la herramienta de sensado de impacto.

20 La FIG. 9 es un diagrama de flujo esquemático para el método.

La FIG. 10 es un diagrama de bloques esquemático de un modelo de impacto, junto con sus entradas y salidas.

25

DESCRIPCIÓN DETALLADA

En la FIG. 1 se ilustra representativamente un sistema de pozo 10 y un método asociado el cual puede incorporar los principios de la presente descripción. En el sistema de pozo 10, una sarta de perforación 12 se instala en un agujero de
 30 pozo 14. La sarta de perforación representada 12 incluye un

obturador 16, una cabeza de detonación 18, cañones de punzado 20 y las herramientas de sensado de impacto 22.

En otros ejemplos, la sarta de perforación 12 puede incluir más o menos de estos componentes. Por ejemplo, se
5 pueden proporcionar el equipo de filtros de pozo y/o empaquetadura de grava, se pueden proporcionar cualquier número (incluyendo uno) de los cañones de punzado 20 y las herramientas de sensado de impacto 22, etc. Por lo tanto, se debe entender claramente que el sistema de pozo 10 como se
10 describe en la FIG. 1 es meramente un ejemplo de una amplia variedad de posibles sistemas de pozo los cuales pueden incorporar los principios de esta descripción.

Un modelo de impacto puede usar un modelo tridimensional de la sarta de perforación 12 y del agujero
15 de pozo 14 para modelar de manera real el comportamiento físico del sistema 10 durante un evento de perforación. Preferiblemente, el modelo de impacto predecirá al menos la carga axial, torsional y de flexión, así como también el movimiento en todas las direcciones (movimiento
20 tridimensional). El modelo puede incluir predicciones de fricción y contacto con la carcasa, y las cargas que resulten de esto.

En un ejemplo preferido, los modelos de los elementos finitos detallados de los componentes de la sarta de
25 perforación 12 permiten una predicción de mayor fidelidad de los esfuerzos en los componentes. Las dinámicas de presiones del agujero de pozo y la comunicación con una formación también se pueden incorporar en el modelo.

El modelo de impacto se calibra preferiblemente usando
30 las aceleraciones y cargas de la sarta de perforación real, así como también las presiones del agujero de pozo, recogidas de una o más de las herramientas de sensado de impacto 22. Las mediciones tomadas mediante las herramientas

de sensado de impacto 22 se pueden usar para verificar las predicciones hechas por el modelo de impacto, y para hacer ajustes al modelo de impacto, de manera que las predicciones futuras sean más exactas.

5 La herramienta de sensado de impacto 22 puede ser como se describe en la solicitud de patente internacional titulada, "Sensado de impacto durante la perforación de un pozo," presentada en la misma fecha que la presente. Esa solicitud de patente describe que las herramientas de
10 sensado de impacto 22 se pueden interconectar en varias localizaciones a lo largo de la sarta de perforación 12.

 Una ventaja de interconectar las herramientas de sensado de impacto 22 debajo del obturador 16 y en proximidad cercana a los cañones de punzado 20 es que se
15 pueden obtener mediciones más exactas de tensión y aceleración en los cañones de punzado. Los sensores de presión y temperatura de las herramientas de sensado de impacto 22 también pueden sensar las condiciones en el agujero de pozo 14 en proximidad cercana a las perforaciones
20 24 inmediatamente después de que las perforaciones se forman, facilitando de esta manera un análisis más exacto de las características de una formación de tierra 26 penetrada por las perforaciones.

 Una herramienta de sensado de impacto 22 interconectada
25 entre el obturador 16 y el cañón de punzado superior 20 puede registrar los efectos de la perforación en la sarta de perforación 12 por encima de los cañones de punzado. Esta información puede ser útil para evitar el desmontaje u otros daños al obturador 16, la cabeza de detonación 18, etc.,
30 debido a la detonación de los cañones de punzado 20 en diseños futuros.

 Una herramienta de sensado de impacto 22 interconectada entre los cañones de punzado 20 puede registrar los efectos

de perforación en los mismos cañones de punzado. Esta información puede ser útil para evitar daños a los componentes de los cañones de punzado 20 en diseños futuros.

Una herramienta de sensado de impacto 22 se puede
5 conectar por debajo del cañón de punzado inferior 20, si se desea, para registrar los efectos de perforación en esta localización. En otros ejemplos, la sarta de perforación 12 se podría punzar en una sarta de completamiento inferior, conectada a un tapón puente o obturador en el extremo
10 inferior de la sarta de perforación, etc., en cuyo caso la información registrada por la herramienta de sensado de impacto inferior 22 podría ser útil para evitar daños a estos componentes en diseños futuros.

Visto como un sistema completo, la colocación de las
15 herramientas de sensado de impacto 22 separada longitudinalmente a lo largo de la sarta de perforación 12 permite la adquisición de datos en varios puntos en el sistema, lo cual puede ser útil para validar un modelo del sistema. Por lo tanto, recoger datos por encima, entre y por
20 debajo de los cañones, por ejemplo, puede ayudar a entender el evento de perforación global y sus efectos sobre el sistema como un todo.

La información obtenida por las herramientas de sensado de impacto 22 no solamente es útil para diseños futuros,
25 sino que también puede ser útil para diseños actuales, por ejemplo, en análisis post trabajo, pruebas de formación, etc. Las aplicaciones de la información obtenida por las herramientas de sensado de impacto 22 no se limitan para nada a los ejemplos específicos descritos en la presente.

30 Con referencia adicional ahora a las FIGS. 2-5, un ejemplo de la herramienta de sensado de impacto 22 se ilustra de manera representativa. Como se describe en la FIG. 2, la herramienta de sensado de impacto 22 se

proporciona con los conectores de extremo 28 (tales como, conectores de cañón de punzado, etc.) para interconectar la herramienta en la sarta de perforación 12 en el sistema de pozo 10. Sin embargo, otro tipo de conectores se puede usar, y la herramienta 22 se puede usar en otras sarts de perforación y en otros sistemas de pozo, manteniendo los principios de esta descripción.

En la FIG. 3, una vista en sección transversal de la herramienta de sensado de impacto 22 se ilustra de manera representativa. En esta vista, se puede observar que la herramienta 22 incluye una variedad de sensores, y un tren de detonación 30 el cual se extiende a través del interior de la herramienta.

El tren de detonación 30 puede transferir la detonación entre los cañones de punzado 20, entre una cabeza de detonación (no mostrada) y un cañón de punzado, y/o entre cualquiera otros componentes explosivos en la sarta de perforación 12. En el ejemplo de las FIGS. 2-5, el tren de detonación 30 incluye un cordón de detonación 32 y los detonadores de explosivos 34, pero otros componentes se pueden usar, si se desea.

Uno o más sensores de presión 36 se pueden usar para sensar la presión en los cañones de punzado, las cabezas de detonación, etc., unidos a los conectores 28. Tales sensores de presión 36 se refuerzan preferiblemente (por ejemplo, para resistir aproximadamente 20000 g de aceleración) y tienen capacidad de ancho de banda alto (por ejemplo, >20 kHz). Los sensores de presión 36 son preferiblemente capaces de sensar hasta aproximadamente 60 ksi (aproximadamente 414 MPa) y resistir aproximadamente 175 grados C. Por supuesto, los sensores de presión que tienen otras especificaciones se pueden usar, si se desea.

Los sensores de tensión 38 se unen a una superficie interior de una estructura generalmente tubular 40 interconectada entre los conectores 28. La estructura 40 se equilibra preferiblemente en cuanto a la presión, es decir, sustancialmente sin que se apliquen un diferencial de presión a través de la estructura.

En particular, los puertos 42 se proporcionan para igualar la presión entre un interior y un exterior de la estructura 40. Igualando la presión a través de la estructura 40, las mediciones del sensor de tensión 38 no son influenciadas por ninguna presión diferencial a través de la estructura antes, durante o después de la detonación de los cañones de punzado 20.

Los sensores de tensión 38 son preferiblemente de calibres de tensión tipo alambre de resistencia, aunque otros tipos de sensores de tensión (por ejemplo, piezoeléctricos, piezorresistivos, fibra óptica, etc.) se pueden usar, si se desea. En este ejemplo, los sensores de tensión 38 se montan en una banda (tales como una banda KAPTON(TM)) para un alineamiento preciso, y luego se adhieren al interior de la estructura 40.

Preferiblemente, cuatro puentes de Wheatstone completos se usan, con sensores de tensión que se oponen orientados a 0 y 90 grados que se usan para sensar la tensión de flexión y axial, y calibres de +/- 45 grados que se usan para sensar la tensión torsional.

Los sensores de tensión 38 se pueden hacer de un material (tal como una aleación de KARMA(TM)) el cual proporciona compensación térmica, y permite el funcionamiento hasta aproximadamente 150 grados C. Por supuesto, cualquier tipo o número de sensores de tensión se puede usar manteniendo los principios de esta descripción.

Los sensores de tensión 38 se usan preferiblemente de manera similar a la de una celda de carga o sensor de carga. Un objetivo es tener todas las cargas en la sarta de perforación 12 pasando a través de la estructura 40 las cual
5 se instrumenta con los sensores 38.

Tener la presión de fluido de la estructura 40 equilibrada permite que las cargas (por ejemplo, axial, de flexión y torsional) se midan mediante los sensores 38, sin la influencia de un diferencial de presión a través de la
10 estructura. Además, el cordón de detonación 32 se aloja en un tubo 33 que no está asegurado de manera rígida en uno o ambos de sus extremos, de manera que no puede compartir la carga con, o impartir ninguna carga a, la estructura 40.

Un sensor de temperatura 44 (tales como un termistor, termopar, etc.) se puede usar para monitorear la temperatura exterior a la herramienta. Las mediciones de temperatura pueden ser útiles para evaluar las características de la formación 26, y cualquier fluido producido de la formación, seguido inmediatamente de la detonación de los cañones de
15 punzado 20. Preferiblemente, el sensor de temperatura 44 es capaz de hacer mediciones exactas de alta resolución de temperaturas hasta aproximadamente 170 grados C.

Otro sensor de temperatura (no mostrado) se puede incluir con un paquete electrónico 46 posicionado en una
25 cámara aislada 48 de la herramienta 22. De esta manera, la temperatura dentro de la herramienta 22 se puede monitorear, por ejemplo, para propósitos de diagnóstico o para compensación térmica de otros sensores (por ejemplo, para corregir errores en el desempeño de sensores relacionados
30 con los cambios de temperatura). Tal sensor de temperatura en la cámara 48 no necesariamente necesita la capacidad o sensibilidad de alta resolución para rastrear rápidamente

los cambios de temperatura en el fluido del agujero de pozo del otro sensor de temperatura 44.

El paquete electrónico 46 se conecta a al menos los sensores de tensión 38 mediante conectores de panel o alimentación pasante aisladores de presión 50. Conectores similares se pueden usar para conectar otros sensores al paquete electrónico 46. Las baterías 52 y/u otra fuente de energía se puede usar para proporcionar energía eléctrica al paquete electrónico 46.

El paquete electrónico 46 y las baterías 52 preferiblemente se refuerzan y se montan para impacto de manera que les permite resistir las cargas de impacto con hasta aproximadamente 10000 g de aceleración. Por ejemplo, el paquete electrónico 46 y las baterías 52 se pueden acomodar después del ensamble, etc.

En la FIG. 4 se puede observar que cuatro de los conectores 50 se instalan en un conector 54 en un extremo de la estructura 40. Además, un sensor de presión 56, un sensor de temperatura 58 y un acelerómetro 60 se montan preferiblemente en el conector 54.

El sensor de presión 56 se usa para monitorear la presión exterior a la herramienta 22, por ejemplo, en un anillo 62 formado radialmente entre la sarta de perforación 12 y el agujero de pozo 14 (ver la FIG. 1). El sensor de presión 56 puede ser similar a los sensores de presión 36 descritos anteriormente. Un transductor de presión adecuado es el Kulite modelo HKM-15-500.

El sensor de temperatura 58 se puede usar para monitorear la temperatura dentro de la herramienta 22. Este sensor de temperatura 58 se puede usar en lugar de, o además de, el sensor de temperatura descrito anteriormente incluyéndose en el paquete electrónico 46.

El acelerómetro 60 es preferiblemente un acelerómetro tipo piezorresistivo, aunque otros tipos de acelerómetros se pueden usar, si se desea. Los acelerómetros adecuados están disponibles de Endevco y PCB (tal como la serie PCB 3501A, el cual está disponible en paquetes de eje simple o triaxiales, capaces de sensar hasta aproximadamente 60000 g de aceleración).

En la FIG. 5, otra vista en sección transversal de la herramienta 22 se ilustra de manera representativa. En esta vista, la manera en la cual el transductor de presión 56 se lleva al exterior de la herramienta 22 se puede observar claramente. Preferiblemente, el transductor de presión 56 está cercano a una superficie exterior de la herramienta, de manera que se evita la distorsión de la presión medida que resulta de las ondas transmisión de presión a través de un conducto largo y estrecho.

También se observa en la FIG. 5 un conector de puerto lateral 64 el cual se puede usar para la comunicación con el paquete electrónico 46 después del ensamble. Por ejemplo, una computadora se puede conectar al conector 64 para energizar el paquete electrónico 46, extraer las mediciones del sensor registradas del paquete electrónico, programar el paquete electrónico para responder a una señal particular o para "despertar" después de un tiempo seleccionado, comunicándose con, o intercambiando datos con el paquete electrónico, etc.

Note que esto puede tomar varias horas o incluso días entre el ensamble de la herramienta 22 y la detonación de los cañones de punzado 20. Para conservar la energía de la batería, el paquete electrónico 46 se programa preferiblemente para "dormir" (es decir, mantener un estado de uso de bajo consumo), hasta que una señal particular se

recibe, o hasta que un período de tiempo particular transcurre.

La señal la cual "despierta" el paquete electrónico 46 pudiera ser cualquier tipo de señal de presión, temperatura, acústica, electromagnética u otra señal la cual se pueda detectar por uno o más de los sensores 36, 38, 44, 56, 58, 60. Por ejemplo, el sensor de presión 56 pudiera detectar cuando un cierto nivel de presión se ha alcanzado o aplicado exterior a la herramienta 22, o cuando series particulares de niveles de presión se han aplicado, etc. En respuesta a la señal, el paquete electrónico 46 se puede activar a una frecuencia de registro de medición más alta, las mediciones de sensores adicionales se pueden registrar, etc.

Como otro ejemplo, el sensor de temperatura 58 pudiera sensar una temperatura elevada que resulta de la instalación de la herramienta 22 en el agujero de pozo 14. En respuesta a esta detección de temperatura elevada, el paquete electrónico 46 pudiera "despertar" para registrar las mediciones de más sensores y/o mediciones de sensores de frecuencia más alta.

Como aún otro ejemplo, los sensores de tensión 38 pudieran detectar un patrón predeterminado de manipulaciones de la sarta de perforación 12 (tales como manipulaciones particulares usadas para ajustar el obturador 16). En respuesta a esta detección de manipulaciones de tubería, el paquete electrónico 46 pudiera "despertar" para registrar las mediciones de más sensores y/o mediciones de sensores de frecuencia más alta.

El paquete electrónico 46 representado en la FIG. 3 preferiblemente incluye una memoria no volátil 66 de manera que, incluso si la energía eléctrica no está disponible por mucho tiempo (por ejemplo, las baterías 52 se descargan), las mediciones del sensor anteriormente registradas aún se

pueden descargar cuando la herramienta 22 se recupera más tarde del pozo. La memoria no volátil 66 puede ser cualquier tipo de memoria la cual mantenga almacenada la información cuando se desenergice. Esta memoria 66 pudiera ser una
 5 memoria de solo lectura programable que se puede borrar eléctricamente, memoria flash, o cualquier otro tipo de memoria no volátil. El paquete electrónico 46 es preferiblemente capaz de recoger y almacenar datos en la memoria 66 a un >rango de muestreo de 100 kHz.

10 Con referencia adicional ahora a las FIGS. 6-8, otra configuración de la herramienta de sensado de impacto 22 se ilustra de manera representativa. En esta configuración, un conducto de flujo 68 (ver la FIG. 7) se extiende longitudinalmente a través de la herramienta 22. Por lo
 15 tanto, la herramienta 22 puede ser especialmente útil para la interconexión entre el obturador 16 y el cañón de punzado superior 20, aunque la herramienta 22 se pudiera usar en otras posiciones y en otros sistemas de pozo manteniendo los principios de esta descripción.

20 En la FIG. 6 se puede observar que una cubierta removible 70 se usa para alojar el paquete electrónico 46, las baterías 52, etc. en la FIG. 8, la cubierta 70 se remueve, y se puede observar que el sensor de temperatura 58 se incluye con el paquete electrónico 46 en este ejemplo. El
 25 acelerómetro 60 pudiera ser parte también del paquete electrónico 46, o pudiera localizarse en la cámara 48 debajo de la cubierta 70.

Un manguito protector relativamente delgado 72 se usa para evitar daños a los sensores de tensión 38, los cuales
 30 se unen a un exterior de la estructura 40 (ver la FIG. 8, de la cual el manguito se remueve, de manera que los sensores de tensión estén visibles). Aunque en este ejemplo la estructura 40 no está equilibrada en cuanto a la presión,

otro sensor de presión 74 (ver la FIG. 7) se puede usar para monitorear la presión en el conducto 68, de manera que cualquier contribución del diferencial de presión a través de la estructura 40 a la tensión sensada por los sensores de tensión 38 se puede determinar rápidamente (por ejemplo, la tensión efectiva debido a que el diferencial de presión a través de la estructura 40 se resta de la tensión medida, para producir la tensión relacionada solamente con la carga estructural).

10 Note que preferiblemente no existe un diferencial de presión a través del manguito 72, y una sustancia adecuada (tal como aceite de silicona, etc.) se usa preferiblemente para rellenar el espacio anular entre el manguito y la estructura 40. El manguito 72 no se asegura de manera rígida en uno o ambos de sus extremos, de manera que no comparte 15 carga con, o imparte carga a, la estructura 40.

Cualquiera de los sensores descritos anteriormente para su uso con la configuración de la herramienta 22 de las FIGS. 2-5 se pueden usar con la configuración de la 20 herramienta de las FIGS. 6-8.

En general, es preferible para la estructura 40 (en la cual la carga se mide mediante los sensores de tensión 38) experimentar carga dinámica debido solamente al impacto estructural estando balanceada en cuanto a la presión, con la configuración de las FIGS. 2-5. Sin embargo, otras 25 configuraciones son posibles en las cuales esta condición se puede satisfacer. Por ejemplo, un par de manguitos para aislar la presión se pudiera usar, uno exterior a, y el otro interno a, la estructura que porta la carga 40 de la configuración de las FIGS. 6-8. Los manguitos pudieran 30 encapsular aire a presión atmosférica a ambos lados de la estructura 40, para aislar de manera efectiva la estructura de los efectos de carga de la presión diferencial. Los

manguitos deben ser lo suficientemente fuertes para resistir la presión en el pozo, y se puede sellar con anillos O u otros sellos en ambos extremos. Los manguitos se pueden conectar estructuralmente a la herramienta en no más de un extremo, de manera que se evita una trayectoria de carga secundaria alrededor de los sensores de tensión 38.

Aunque la sarta de perforación 12 descrita anteriormente es del tipo usada en perforación con tubería, se debe entender claramente que los principios de esta descripción no se limitan a la perforación con tubería. Otros tipos de perforación (tales como, perforación con tubo arrollado, con cable o alambre, etc.) pueden incorporar los principios descritos en la presente. Note que el obturador 16 no necesariamente es parte de la sarta de perforación 12.

Con las mediciones obtenidas mediante el uso de las herramientas de sensado de impacto 22, un modelo de impacto se puede calibrar de manera precisa, de manera que se pueda aplicar a diseños propuestos de sistemas de perforación, para mejorar estos diseños (por ejemplo, evitando fallas de, o daños a, cualquiera de los componentes del sistema de perforación, etc.), para optimizar los diseños en términos de desempeño, eficiencia, efectividad, etc., y/o para generar diseños optimizados.

En la FIG. 9, un diagrama de flujo para el método 80 se ilustra de manera representativa. El método 80 representado en forma de diagrama de flujo en la FIG. 9 se puede usar con el sistema 10 descrito anteriormente, o se puede usar con una variedad de otros sistemas.

En la etapa 82, se modela un trabajo de perforación planeado o propuesto. Preferiblemente, al menos la sarta de perforación 12 y el agujero de pozo 14 se modelan geométricamente en tres dimensiones, incluyendo los tipos de material de cada componente, comunicación del agujero de

pozo esperada con la formación 26 después de la perforación, etc. Los modelos de elementos finitos se pueden usar para los elementos estructurales del sistema 10.

Un software de modelado de elementos finito adecuado es
 5 LS-DYNA(TM) disponible de Livermore Software Technology Corporation. Este software puede utilizar modelos de carga hueca, modelos de interacción de carga hueca múltiple, modelos de roca permeable al paso de flujo, etc.

En las etapas 90, 84, 86, 87, 88, la sarta de
 10 perforación 12 se optimiza usando el modelo de impacto. Varias métricas se pueden usar para este proceso de optimización. Por ejemplo, el desempeño, costo-efectividad, eficiencia, fidelidad, y/o cualquiera otra métrica se puede maximizar mediante el uso del modelo de impacto.

La optimización puede también incluir mejorar los
 15 márgenes de seguridad para fallas como una compensación con otras métricas de desempeño. En un ejemplo, se puede desear tener un tubo encima de los cañones de punzado 20 tan corto como sea práctico, pero los riesgos de falla pueden requerir
 20 que el tubo sea más largo. Por tanto existe una compensación, y un modelo de impacto de exactitud que puede ayudar a seleccionar una longitud apropiada para el tubo.

La optimización es un proceso interactivo de llevar a
 cabo las simulaciones del modelo de impacto y para modificar
 25 el diseño de trabajo de perforación que se necesita mejorar después de una métrica de desempeño estimada. Cada iteración para modificar el diseño influye en la respuesta del sistema al impacto y, por lo tanto, requiere que el criterio de fallas se revise en cada iteración del proceso de
 30 optimización.

En la etapa 90, el impacto producido por la sarta de perforación 12 y sus efectos sobre los varios componentes de la sarta de perforación se predicen llevando a cabo una

simulación de modelo de impacto del trabajo de perforación. Por ejemplo, el sistema de perforación puede ser una entrada del modelo de impacto para obtener una predicción de los esfuerzos, tensiones, presiones, carga, movimiento, etc., en la sarta de perforación 12.

Basado en el resultado de aplicar el criterio de fallas a estas predicciones en la etapa 84 y el deseo de optimizar adicionalmente el diseño, la sarta de perforación 12 se puede modificar en la etapa 88 lo que es necesario para mejorar el desempeño, costo-efectividad, eficiencia, fidelidad, etc., del sistema de perforación.

La sarta de perforación modificada 12 puede entonces ser una entrada al modelo de impacto para obtener otra predicción, y otra modificación de la sarta de perforación se puede hacer basado en la predicción. Este proceso se puede repetir tantas veces como sea necesario para obtener un nivel aceptable de desempeño, costo-efectividad, eficiencia, fidelidad, etc., para el sistema de perforación.

Una vez que la sarta de perforación 12 y el sistema de perforación global se optimizan, en la etapa 92 una sarta de perforación real se instala en el agujero de pozo 14. La sarta de perforación real 12 debe ser la misma que la del modelo de sarta de perforación, el agujero de pozo real 14 debe ser el mismo que el agujero de pozo modelado, etc., usados en el modelo de impacto para producir la predicción en la etapa 90.

En la etapa 94, la herramienta de sensado de impacto 22 espera por una señal de disparo para iniciar el registro de mediciones. Como se describió anteriormente, la señal de disparo puede ser cualquier señal que se pueda detectar por la herramienta de sensado de impacto 22 (por ejemplo, un cierto nivel de presión, un cierto patrón de niveles de

presión, manipulación de tubería, una señal de telemetría, etc.).

En la etapa 96, el evento de perforación ocurre, con los cañones de punzado 20 siendo detonados, formando de esta manera las perforaciones 24 e iniciando la comunicación de fluido entre la formación 26 y el agujero de pozo 14. Simultáneamente con el evento de perforación, la herramienta de sensado de impacto 22 en la etapa 98 registra varias mediciones, tales como, tensiones, presiones, temperaturas, aceleraciones, etc. Cualquiera de las mediciones o combinación de mediciones se pueden tomar en esta etapa.

En la etapa 100, las herramientas de sensado de impacto 22 se recuperan del agujero de pozo 14. Esta permite que los datos de medición registrados se descarguen a una base de datos en la etapa 102. En otros ejemplos, los datos pudieran recuperarse mediante telemetría, mediante una sonda alámbrica, etc., sin recuperar las herramientas de sensado de impacto 22 en sí mismas, o el resto de la sarta de perforación 12, del agujero de pozo.

En la etapa 104, los datos de medición se comparan con las predicciones hechas por el modelo de impacto en la etapa 90. Si las predicciones hechas por el modelo de impacto no coinciden de manera aceptable con los datos de medición, se pueden hacer ajustes apropiados al modelo de impacto en la etapa 106 y un nuevo conjunto de predicciones se genera llevando a cabo una simulación del modelo de impacto ajustado. Si las predicciones hechas por el modelo de impacto ajustado aún no coinciden de manera aceptable con los datos de medición, aún se pueden hacer ajustes adicionales al modelo de impacto, y este proceso se puede repetir hasta que se obtenga una coincidencia aceptable.

Una vez que una coincidencia aceptable se obtiene, el modelo de impacto se puede considerar calculado y listo para

su uso con el próximo trabajo de perforación. Cada vez que el método 80 se lleva a cabo, el modelo de impacto debe hacerse más experto en predecir cargas, esfuerzos, presiones, movimientos, etc., para un sistema de perforación, y por lo tanto debe ser más útil en optimizar la sarta de perforación a usarse en el sistema.

Al cabo del tiempo, una base de datos de muchos conjuntos de datos de medición y predicciones se pueden usar en un proceso de ajuste y comparación más complejo, de manera que los ajustes del modelo de impacto se benefician de la experiencia acumulada representada por la base de datos. Por lo tanto, los ajustes al modelo de impacto se pueden hacer basado en múltiples conjuntos de datos de medición y predicciones.

Con referencia adicional ahora a la FIG. 10, un diagrama de bloques del modelo de impacto 110 y el modelo de pozo asociado 112, el modelo de sarta de perforación 114 y las predicciones de salida 116 se ilustran representativamente. Como se describió anteriormente, el modelo de impacto 110 utiliza el modelo de pozo 112 (incluyendo, por ejemplo, la geometría del agujero de pozo 14, las características de la formación 26, el fluido en el agujero de pozo, los modelos de roca permeable al paso de flujo, etc.) y el modelo 114 de la sarta de perforación 12 (incluyendo, por ejemplo, las geometrías de los varios componentes de la sarta de perforación, los modelos de carga hueca, modelos de interacción de carga hueca, etc.), para producir las predicciones 116 de cargas, esfuerzos, presiones, movimientos, etc. en el sistema de pozo 10.

La sarta de perforación 12, el agujero de pozo 14 (incluyendo, por ejemplo, carcasa y recubrimiento de cemento en el agujero de pozo), el fluido en el agujero de pozo, la formación 26, y otros componentes de pozo se modelan

preferiblemente de manera precisa en tres dimensiones en alta resolución usando técnicas de modelado de elementos finito. Por ejemplo, los cañones de punzado 20 se pueden modelar junto con sus agujeros del cuerpo del cañón asociado, aliviaderos roscados, etc.

La desviación del agujero de pozo 14 se puede modelar. Esta se usa para predecir las cargas de contacto, fricción y otras interacciones entre la sarta de perforación 12 y el agujero de pozo 14.

El fluido en el agujero de pozo 14 se puede modelar. El fluido modelado del agujero de pozo es la unión entre las presiones generadas por las cargas huecas, la comunicación de la formación, y el modelo estructural de la sarta de perforación 12. El fluido del agujero de pozo se puede modelar en una dimensión o, preferiblemente, en tres dimensiones. Modelar el fluido del agujero de pozo también se puede describir como un modelo de interacción fluido-estructura, un término que se refiere a las cargas aplicadas a la estructura por el fluido.

Las fallas también pueden ocurrir como resultado de las altas presiones u ondas de presión. Por lo tanto es importante para el modelo predecir el comportamiento del fluido por la razón de que el fluido carga la estructura y el fluido en sí mismo puede dañar el obturador o la carcasa directamente.

Un modelo de carga hueca tridimensional se puede usar para predecir las distribuciones y presiones interiores del cañón, cargas de impacto para casos de cargas en lo interiores de los cuerpos de los cañones, efectos de interacción de carga, etc.

El modelo de impacto 110 puede incluir redes neuronales, algoritmos genéticos, y/o cualquier combinación de métodos numéricos para producir las predicciones. Un

beneficio particular del método 80 descrito anteriormente es que la exactitud de las predicciones 116 producidas por el modelo de impacto 110 se pueden mejorar utilizando las mediciones reales de los efectos de impacto tomadas por la herramienta de sensado de impacto 22 durante un evento de perforación. El modelo de impacto 110 se valida y se calibra preferiblemente usando las mediciones de efectos reales de perforación por la herramienta de sensado de impacto 22 en la sarta de perforación 12.

10 El modelo de impacto 110 y/o herramienta de sensado de impacto 22 puede ser útil en la investigación de fallas, o sea, para determinar por qué ocurrió un daño o falla en un trabajo de perforación particular.

El modelo de impacto 110 se pueden usar para optimizar el diseño de la sarta de perforación 12, por ejemplo, para maximizar el desempeño, para minimizar esfuerzos, movimientos, etc., en la sarta de perforación, para proporcionar un margen aceptable de seguridad contra daños o fallas estructurales, etc.

20 En la aplicación del criterio de fallas a las predicciones generadas por el modelo de impacto 110, típicamente métricas, tales como el límite de elasticidad estática del material, se pueden usar y/o se pueden usar parámetros más complejos que se relacionan con los efectos que dependen de la tasa de tensión que afectan el crecimiento de grietas. La dureza de la fractura dinámica es una medida del crecimiento de grietas bajo carga dinámica. Las inversiones de esfuerzo resultan cuando la carga se desplaza entre compresión y tensión. Los ciclos de cargas repetidas pueden resultar en fatigas. Por lo tanto, la aplicación del criterio de fallas puede involucrar más que simplemente una métrica de elasticidad contra esfuerzo.

El modelo de impacto 110 puede incorporar otras herramientas que pueden tener un comportamiento más complejo que puede afectar las predicciones del modelo. Por ejemplo, los conectores de cañón avanzado se han modelado específicamente debido a que exhiben un comportamiento no lineal que tiene un gran efecto en las predicciones.

Ahora se puede apreciar totalmente que la descripción anterior proporciona varios avances a la materia. El modelo de impacto 110 se pueden usar para predecir los efectos de un evento de perforación en varios componentes de la sarta de perforación 14, y para investigar una falla de, o daños a, una sarta de perforación real. En el método 80 descrito anteriormente, el modelo de impacto 110 también se puede usar para optimizar el diseño de la sarta de perforación 14.

La descripción anterior proporciona a la materia un método 80 para utilizar un modelo de impacto 110 para la predicción de los efectos de perforación. El método 80 puede incluir registro de mediciones de los efectos de perforación en una sarta de perforación real 12 en un agujero de pozo 14; ajustar el modelo de impacto 110 de manera que las predicciones de las salidas de los efectos de perforación mediante el modelo de impacto 110 coincida sustancialmente con las mediciones de los efectos de perforación; y provocar que el modelo de impacto ajustado 110 prediga los efectos de perforación para una sarta de perforación propuesta 12.

Las mediciones registradas pueden incluir tensión axial, de flexión y torsional en la sarta de perforación real 12. Las mediciones registradas pueden también incluir presión exterior a, interior a, y/o en un cañón de punzado 20 de, la sarta de perforación real 12.

Ajustar el modelo de impacto puede incluir repetidamente: a) recibir una comparación de las predicciones de los efectos de perforación a las mediciones

de los efectos de perforación, y b) ajustar el modelo de impacto 110 para reducir las diferencias entre las predicciones de los efectos de perforación y las mediciones de los efectos de perforación, hasta que las diferencias se
5 reduzcan aceptablemente.

El método puede incluir, antes de la etapa de registro, entrar un modelo geométrico tridimensional 114 de la sarta de perforación real 12 en el modelo de impacto 110.

El método puede incluir, después de la etapa de ajuste
10 y antes de la etapa de provocar las predicciones, entrar un modelo tridimensional 114 de la sarta de perforación propuesta 12 en el modelo de impacto 110.

Las predicciones de los efectos de perforación pueden incluir los esfuerzos a lo largo de la sarta de perforación
15 real 12, movimientos a lo largo de la sarta de perforación real 12, y/o interacciones entre la sarta de perforación real 12 y el agujero de pozo 14. Las interacciones entre la sarta de perforación real 12 y el agujero de pozo 14 pueden incluir cargas de contacto y fricción entre la sarta de
20 perforación real 12 y el agujero de pozo 14.

La descripción anterior también describe un método 80 para predecir los efectos de perforación en una sarta de perforación 12 en un agujero de pozo 14. El método 80 puede incluir entrar un modelo de pozo tridimensional 112 y un
25 modelo tridimensional 114 de la sarta de perforación 12 en un modelo de impacto 110; y provocar que el modelo de impacto 110 prediga los efectos de perforación en la sarta de perforación 12.

El modelo tridimensional 114 de la sarta de perforación
30 12 puede incluir un modelo de una o más herramientas de sensado de impacto 22 interconectadas en la sarta de perforación 12.

El modelo tridimensional 114 de la sarta de perforación 12 puede incluir las propiedades de los materiales de los componentes de la sarta de perforación 12.

5 El método 80 puede incluir medir los efectos de perforación en la sarta de perforación 12 provocados por la detonación de los cañones de punzado 20.

10 El método 80 puede incluir ajustar el modelo de impacto 110 de manera que la salida predicha de los efectos de perforación por el modelo de impacto 110 coincida sustancialmente con las mediciones de los efectos de perforación.

15 Los efectos de perforación pueden incluir al menos tensión axial, de flexión y torsional en la sarta de perforación 12. Los efectos de perforación pueden incluir los esfuerzos a lo largo de la sarta de perforación 12, los movimientos a lo largo de la sarta de perforación 12, y/o las interacciones entre la sarta de perforación 12 y el agujero de pozo 14. Las interacciones entre la sarta de perforación 12 y el agujero de pozo 14 pueden incluir cargas de contacto y fricción entre la sarta de perforación 12 y el agujero de pozo 14.

25 Debe entenderse que las diferentes modalidades descritas en la presente pueden utilizarse en diferentes orientaciones, tales como inclinada, invertida, horizontal, vertical, etc., y en varias configuraciones, sin irse de los principios de la presente descripción. Las modalidades se describen meramente como ejemplos de aplicaciones útiles de los principios de la descripción, las cuales no están limitadas a ninguno de los detalles específicos de estas modalidades.

30 En la descripción anterior de las modalidades representativas de la descripción, términos direccionales, tales como, "encima", "debajo", "superior", "inferior",

etc., se usan para conveniencia en referencia a las figuras
acompañantes. En general, "encima", "superior", "hacia
arriba" y términos similares se refieren a una dirección
hacia la superficie de la tierra a lo largo de un hoyo, y
5 "debajo", "inferior", "hacia abajo" y términos similares se
refieren a una dirección lejos de la superficie de la tierra
a lo largo del hoyo.

Por supuesto, una persona experta en la materia podría,
bajo una consideración cuidadosa de la descripción anterior
10 de las modalidades representativas, fácilmente apreciar que
muchas modificaciones, adiciones, sustituciones, supresiones
y otros cambios se pueden hacer a estas modalidades
específicas, y tales cambios están dentro del alcance de los
principios de la presente descripción. Consecuentemente, la
15 descripción detallada anterior debe ser entendida claramente
ya que se ha impartido a modo de ilustración y ejemplo
solamente, el espíritu y el alcance de la presente invención
están limitados solamente por las reivindicaciones adjuntas
y sus equivalentes.

20

REIVINDICACIONES:

1. Un método para utilizar un modelo de impacto para la predicción de los efectos de perforación, el método que
5 comprende:

registrar las mediciones de los efectos de perforación en una sarta de perforación real en un agujero de pozo;

ajustar el modelo de impacto de manera que las predicciones de los salida de los efectos de perforación del
10 modelo de impacto coincidan sustancialmente con las mediciones de los efectos de perforación; y

provocar que el modelo de impacto ajustado prediga los efectos de perforación para una sarta de perforación propuesta.

15

2. El método de la reivindicación 1, en donde las mediciones registradas incluyen tensión axial, de flexión y torsional en la sarta de perforación real.

20

3. El método de la reivindicación 1, en donde las mediciones registradas incluyen presión exterior a la sarta de perforación real.

25

4. El método de la reivindicación 1, en donde las mediciones registradas incluyen presión interior a la sarta de perforación real.

30

5. El método de la reivindicación 1, en donde las mediciones registradas incluyen presión interior a un cañón de punzado de la sarta de perforación real.

6. El método de la reivindicación 1, en donde ajustar el modelo de impacto comprende además repetidamente: a) recibir una comparación de las predicciones de los efectos de perforación con las mediciones de los efectos de perforación, y b) ajustar el modelo de impacto para reducir las diferencias entre las predicciones de los efectos de perforación y las mediciones de los efectos de perforación, hasta que las diferencias se reduzcan aceptablemente.

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7. El método de la reivindicación 1, que comprende además, antes de la etapa de registro, entrar un modelo geométrico tridimensional de la sarta de perforación real en el modelo de impacto.

15

8. El método de la reivindicación 1, que comprende además, después de la etapa de ajuste y antes de la etapa de provocar las predicciones, entrar un modelo tridimensional de la sarta de perforación propuesta en el modelo de impacto.

20

9. El método de la reivindicación 1, en donde las predicciones de los efectos de perforación incluyen los esfuerzos a lo largo de la sarta de perforación real.

25

10. El método de la reivindicación 1, en donde las predicciones de los efectos de perforación incluyen los movimientos a lo largo de la sarta de perforación real.

30

11. El método de la reivindicación 1, en donde las predicciones de los efectos de perforación incluyen las

interacciones entre la sarta de perforación real y el agujero de pozo.

12. El método de la reivindicación 11, en donde las
5 interacciones entre la sarta de perforación real y el agujero de pozo incluyen cargas de contacto y fricción entre la sarta de perforación real y el agujero de pozo.

13. Un método de predicción de los efectos de
10 perforación en una sarta de perforación en un agujero de pozo, el método que comprende:

entrar un modelo de pozo tridimensional y un modelo tridimensional de la sarta de perforación en un modelo de impacto; y

15 provocar que el modelo de impacto prediga los efectos de perforación en la sarta de perforación.

14. El método de la reivindicación 13, en donde el modelo tridimensional de la sarta de perforación incluye un
20 modelo de una herramienta de sensado de impacto interconectada en la sarta de perforación.

15. El método de la reivindicación 13, en donde el modelo tridimensional de la sarta de perforación incluye un
25 modelo de múltiples herramientas de sensado de impacto interconectadas en la sarta de perforación.

16. El método de la reivindicación 13, en donde el modelo tridimensional de la sarta de perforación incluye las
30 propiedades de los materiales de los componentes de la sarta de perforación.

17. El método de la reivindicación 13, que comprende además medir los efectos de perforación en la sarta de perforación provocados por la detonación de cañones de punzado.

18. El método de la reivindicación 17, que comprende además ajustar el modelo de impacto de manera que la salida predicha de los efectos de perforación por el modelo de impacto coincida sustancialmente con las mediciones de los efectos de perforación.

19. El método de la reivindicación 13, en donde los efectos de perforación incluyen al menos cargas axiales en la sarta de perforación.

20. El método de la reivindicación 19, en donde los efectos de perforación incluyen además cargas de flexión en la sarta de perforación.

21. El método de la reivindicación 20, en donde los efectos de perforación incluyen además cargas torsionales en la sarta de perforación.

22. El método de la reivindicación 13, en donde los efectos de perforación incluyen los esfuerzos a lo largo de la sarta de perforación.

23. El método de la reivindicación 13, en donde los efectos de perforación incluyen los movimientos a lo largo de la sarta de perforación.

5 24. El método de la reivindicación 13, en donde los efectos de perforación incluyen las interacciones entre la sarta de perforación y el agujero de pozo.

10 25. El método de la reivindicación 24, en donde las interacciones entre la sarta de perforación y el agujero de pozo incluyen las cargas de contacto y fricción entre la sarta de perforación y el agujero de pozo.

RESUMEN

Un método para utilizar un modelo de impacto para la
5 predicción de los efectos de perforación puede incluir
registrar las mediciones de los efectos de perforación en
una sarta de perforación real en un agujero de pozo, ajustar
el modelo de impacto de manera que las predicciones de las
salida de los efectos de perforación del modelo de impacto
10 coincidan sustancialmente con las mediciones de los efectos
de perforación, y provocar que el modelo de impacto ajustado
prediga los efectos de perforación para una sarta de
perforación propuesta. Un método de predicción de los
efectos de perforación en una sarta de perforación en un
15 agujero de pozo puede incluir entrar un modelo de pozo
tridimensional y un modelo tridimensional de la sarta de
perforación en un modelo de impacto, y provocar que el
modelo de impacto prediga los efectos de perforación en la
sarta de perforación.

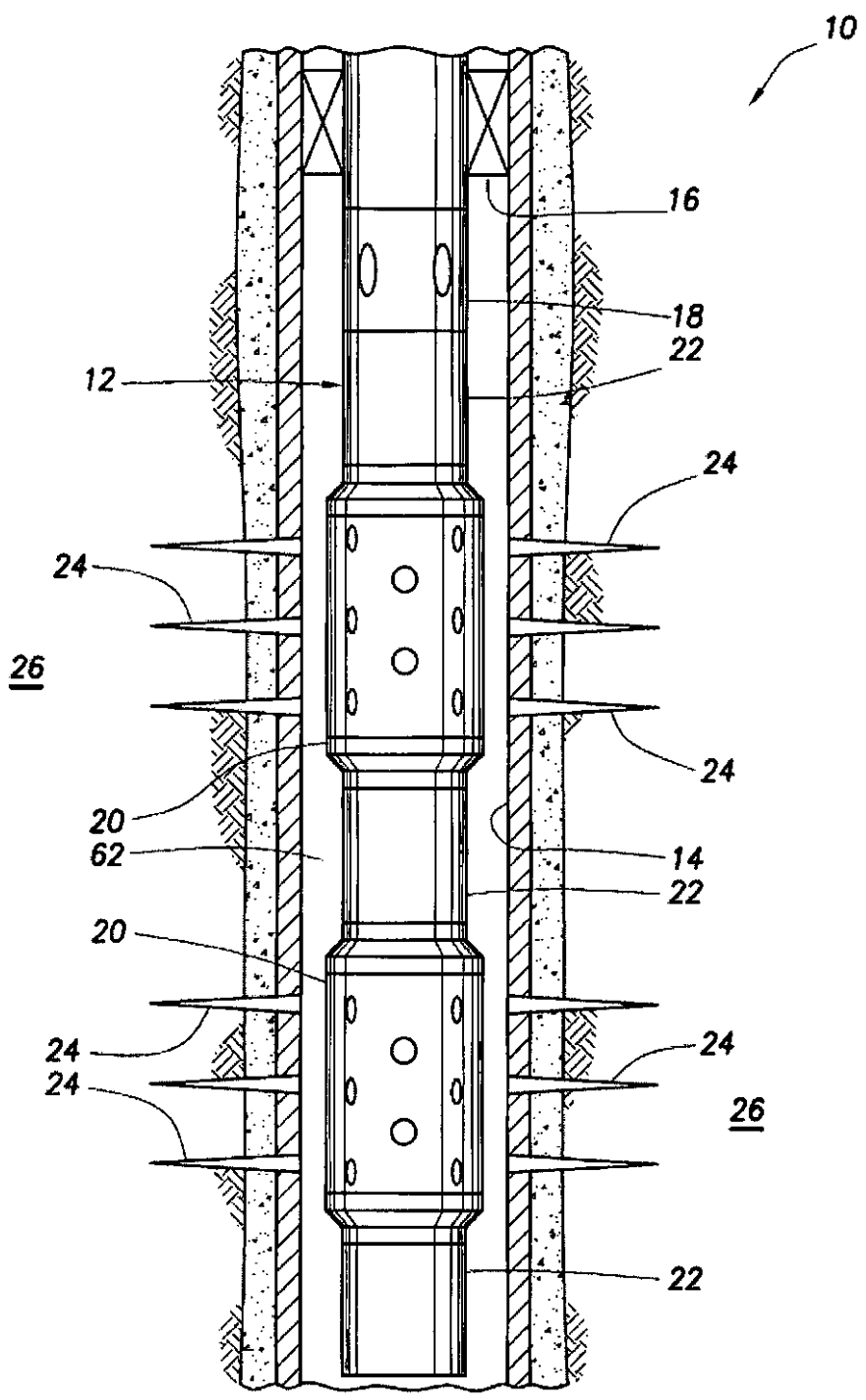
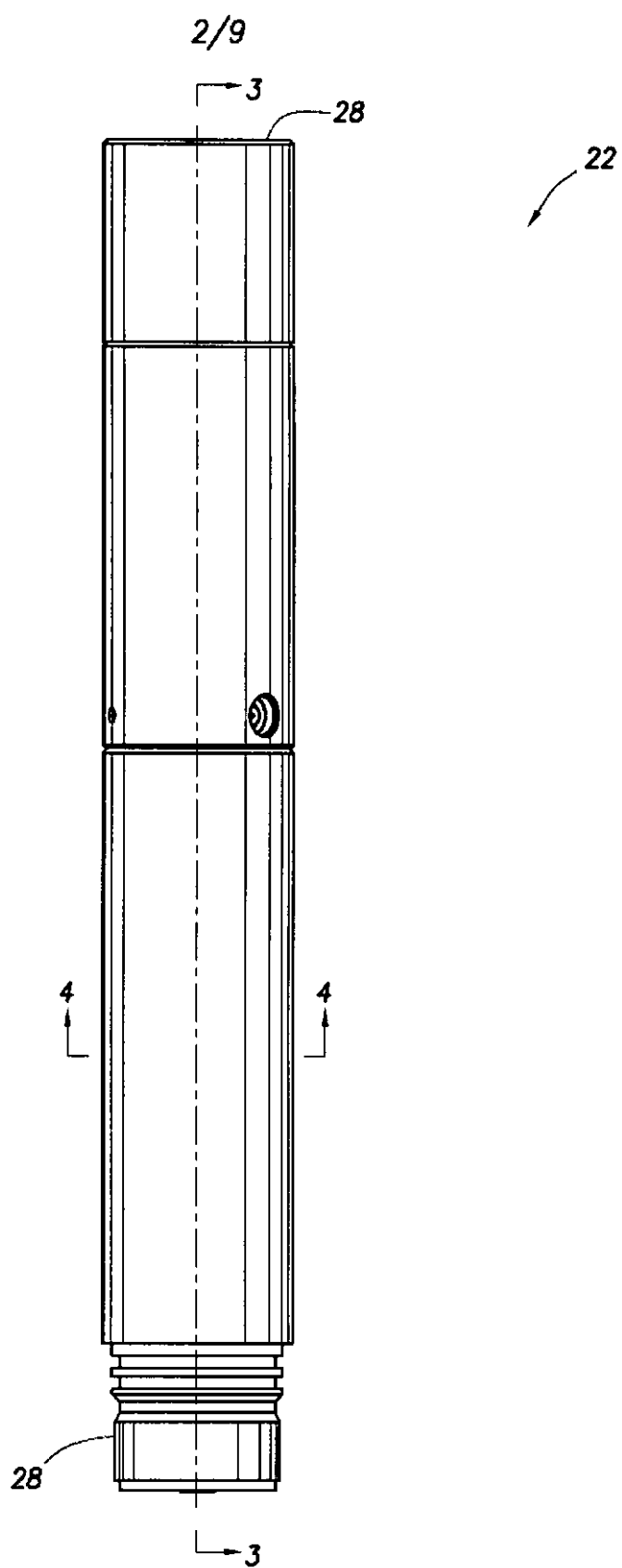


FIG. 1

FIG.2



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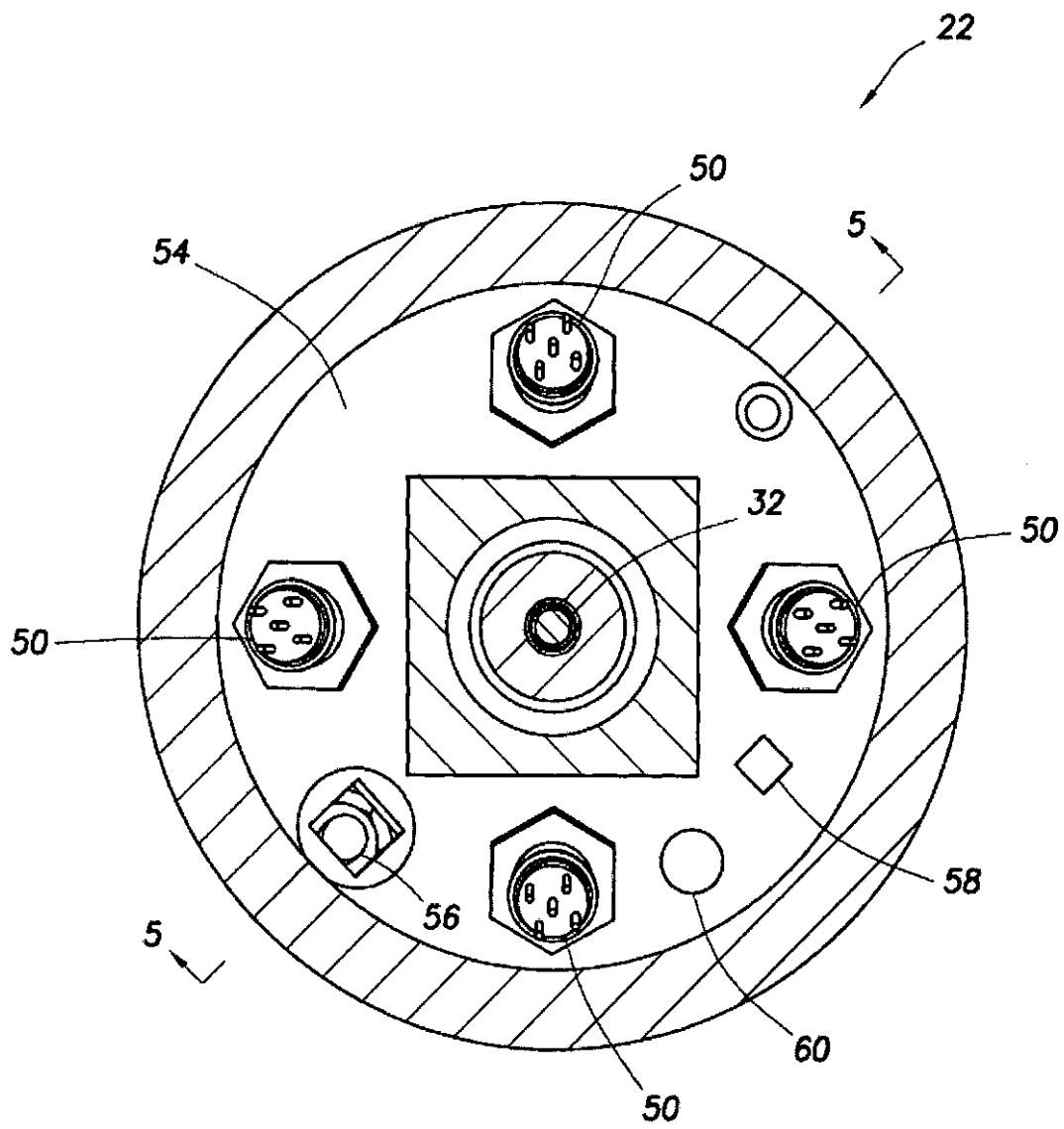


FIG. 4

5/9

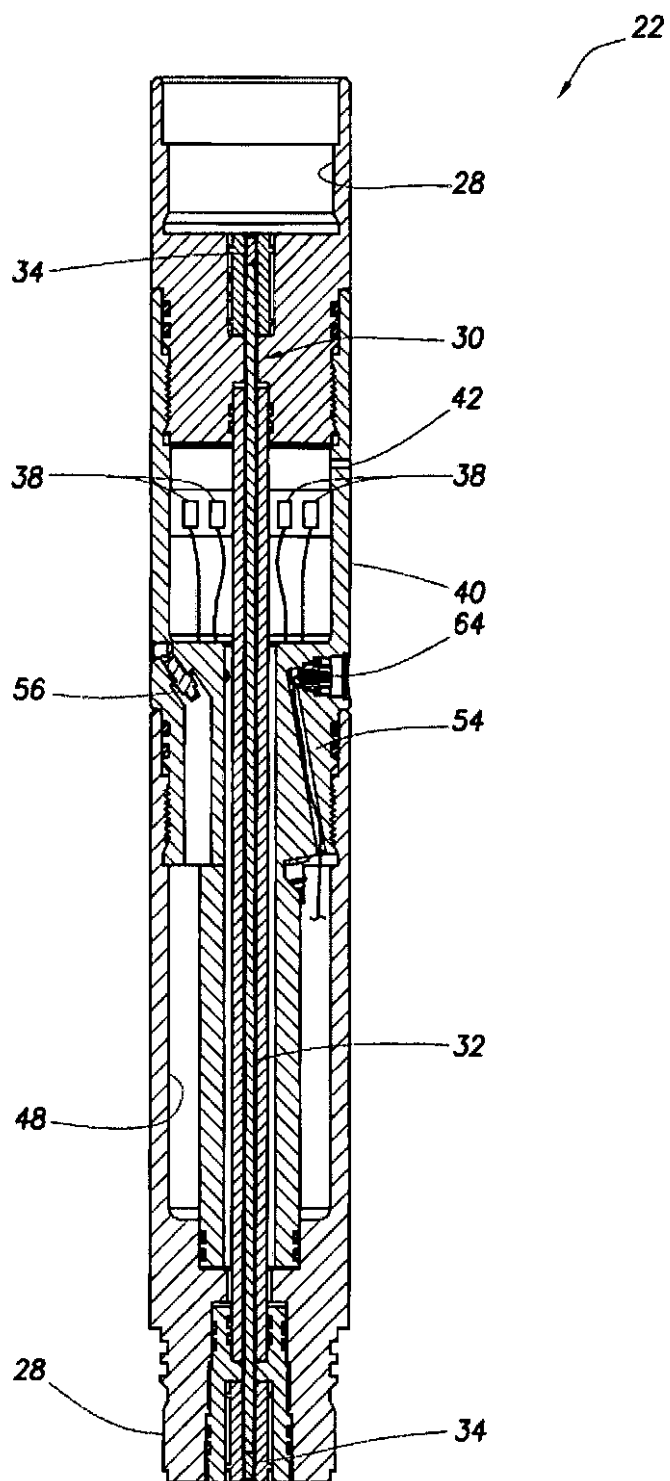


FIG.5

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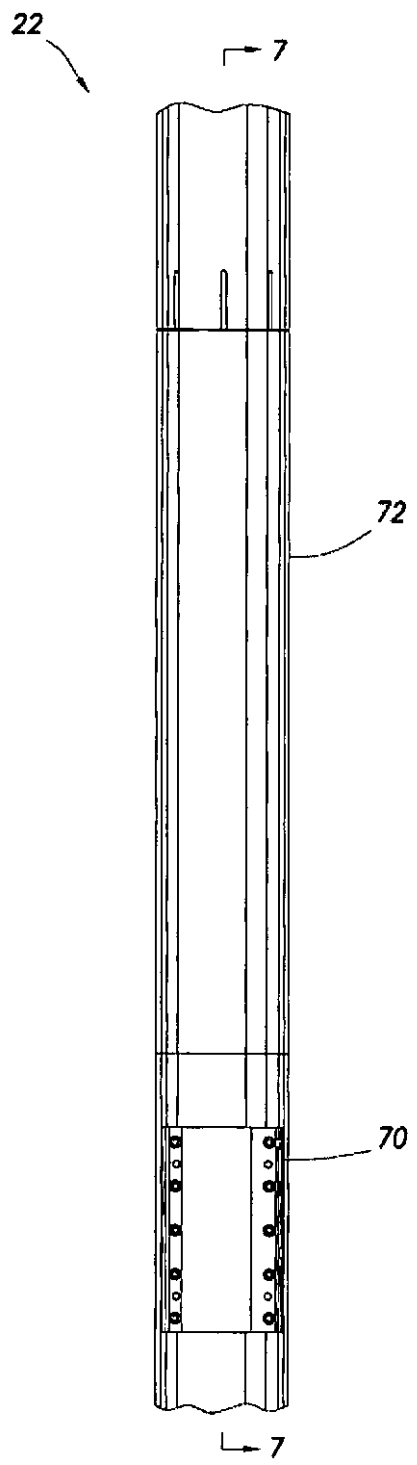


FIG. 6

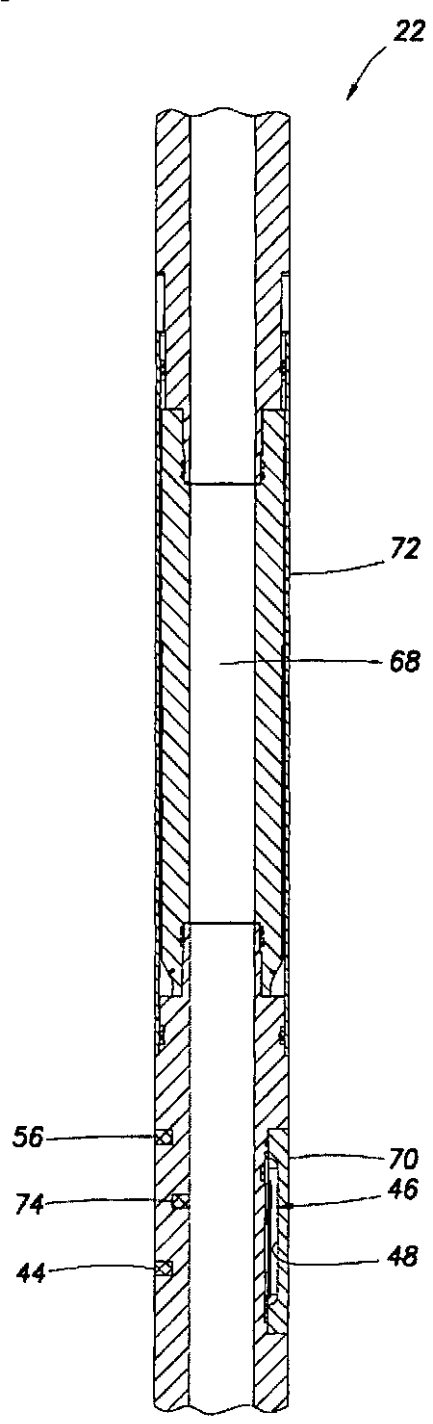
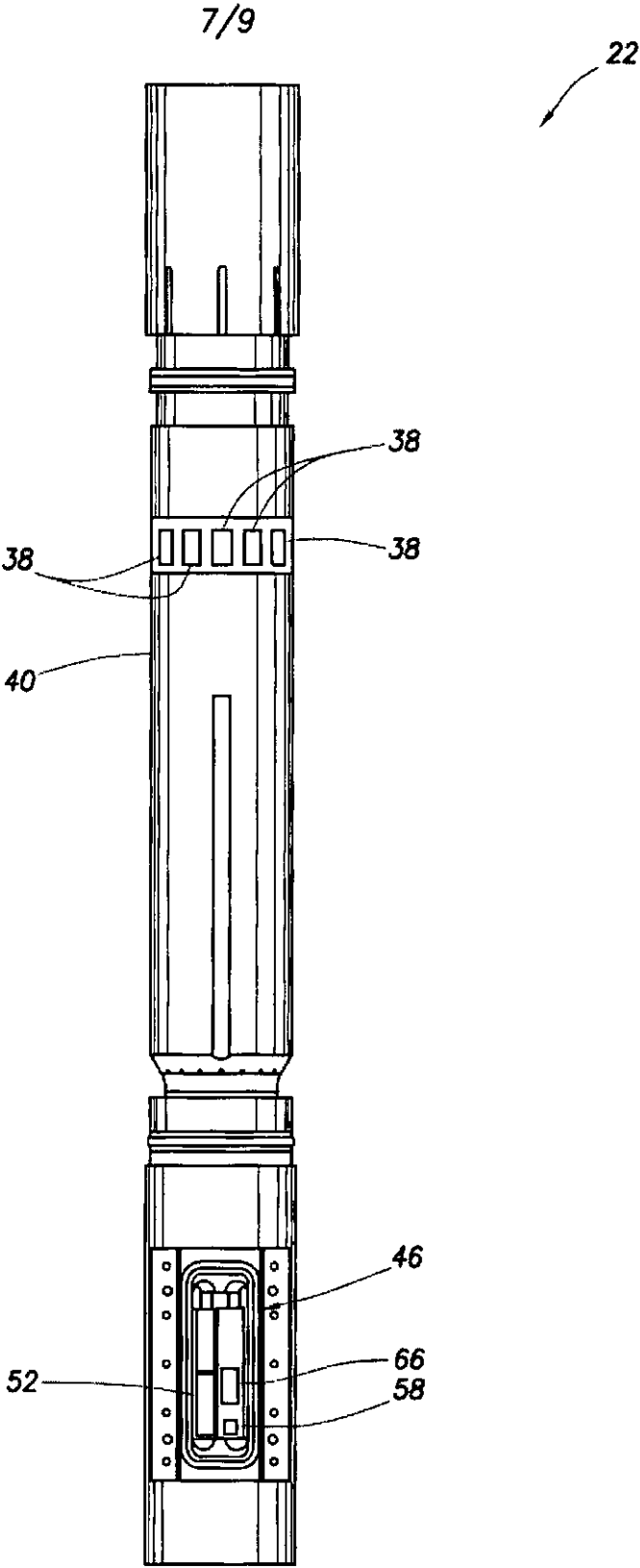


FIG. 7

FIG. 8



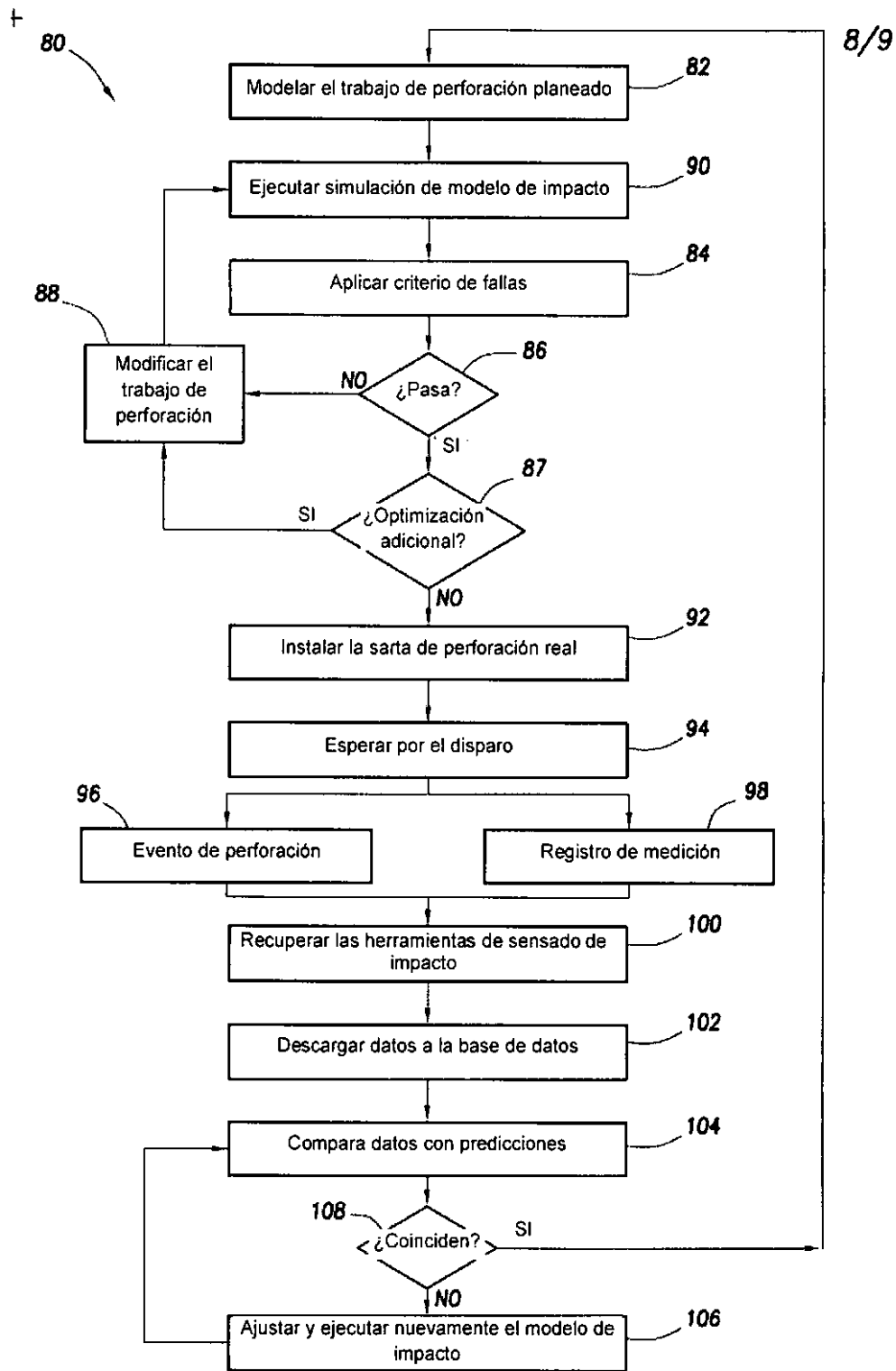
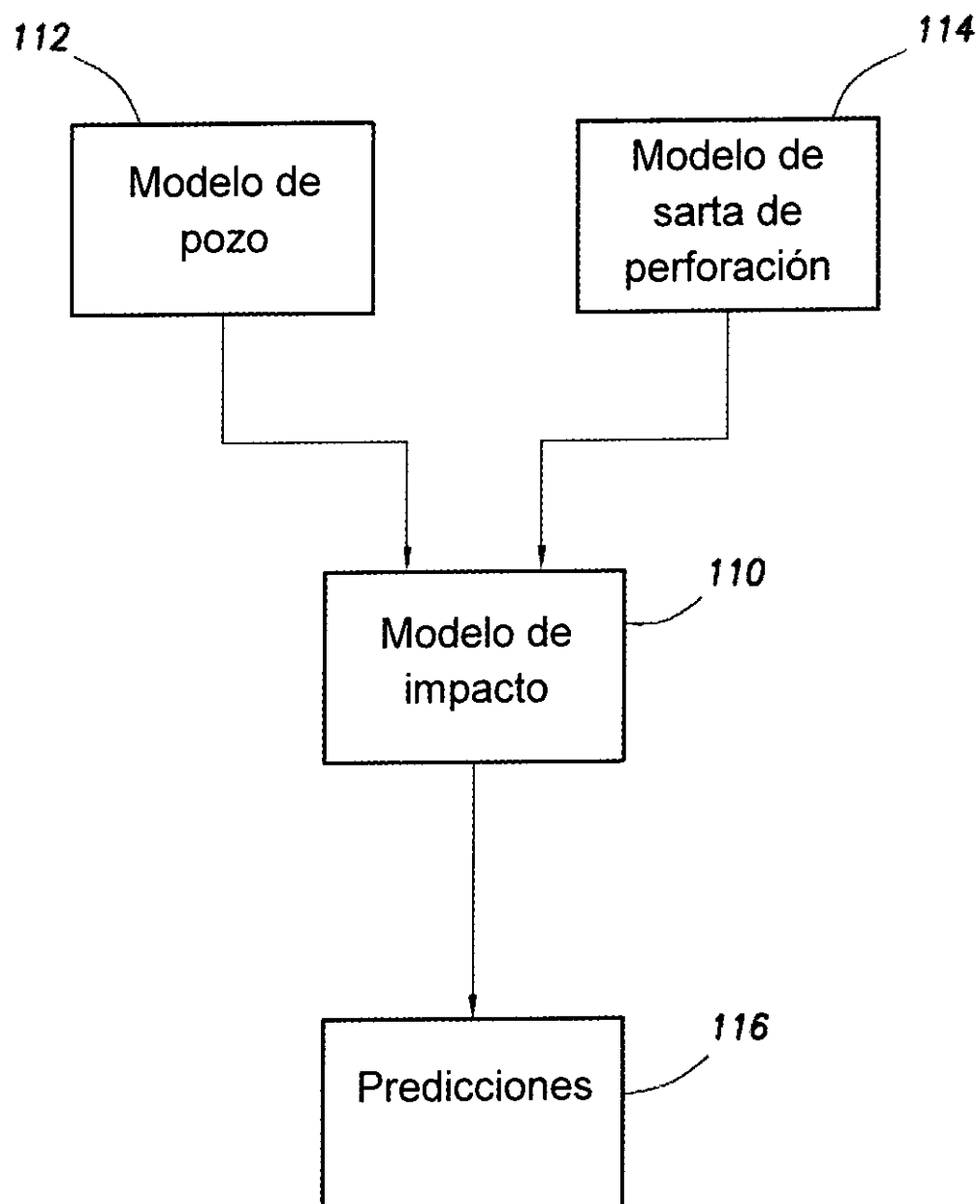


FIG. 9

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**FIG.10**

5

MODELING SHOCK PRODUCED BY WELL PERFORATING

TECHNICAL FIELD

10

The present disclosure relates generally to equipment utilized and operations performed in conjunction with a subterranean well and, in an embodiment described herein, more particularly provides for modeling shock produced by well perforating.

15

BACKGROUND

20

Attempts have been made to model the effects of shock due to perforating. It would be desirable to be able to predict shock due to perforating, for example, to prevent unsettling a production packer, to prevent failure of a perforating gun body, and to otherwise prevent or at least reduce damage to various components of a perforating string.

25

Unfortunately, past shock models have not been able to predict shock effects in axial, bending and torsional directions, and to apply these shock effects to three dimensional structures, thereby predicting stresses in particular components of the perforating string. One hindrance to the development of such a shock model has been the lack of satisfactory measurements of the strains, loads,

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stresses, pressures, and/or accelerations, etc., produced by perforating. Such measurements can be useful in verifying a shock model and refining its output.

Therefore, it will be appreciated that improvements are
5 needed in the art. These improvements can be used, for example, in designing new perforating string components which are properly configured for the conditions they will experience in actual perforating situations, and in preventing damage to any equipment.

10

SUMMARY

In carrying out the principles of the present disclosure, a method is provided which brings improvements to the art of predicting shock produced by well perforating.
15 One example is described below in which the method is used to adjust predictions made by a shock model, in order to make the predictions more precise. Another example is described below in which the shock model is used to optimize a design of a perforating string.

20 A method of utilizing a shock model for prediction of perforating effects is provided by the disclosure below. In one example, the method can include recording measurements of the perforating effects on an actual perforating string in a wellbore; adjusting the shock model so that predictions
25 of the perforating effects output by the shock model substantially match the measurements of the perforating effects; and causing the adjusted shock model to predict the perforating effects for a proposed perforating string.

Also described below is a method of predicting
30 perforating effects on a perforating string in a wellbore. The method can include inputting a three dimensional well

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model and a three dimensional model of the perforating string into a shock model; and causing the shock model to predict the perforating effects on the perforating string.

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 indicated in the various figures using the same reference numbers.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIGS. 2-5 are schematic views of a shock sensing tool which may be used in the system and method of FIG. 1.

FIGS. 6-8 are schematic views of another configuration of the shock sensing tool.

FIG. 9 is a schematic flowchart for the method.

FIG. 10 is a schematic block diagram of a shock model, along with its inputs and outputs.

DETAILED DESCRIPTION

Representatively illustrated in FIG. 1 is a well system 10 and associated method which can embody principles of the present disclosure. In the well system 10, a perforating string 12 is installed in a wellbore 14. The depicted perforating string 12 includes a packer 16, a firing head 18, perforating guns 20 and shock sensing tools 22.

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In other examples, the perforating string 12 may include more or less of these components. For example, well screens and/or gravel packing equipment may be provided, any number (including one) of the perforating guns 20 and shock
5 sensing tools 22 may be provided, etc. Thus, it should be clearly understood that the well system 10 as depicted in FIG. 1 is merely one example of a wide variety of possible well systems which can embody the principles of this disclosure.

10 A shock model can use a three dimensional model of the perforating string 12 and wellbore 14 to realistically model the physical behavior of the system 10 during a perforating event. Preferably, the shock model will predict at least bending, torsional and axial loading, as well as motion in
15 all directions (three dimensional motion). The model can include predictions of casing contact and friction, and the loads that result from it.

In a preferred example, detailed finite element models of the components of the perforating string 12 enable a
20 higher fidelity prediction of stresses in the components. Wellbore pressure dynamics and communication with a formation can also be incorporated into the model.

The shock model is preferably calibrated using actual perforating string loads and accelerations, as well as
25 wellbore pressures, collected from one or more of the shock sensing tools 22. Measurements taken by the shock sensing tools 22 can be used to verify the predictions made by the shock model, and to make adjustments to the shock model, so that future predictions are more accurate.

30 The shock sensing tool 22 can be as described in the International patent application entitled, "Sensing Shock During Well Perforating," filed on even date herewith. That

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patent application discloses that the shock sensing tools 22 can be interconnected in various locations along the perforating string 12.

One advantage of interconnecting the shock sensing tools 22 below the packer 16 and in close proximity to the perforating guns 20 is that more accurate measurements of strain and acceleration at the perforating guns can be obtained. Pressure and temperature sensors of the shock sensing tools 22 can also sense conditions in the wellbore 14 in close proximity to perforations 24 immediately after the perforations are formed, thereby facilitating more accurate analysis of characteristics of an earth formation 26 penetrated by the perforations.

A shock sensing tool 22 interconnected between the packer 16 and the upper perforating gun 20 can record the effects of perforating on the perforating string 12 above the perforating guns. This information can be useful in preventing unsettling or other damage to the packer 16, firing head 18, etc., due to detonation of the perforating guns 20 in future designs.

A shock sensing tool 22 interconnected between perforating guns 20 can record the effects of perforating on the perforating guns themselves. This information can be useful in preventing damage to components of the perforating guns 20 in future designs.

A shock sensing tool 22 can be connected below the lower perforating gun 20, if desired, to record the effects of perforating at this location. In other examples, the perforating string 12 could be stabbed into a lower completion string, connected to a bridge plug or packer at the lower end of the perforating string, etc., in which case the information recorded by the lower shock sensing tool 22

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could be useful in preventing damage to these components in future designs.

Viewed as a complete system, the placement of the shock sensing tools 22 longitudinally spaced apart along the perforating string 12 allows acquisition of data at various points in the system, which can be useful in validating a model of the system. Thus, collecting data above, between and below the guns, for example, can help in an understanding of the overall perforating event and its effects on the system as a whole.

The information obtained by the shock sensing tools 22 is not only useful for future designs, but can also be useful for current designs, for example, in post-job analysis, formation testing, etc. The applications for the information obtained by the shock sensing tools 22 are not limited at all to the specific examples described herein.

Referring additionally now to FIGS. 2-5, one example of the shock sensing tool 22 is representatively illustrated. As depicted in FIG. 2, the shock sensing tool 22 is provided with end connectors 28 (such as, perforating gun connectors, etc.) for interconnecting the tool in the perforating string 12 in the well system 10. However, other types of connectors may be used, and the tool 22 may be used in other perforating strings and in other well systems, in keeping with the principles of this disclosure.

In FIG. 3, a cross-sectional view of the shock sensing tool 22 is representatively illustrated. In this view, it may be seen that the tool 22 includes a variety of sensors, and a detonation train 30 which extends through the interior of the tool.

The detonation train 30 can transfer detonation between perforating guns 20, between a firing head (not shown) and a

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perforating gun, and/or between any other explosive components in the perforating string 12. In the example of FIGS. 2-5, the detonation train 30 includes a detonating cord 32 and explosive boosters 34, but other components may
5 be used, if desired.

One or more pressure sensors 36 may be used to sense pressure in perforating guns, firing heads, etc., attached to the connectors 28. Such pressure sensors 36 are preferably ruggedized (e.g., to withstand ~20000 g
10 acceleration) and capable of high bandwidth (e.g., >20 kHz). The pressure sensors 36 are preferably capable of sensing up to ~60 ksi (~414 MPa) and withstanding ~175 degrees C. Of course, pressure sensors having other specifications may be used, if desired.

15 Strain sensors 38 are attached to an inner surface of a generally tubular structure 40 interconnected between the connectors 28. The structure 40 is preferably pressure balanced, i.e., with substantially no pressure differential being applied across the structure.

20 In particular, ports 42 are provided to equalize pressure between an interior and an exterior of the structure 40. By equalizing pressure across the structure 40, the strain sensor 38 measurements are not influenced by any differential pressure across the structure before,
25 during or after detonation of the perforating guns 20.

The strain sensors 38 are preferably resistance wire-type strain gauges, although other types of strain sensors (e.g., piezoelectric, piezoresistive, fiber optic, etc.) may be used, if desired. In this example, the strain sensors 38
30 are mounted to a strip (such as a KAPTON(TM) strip) for precise alignment, and then are adhered to the interior of the structure 40.

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Preferably, four full Wheatstone bridges are used, with opposing 0 and 90 degree oriented strain sensors being used for sensing axial and bending strain, and +/- 45 degree gauges being used for sensing torsional strain.

5 The strain sensors 38 can be made of a material (such as a KARMA(TM) alloy) which provides thermal compensation, and allows for operation up to ~150 degrees C. Of course, any type or number of strain sensors may be used in keeping with the principles of this disclosure.

10 The strain sensors 38 are preferably used in a manner similar to that of a load cell or load sensor. A goal is to have all of the loads in the perforating string 12 passing through the structure 40 which is instrumented with the sensors 38.

15 Having the structure 40 fluid pressure balanced enables the loads (e.g., axial, bending and torsional) to be measured by the sensors 38, without influence of a pressure differential across the structure. In addition, the detonating cord 32 is housed in a tube 33 which is not
20 rigidly secured at one or both of its ends, so that it does not share loads with, or impart any loading to, the structure 40.

A temperature sensor 44 (such as a thermistor, thermocouple, etc.) can be used to monitor temperature
25 external to the tool. Temperature measurements can be useful in evaluating characteristics of the formation 26, and any fluid produced from the formation, immediately following detonation of the perforating guns 20. Preferably, the temperature sensor 44 is capable of accurate
30 high resolution measurements of temperatures up to ~170 degrees C.

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Another temperature sensor (not shown) may be included with an electronics package 46 positioned in an isolated chamber 48 of the tool 22. In this manner, temperature within the tool 22 can be monitored, e.g., for diagnostic purposes or for thermal compensation of other sensors (for example, to correct for errors in sensor performance related to temperature change). Such a temperature sensor in the chamber 48 would not necessarily need the high resolution, responsiveness or ability to track changes in temperature quickly in wellbore fluid of the other temperature sensor 44.

The electronics package 46 is connected to at least the strain sensors 38 via pressure isolating feed-throughs or bulkhead connectors 50. Similar connectors may also be used for connecting other sensors to the electronics package 46. Batteries 52 and/or another power source may be used to provide electrical power to the electronics package 46.

The electronics package 46 and batteries 52 are preferably ruggedized and shock mounted in a manner enabling them to withstand shock loads with up to ~10000 g acceleration. For example, the electronics package 46 and batteries 52 could be potted after assembly, etc.

In FIG. 4 it may be seen that four of the connectors 50 are installed in a bulkhead 54 at one end of the structure 40. In addition, a pressure sensor 56, a temperature sensor 58 and an accelerometer 60 are preferably mounted to the bulkhead 54.

The pressure sensor 56 is used to monitor pressure external to the tool 22, for example, in an annulus 62 formed radially between the perforating string 12 and the wellbore 14 (see FIG. 1). The pressure sensor 56 may be

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similar to the pressure sensors 36 described above. A suitable pressure transducer is the Kulite model HKM-15-500.

The temperature sensor 58 may be used for monitoring temperature within the tool 22. This temperature sensor 58
5 may be used in place of, or in addition to, the temperature sensor described above as being included with the electronics package 46.

The accelerometer 60 is preferably a piezoresistive type accelerometer, although other types of accelerometers
10 may be used, if desired. Suitable accelerometers are available from Endevco and PCB (such as the PCB 3501A series, which is available in single axis or triaxial packages, capable of sensing up to ~60000 g acceleration).

In FIG. 5, another cross-sectional view of the tool 22
15 is representatively illustrated. In this view, the manner in which the pressure transducer 56 is ported to the exterior of the tool 22 can be clearly seen. Preferably, the pressure transducer 56 is close to an outer surface of the tool, so that distortion of measured pressure resulting
20 from transmission of pressure waves through a long narrow passage is prevented.

Also visible in FIG. 5 is a side port connector 64 which can be used for communication with the electronics package 46 after assembly. For example, a computer can be
25 connected to the connector 64 for powering the electronics package 46, extracting recorded sensor measurements from the electronics package, programming the electronics package to respond to a particular signal or to "wake up" after a selected time, otherwise communicating with or exchanging
30 data with the electronics package, etc.

Note that it can be many hours or even days between assembly of the tool 22 and detonation of the perforating

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guns 20. In order to preserve battery power, the electronics package 46 is preferably programmed to "sleep" (i.e., maintain a low power usage state), until a particular signal is received, or until a particular time period has elapsed.

The signal which "wakes" the electronics package 46 could be any type of pressure, temperature, acoustic, electromagnetic or other signal which can be detected by one or more of the sensors 36, 38, 44, 56, 58, 60. For example, the pressure sensor 56 could detect when a certain pressure level has been achieved or applied external to the tool 22, or when a particular series of pressure levels has been applied, etc. In response to the signal, the electronics package 46 can be activated to a higher measurement recording frequency, measurements from additional sensors can be recorded, etc.

As another example, the temperature sensor 58 could sense an elevated temperature resulting from installation of the tool 22 in the wellbore 14. In response to this detection of elevated temperature, the electronics package 46 could "wake" to record measurements from more sensors and/or higher frequency sensor measurements.

As yet another example, the strain sensors 38 could detect a predetermined pattern of manipulations of the perforating string 12 (such as particular manipulations used to set the packer 16). In response to this detection of pipe manipulations, the electronics package 46 could "wake" to record measurements from more sensors and/or higher frequency sensor measurements.

The electronics package 46 depicted in FIG. 3 preferably includes a non-volatile memory 66 so that, even if electrical power is no longer available (e.g., the

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batteries 52 are discharged), the previously recorded sensor measurements can still be downloaded when the tool 22 is later retrieved from the well. The non-volatile memory 66 may be any type of memory which retains stored information when powered off. This memory 66 could be electrically erasable programmable read only memory, flash memory, or any other type of non-volatile memory. The electronics package 46 is preferably able to collect and store data in the memory 66 at >100 kHz sampling rate.

Referring additionally now to FIGS. 6-8, another configuration of the shock sensing tool 22 is representatively illustrated. In this configuration, a flow passage 68 (see FIG. 7) extends longitudinally through the tool 22. Thus, the tool 22 may be especially useful for interconnection between the packer 16 and the upper perforating gun 20, although the tool 22 could be used in other positions and in other well systems in keeping with the principles of this disclosure.

In FIG. 6 it may be seen that a removable cover 70 is used to house the electronics package 46, batteries 52, etc. In FIG. 8, the cover 70 is removed, and it may be seen that the temperature sensor 58 is included with the electronics package 46 in this example. The accelerometer 60 could also be part of the electronics package 46, or could otherwise be located in the chamber 48 under the cover 70.

A relatively thin protective sleeve 72 is used to prevent damage to the strain sensors 38, which are attached to an exterior of the structure 40 (see FIG. 8, in which the sleeve is removed, so that the strain sensors are visible). Although in this example the structure 40 is not pressure balanced, another pressure sensor 74 (see FIG. 7) can be used to monitor pressure in the passage 68, so that any

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contribution of the pressure differential across the structure 40 to the strain sensed by the strain sensors 38 can be readily determined (e.g., the effective strain due to the pressure differential across the structure 40 is
5 subtracted from the measured strain, to yield the strain due to structural loading alone).

Note that there is preferably no pressure differential across the sleeve 72, and a suitable substance (such as silicone oil, etc.) is preferably used to fill the annular
10 space between the sleeve and the structure 40. The sleeve 72 is not rigidly secured at one or both of its ends, so that it does not share loads with, or impart loads to, the structure 40.

Any of the sensors described above for use with the
15 tool 22 configuration of FIGS. 2-5 may also be used with the tool configuration of FIGS. 6-8.

In general, it is preferable for the structure 40 (in which loading is measured by the strain sensors 38) to experience dynamic loading due only to structural shock by way of being pressure balanced, as in the configuration of
20 FIGS. 2-5. However, other configurations are possible in which this condition can be satisfied. For example, a pair of pressure isolating sleeves could be used, one external to, and the other internal to, the load bearing structure 40
25 of the FIGS. 6-8 configuration. The sleeves could encapsulate air at atmospheric pressure on both sides of the structure 40, effectively isolating the structure from the loading effects of differential pressure. The sleeves should be strong enough to withstand the pressure in the
30 well, and may be sealed with o-rings or other seals on both ends. The sleeves may be structurally connected to the tool

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at no more than one end, so that a secondary load path around the strain sensors 38 is prevented.

Although the perforating string 12 described above is of the type used in tubing-conveyed perforating, it should be clearly understood that the principles of this disclosure are not limited to tubing-conveyed perforating. Other types of perforating (such as, perforating via coiled tubing, wireline or slickline, etc.) may incorporate the principles described herein. Note that the packer 16 is not necessarily a part of the perforating string 12.

With measurements obtained by use of shock sensing tools 22, a shock model can be precisely calibrated, so that it can be applied to proposed perforating system designs, in order to improve those designs (e.g., by preventing failure of, or damage to, any perforating system components, etc.), to optimize the designs in terms of performance, efficiency, effectiveness, etc., and/or to generate optimized designs.

In FIG. 9, a flowchart for the method 80 is representatively illustrated. The method 80 depicted in flowchart form in FIG. 9 can be used with the system 10 described above, or it may be used with a variety of other systems.

In step 82, a planned or proposed perforating job is modeled. Preferably, at least the perforating string 12 and wellbore 14 are modeled geometrically in three dimensions, including material types of each component, expected wellbore communication with the formation 26 upon perforating, etc. Finite element models can be used for the structural elements of the system 10.

Suitable finite element modeling software is LS-DYNA(TM) available from Livermore Software Technology Corporation. This software can utilize shaped charge

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models, multiple shaped charge interaction models, flow through permeable rock models, etc.

5 In steps 90, 84, 86, 87, 88, the perforating string 12 is optimized using the shock model. Various metrics may be used for this optimization process. For example, performance, cost-effectiveness, efficiency, reliability, and/or any other metric may be maximized by use of the shock model.

10 Optimization may also include improving the safety margins for failure as a trade-off with other performance metrics. In one example, it may be desired to have tubing above the perforating guns 20 as short as practical, but failure risks may require that the tubing be longer. So there is a trade-off, and an accurate shock model can help
15 in selecting an appropriate length for the tubing.

Optimization is an iterative process of running shock model simulations and modifying the perforating job design as needed to improve upon a valued performance metric. Each iteration of modifying the design influences the response of
20 the system to shock and, thus, requires that the failure criteria be checked every iteration of the optimization process.

In step 90, the shock produced by the perforating string 12 and its effects on the various components of the
25 perforating string are predicted by running a shock model simulation of the perforating job. For example, the perforating system can be input to the shock model to obtain a prediction of stresses, strains, pressures, loading, motion, etc., in the perforating string 12.

30 Based on the outcome of applying failure criteria to these predictions in step 84 and the desire to optimize the design further, the perforating string 12 can be modified in

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step 88 as needed to enhance the performance, cost-effectiveness, efficiency, reliability, etc., of the perforating system.

5 The modified perforating string 12 can then be input into the shock model to obtain another prediction, and another modification of the perforation string can be made based on the prediction. This process can be repeated as many times as needed to obtain an acceptable level of performance, cost-effectiveness, efficiency, reliability,
10 etc., for the perforating system.

Once the perforating string 12 and overall perforating system are optimized, in step 92 an actual perforating string is installed in the wellbore 14. The actual perforating string 12 should be the same as the perforating
15 string model, the actual wellbore 14 should be the same as the modeled wellbore, etc., used in the shock model to produce the prediction in step 90.

In step 94, the shock sensing tool(s) 22 wait for a trigger signal to start recording measurements. As
20 described above, the trigger signal can be any signal which can be detected by the shock sensing tool 22 (e.g., a certain pressure level, a certain pattern of pressure levels, pipe manipulation, a telemetry signal, etc.).

In step 96, the perforating event occurs, with the
25 perforating guns 20 being detonated, thereby forming the perforations 24 and initiating fluid communication between the formation 26 and the wellbore 14. Concurrently with the perforating event, the shock sensing tool(s) 22 in step 98 record various measurements, such as, strains, pressures,
30 temperatures, accelerations, etc. Any measurements or combination of measurements may be taken in this step.

In step 100, the shock sensing tools 22 are retrieved from the wellbore 14. This enables the recorded measurement data to be downloaded to a database in step 102. In other examples, the data could be retrieved by telemetry, by a
5 wireline sonde, etc., without retrieving the shock sensing tools 22 themselves, or the remainder of the perforating string 12, from the wellbore.

In step 104, the measurement data is compared to the predictions made by the shock model in step 90. If the
10 predictions made by the shock model do not acceptably match the measurement data, appropriate adjustments can be made to the shock model in step 106 and a new set of predictions generated by running a simulation of the adjusted shock model. If the predictions made by the adjusted shock model
15 still do not acceptably match the measurement data, further adjustments can be made to the shock model, and this process can be repeated until an acceptable match is obtained.

Once an acceptable match is obtained, the shock model can be considered calibrated and ready for use with the next
20 perforating job. Each time the method 80 is performed, the shock model should become more adept at predicting loads, stresses, pressures, motions, etc., for a perforating system, and so should be more useful in optimizing the perforating string to be used in the system.

25 Over the long term, a database of many sets of measurement data and predictions can be used in a more complex comparison and adjustment process, whereby the shock model adjustments benefit from the accumulated experience represented by the database. Thus, adjustments to the shock
30 model can be made based on multiple sets of measurement data and predictions.

Referring additionally now to FIG. 10, a block diagram of the shock model 110 and associated well model 112, perforating string model 114 and output predictions 116 are representatively illustrated. As described above, the shock model 110 utilizes the model 112 of the well (including, for example, the geometry of the wellbore 14, the characteristics of the formation 26, the fluid in the wellbore, flow through permeable rock models, etc.) and the model 114 of the perforating string 12 (including, for example, the geometries of the various perforating string components, shaped charge models, shaped charge interaction models, etc.), in order to produce the predictions 116 of loads, stresses, pressures, motions, etc. in the well system 10.

The perforating string 12, wellbore 14 (including, e.g., casing and cement lining the wellbore), fluid in the wellbore, formation 26, and other well components are preferably precisely modeled in three dimensions in high resolution using finite element modeling techniques. For example, the perforating guns 20 can be modeled along with their associated gun body scallops, thread reliefs, etc.

Deviation of the wellbore 14 can be modeled. This is used in predicting contact loads, friction and other interactions between the perforating string 12 and the wellbore 14.

The fluid in the wellbore 14 can be modeled. The modeled wellbore fluid is the link between the pressures generated by the shaped charges, formation communication, and the perforating string 12 structural model. The wellbore fluid can be modeled in one dimension or, preferably, in three dimensions. Modeling of the wellbore fluid can also be described as a fluid-structure interaction

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model, a term that refers to the loads applied to the structure by the fluid.

Failures can also occur as a result of high pressures or pressure waves. So it is important for the model to
5 predict the fluid behavior for the reasons that the fluid loads the structure and the fluid itself can damage the packer or casing directly.

A three dimensional shaped charge model can be used for predicting internal gun pressures and distributions, impact
10 loads of charge cases on interiors of the gun bodies, charge interaction effects, etc.

The shock model 110 can include neural networks, genetic algorithms, and/or any combination of numerical methods to produce the predictions. One particular benefit
15 of the method 80 described above is that the accuracy of the predictions 116 produced by the shock model 110 can be improved by utilizing the actual measurements of the effects of shock taken by the shock sensing tool(s) 22 during a perforating event. The shock model 110 is preferably
20 validated and calibrated using the measurements of actual perforating effects by the shock sensing tool(s) 22 in the perforating string 12.

The shock model 110 and/or shock sensing tool 22 can be useful in failure investigation, that is, to determine why
25 damage or failure occurred on a particular perforating job.

The shock model 110 can be used to optimize the perforating string 12 design, for example, to maximize performance, to minimize stresses, motion, etc., in the perforating string, to provide an acceptable margin of
30 safety against structural damage or failure, etc.

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In the application of failure criteria to the predictions generated by the shock model 110, typical metrics, such as material static yield strength, may be used and/or more complex parameters that relate to strain rate-
5 dependent effects that affect crack growth may be used. Dynamic fracture toughness is a measure of crack growth under dynamic loading. Stress reversals result when loading shifts between compression and tension. Repeated load cycles can result in fatigue. Thus, the application of
10 failure criteria may involve more than simply a stress versus strength metric.

The shock model 110 can incorporate other tools that may have more complex behavior that can affect the model's predictions. For example, advanced gun connectors have been
15 modeled specifically because they exhibit a nonlinear behavior that has a large effect on predictions.

It may now be fully appreciated that the above disclosure provides several advancements to the art. The shock model 110 can be used to predict the effects of a
20 perforating event on various components of the perforating string 14, and to investigate a failure of, or damage to, an actual perforating string. In the method 80 described above, the shock model 110 can also be used to optimize the design of the perforating string 14.

25 The above disclosure provides to the art a method 80 of utilizing a shock model 110 for prediction of perforating effects. The method 80 can include recording measurements of the perforating effects on an actual perforating string 12 in a wellbore 14; adjusting the shock model 110 so that
30 predictions of the perforating effects output by the shock model 110 substantially match the measurements of the perforating effects; and causing the adjusted shock model

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110 to predict the perforating effects for a proposed perforating string 12.

The recorded measurements may include axial, bending and torsional strain in the actual perforating string 12.

5 The recorded measurements may also include pressure external to, internal to, and/or in a perforating gun 20 of, the actual perforating string 12.

Adjusting the shock model can include repeatedly: a) receiving a comparison of the predictions of the perforating effects to the measurements of the perforating effects, and
10 b) adjusting the shock model 110 to reduce differences between the predictions of the perforating effects and the measurements of the perforating effects, until the differences are acceptably reduced.

15 The method may include, prior to the recording step, inputting a three dimensional geometrical model 114 of the actual perforating string 12 into the shock model 110.

The method may include, after the adjusting step and prior to the causing step, inputting a three dimensional
20 model 114 of the proposed perforating string 12 into the shock model 110.

The predictions of the perforating effects can include stresses along the actual perforating string 12, motions along the actual perforating string 12, and/or interactions
25 between the actual perforating string 12 and the wellbore 14. The interactions between the actual perforating string 12 and the wellbore 14 may include contact loads and friction between the actual perforating string 12 and the wellbore 14.

30 The above disclosure also describes a method 80 of predicting perforating effects on a perforating string 12 in

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a wellbore 14. The method 80 can include inputting a three dimensional well model 112 and a three dimensional model 114 of the perforating string 12 into a shock model 110; and causing the shock model 110 to predict the perforating effects on the perforating string 12.

The three dimensional model 114 of the perforating string 12 may include a model of one or more shock sensing tools 22 interconnected in the perforating string 12.

The three dimensional model 114 of the perforating string 12 may include material properties of components of the perforating string 12.

The method 80 can include measuring the perforating effects on the perforating string 12 caused by detonation of perforating guns 20.

The method 80 may include adjusting the shock model 110 so that the predicted perforating effects output by the shock model 110 substantially match the measurements of the perforating effects.

The perforating effects can include at least axial, bending and torsional strain in the perforating string 12. The perforating effects may include stresses along the perforating string 12, motions along the perforating string 12, and/or interactions between the perforating string 12 and the wellbore 14. The interactions between the perforating string 12 and the wellbore 14 can include contact loads and friction between the perforating string 12 and the wellbore 14.

It is to be understood that the various embodiments described herein may be utilized in various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the

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principles of the present disclosure. The embodiments are described merely as examples of useful applications of the principles of the disclosure, which is not limited to any specific details of these embodiments.

5 In the above description of the representative
embodiments, directional terms, such as "above," "below,"
"upper," "lower," etc., are used for convenience in
referring to the accompanying drawings. In general,
"above," "upper," "upward" and similar terms refer to a
10 direction toward the earth's surface along a wellbore, and
"below," "lower," "downward" and similar terms refer to a
direction away from the earth's surface along the wellbore.

Of course, a person skilled in the art would, upon a
careful consideration of the above description of
15 representative embodiments of the disclosure, readily
appreciate that many modifications, additions,
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,
20 the foregoing detailed description is to be clearly
understood as being given by way of illustration and example
only, the spirit and scope of the present invention being
limited solely by the appended claims and their equivalents.

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WHAT IS CLAIMED IS:

1. A method of utilizing a shock model for prediction of perforating effects, the method comprising:

5 recording measurements of the perforating effects on an actual perforating string in a wellbore;

adjusting the shock model so that predictions of the perforating effects output by the shock model substantially match the measurements of the perforating effects; and

10 causing the adjusted shock model to predict the perforating effects for a proposed perforating string.

2. The method of claim 1, wherein the recorded measurements include axial, bending and torsional strain in
15 the actual perforating string.

3. The method of claim 1, wherein the recorded measurements include pressure external to the actual perforating string.

20 4. The method of claim 1, wherein the recorded measurements include pressure internal to the actual perforating string.

25 5. The method of claim 1, wherein the recorded measurements include pressure internal to a perforating gun of the actual perforating string.

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6. The method of claim 1, wherein adjusting the shock model further comprises repeatedly: a) receiving a comparison of the predictions of the perforating effects to the measurements of the perforating effects, and b)
5 adjusting the shock model to reduce differences between the predictions of the perforating effects and the measurements of the perforating effects, until the differences are acceptably reduced.

10 7. The method of claim 1, further comprising, prior to the recording step, inputting a three dimensional geometrical model of the actual perforating string into the shock model.

15 8. The method of claim 1, further comprising, after the adjusting step and prior to the causing step, inputting a three dimensional model of the proposed perforating string into the shock model.

20 9. The method of claim 1, wherein the predictions of the perforating effects include stresses along the actual perforating string.

25 10. The method of claim 1, wherein the predictions of the perforating effects include motions along the actual perforating string.

30 11. The method of claim 1, wherein the predictions of the perforating effects include interactions between the actual perforating string and the wellbore.

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12. The method of claim 11, wherein the interactions
between the actual perforating string and the wellbore
include contact loads and friction between the actual
5 perforating string and the wellbore.

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13. A method of predicting perforating effects on a perforating string in a wellbore, the method comprising:

inputting a three dimensional well model and a three dimensional model of the perforating string into a shock model; and

causing the shock model to predict the perforating effects on the perforating string.

10 14. The method of claim 13, wherein the three dimensional model of the perforating string includes a model of a shock sensing tool interconnected in the perforating string.

15 15. The method of claim 13, wherein the three dimensional model of the perforating string includes a model of multiple shock sensing tools interconnected in the perforating string.

20 16. The method of claim 13, wherein the three dimensional model of the perforating string includes material properties of components of the perforating string.

25 17. The method of claim 13, further comprising measuring the perforating effects on the perforating string caused by detonation of perforating guns.

18. The method of claim 17, further comprising adjusting the shock model so that the predicted perforating

effects output by the shock model substantially match the measurements of the perforating effects.

19. The method of claim 13, wherein the perforating effects include at least axial loads in the perforating string.

20. The method of claim 19, wherein the perforating effects further include bending loads in the perforating string.

21. The method of claim 20, wherein the perforating effects further include torsional loads in the perforating string.

22. The method of claim 13, wherein the perforating effects include stresses along the perforating string.

23. The method of claim 13, wherein the perforating effects include motions along the perforating string.

24. The method of claim 13, wherein the perforating effects include interactions between the perforating string and the wellbore.

25. The method of claim 24, wherein the interactions between the perforating string and the wellbore include contact loads and friction between the perforating string and the wellbore.

ABSTRACT

5 A method of utilizing a shock model for prediction of
the perforating effects can include recording measurements of
the perforating effects on an actual perforating string in a
wellbore, adjusting the shock model so that predictions of
the perforating effects output by the shock model
substantially match the measurements of the perforating
10 effects, and causing the adjusted shock model to predict the
perforating effects for a proposed perforating string. A
method of predicting perforating effects on a perforating
string in a wellbore can include inputting a three
dimensional well model and a three dimensional model of the
15 perforating string into a shock model, and causing the shock
model to predict the perforating effects on the perforating
string.

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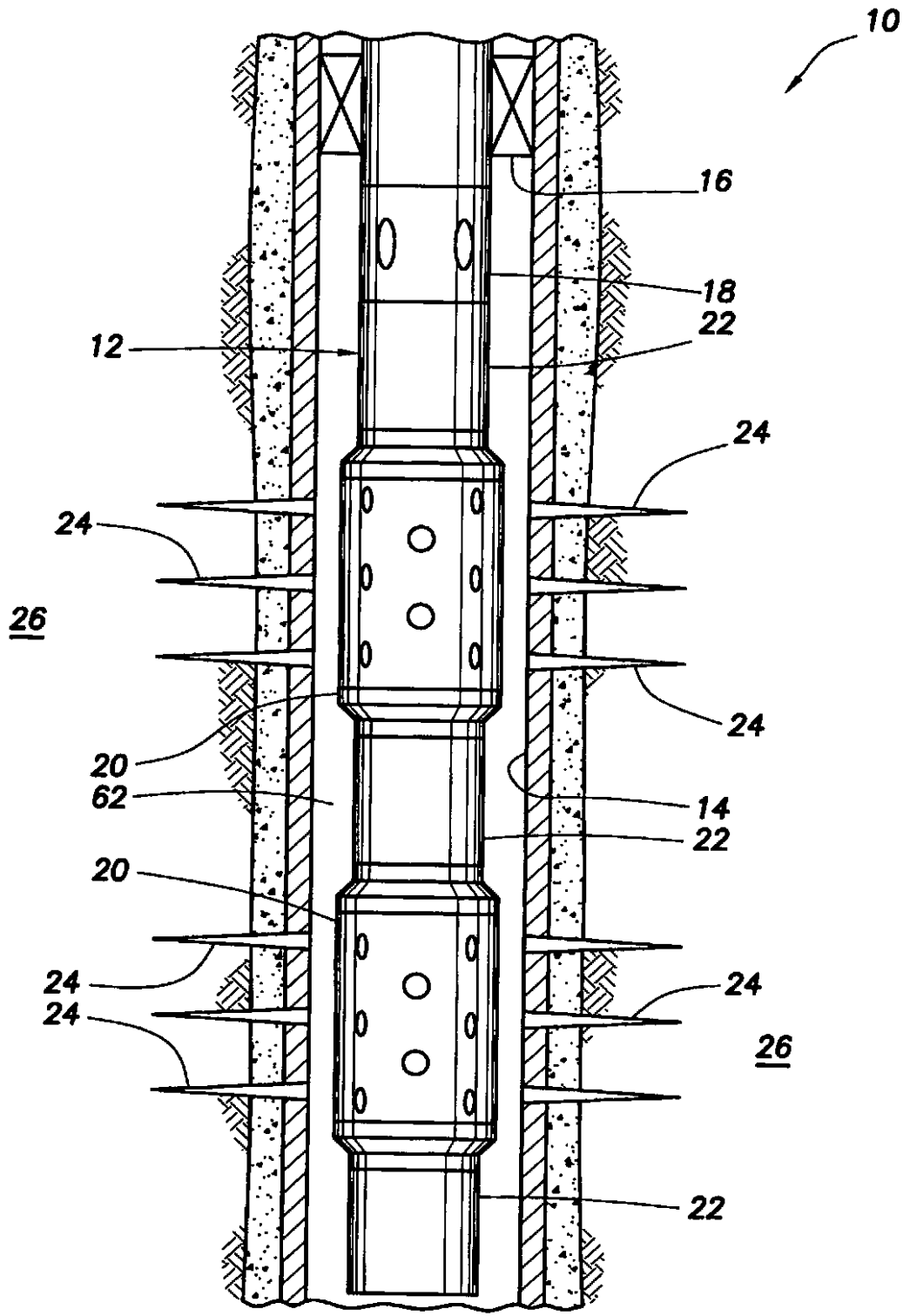
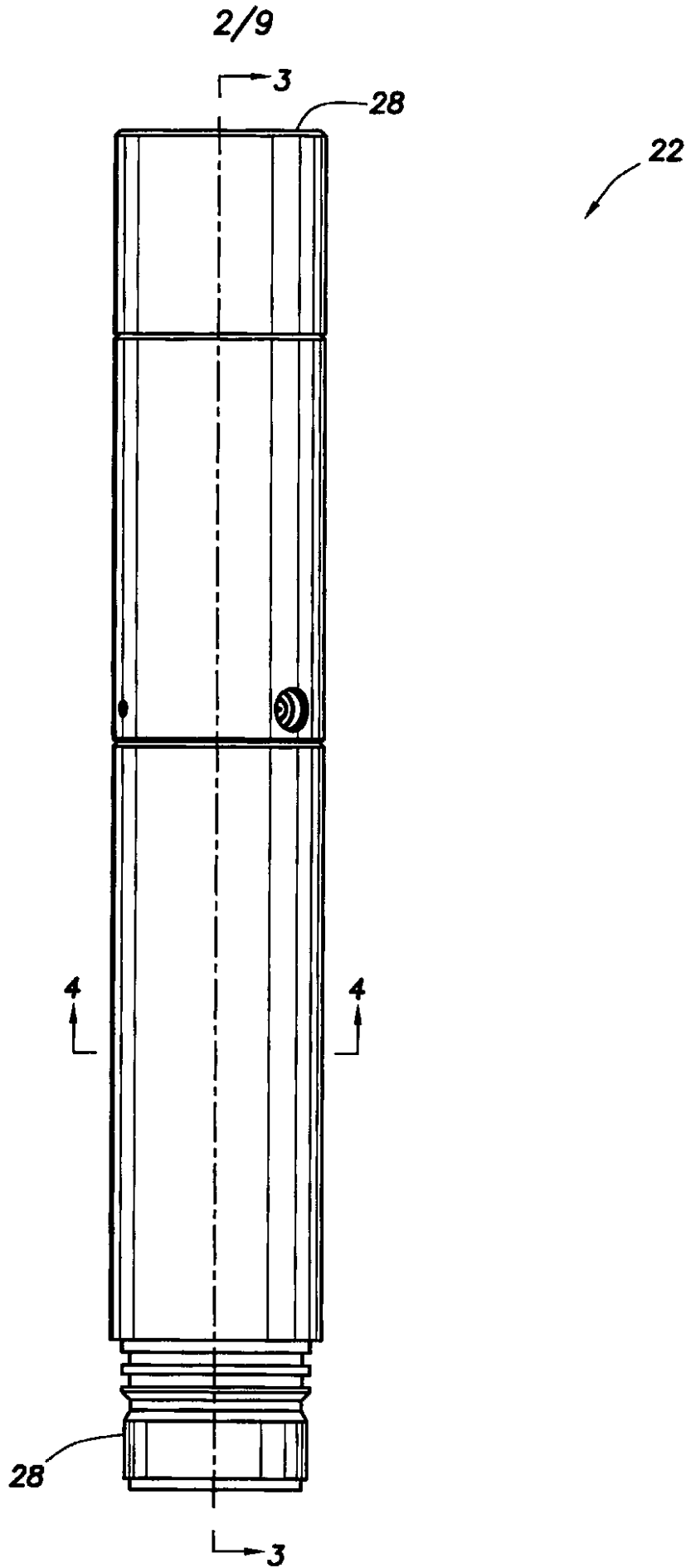


FIG.1

FIG.2



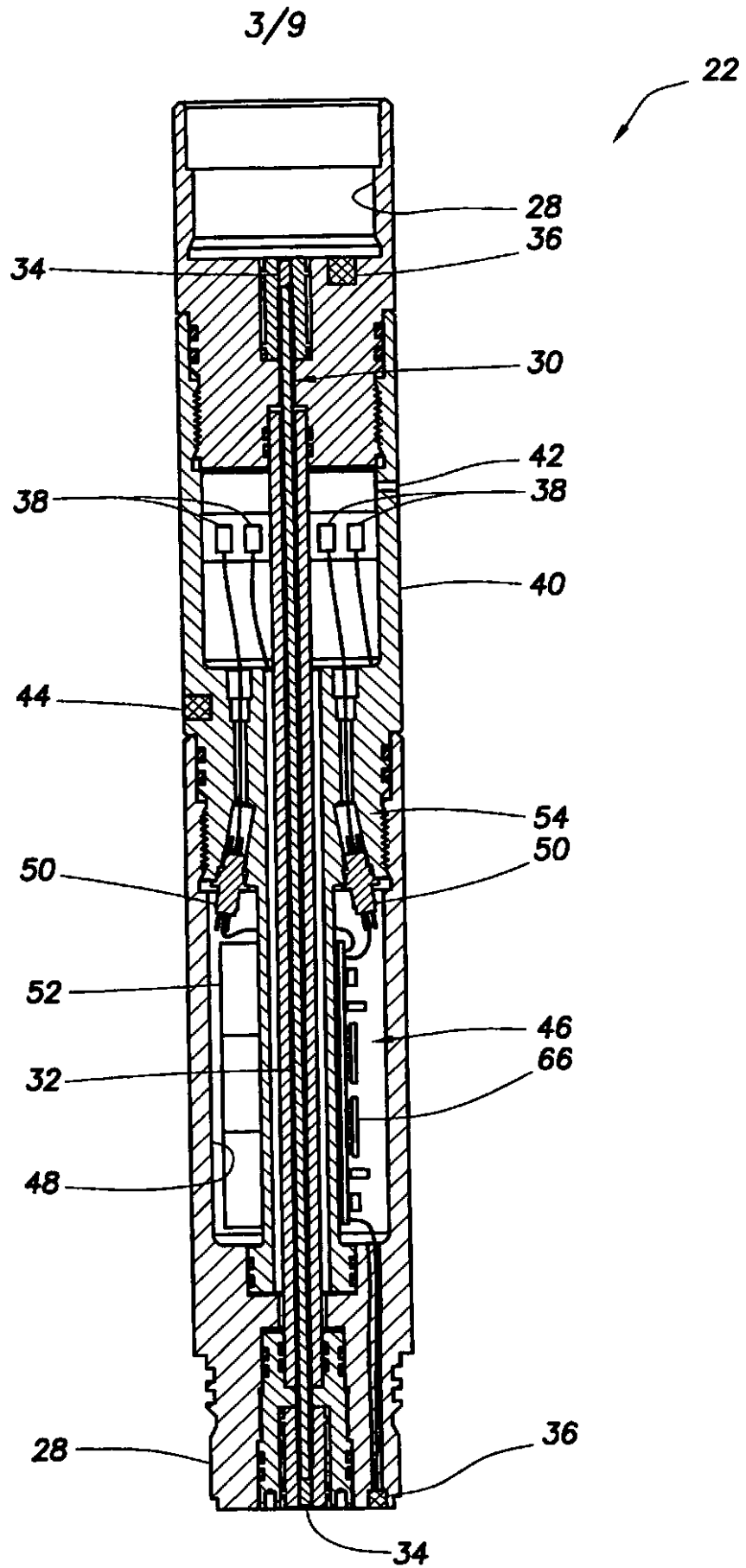


FIG. 3

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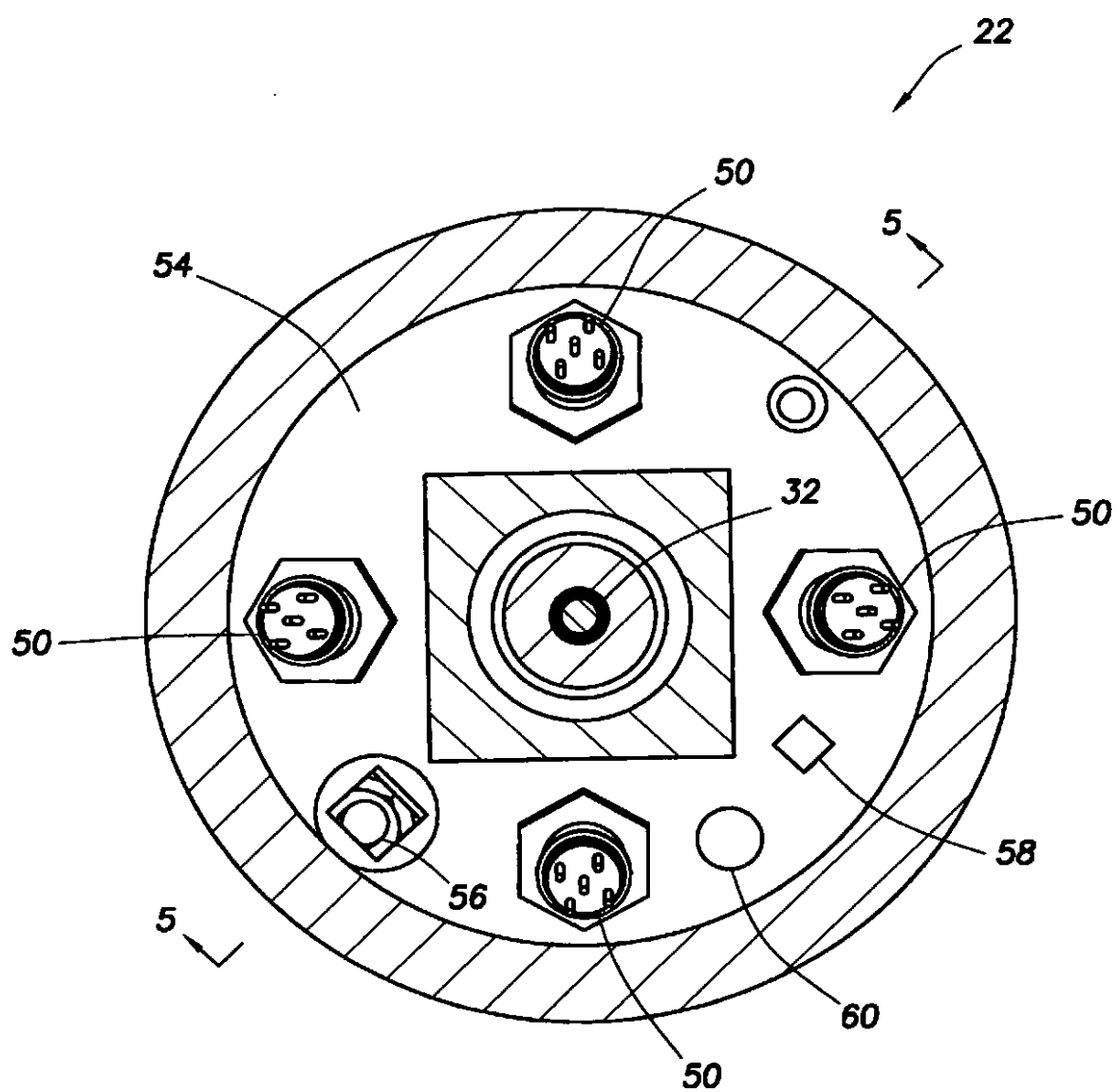


FIG. 4

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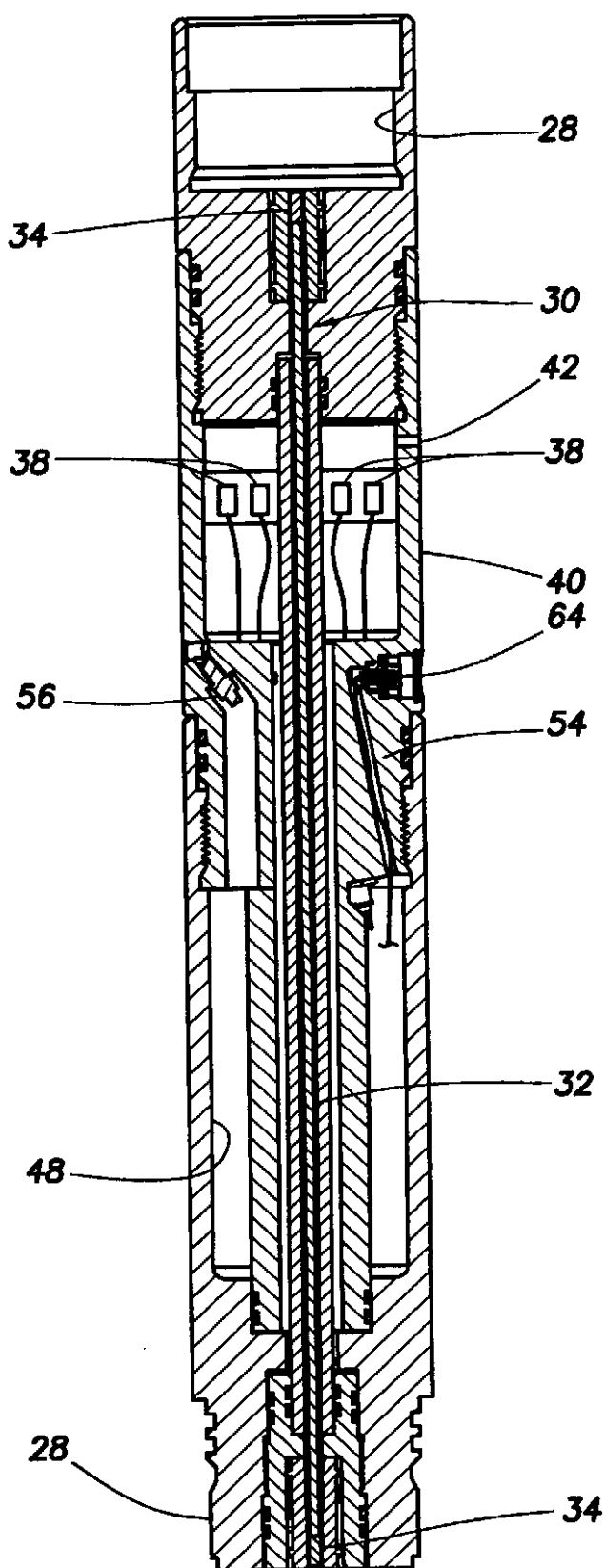


FIG.5

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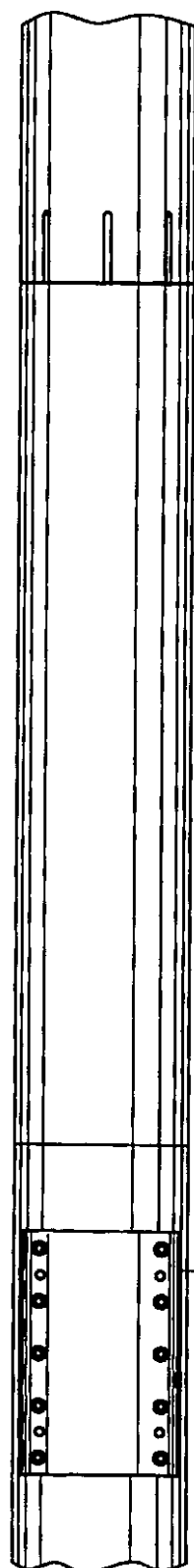
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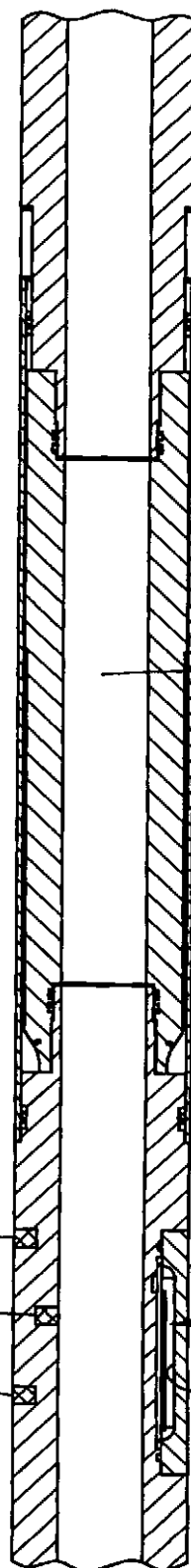


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FIG. 6



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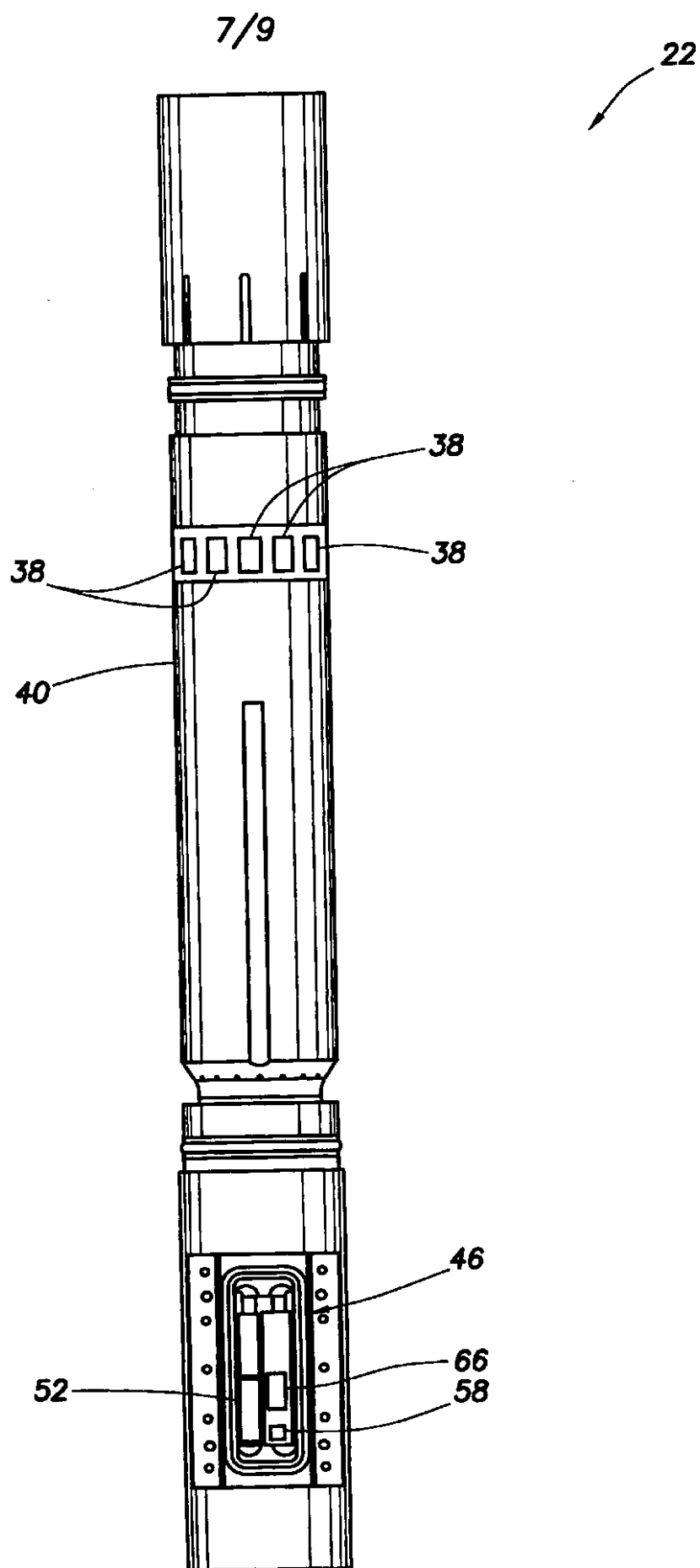
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FIG. 7

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FIG. 8



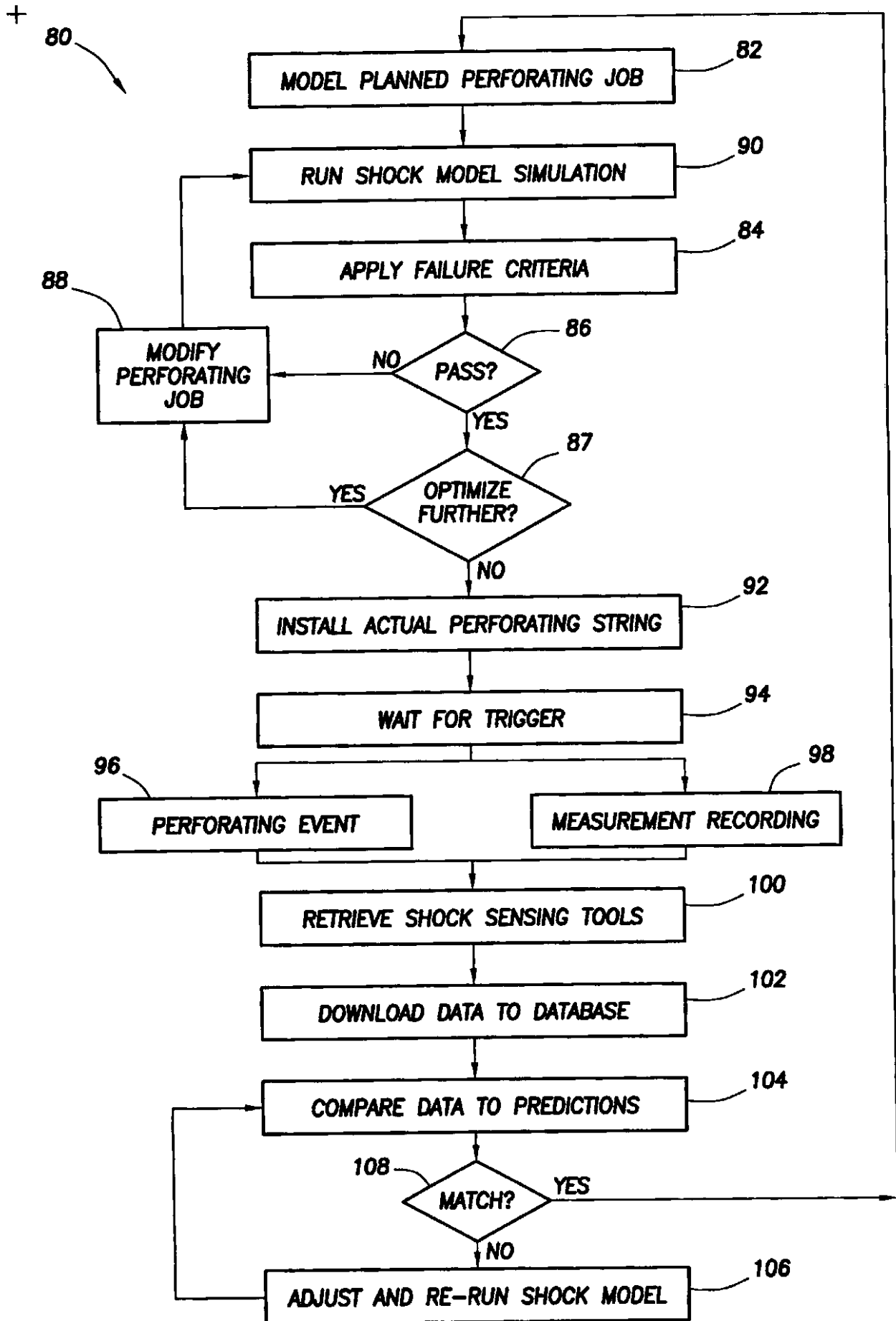


FIG.9

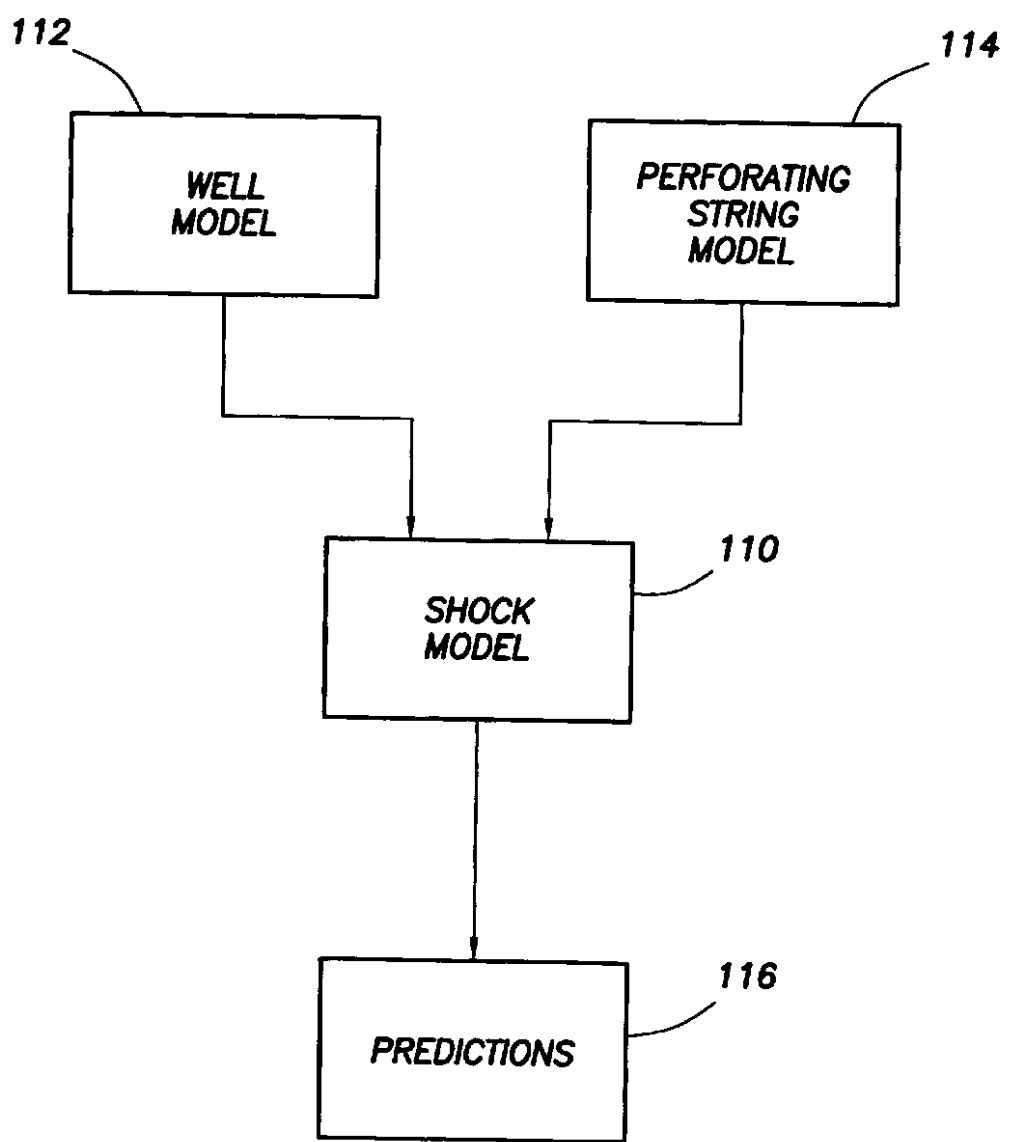
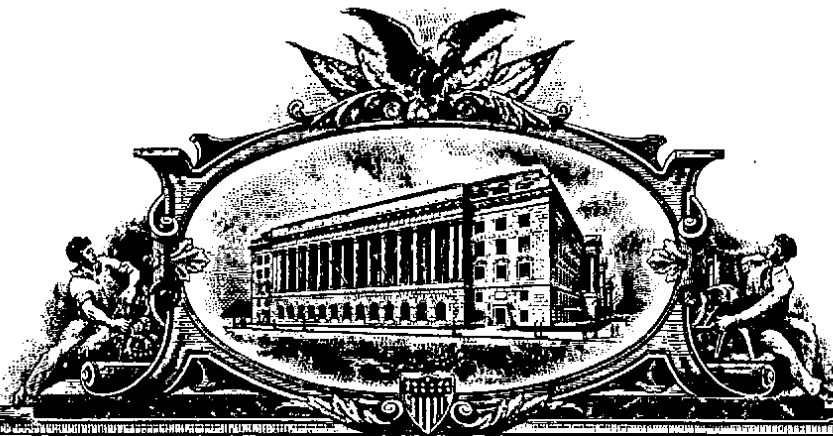


FIG.10

P2 1861270



THE UNITED STATES OF AMERICA

**TO ALL TO WHOM THESE PRESENTS SHALL COME:
UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office**

November 04, 2011

**THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY OF
THE BELOW IDENTIFIED INTERNATIONAL APPLICATION AS
ORIGINALLY FILED AND ANY CORRECTIONS THERETO FROM THE
RECORDS OF THE UNITED STATES PATENT AND TRADEMARK
OFFICE ACTING AS A RECEIVING OFFICE UNDER THE PATENT
COOPERATION TREATY.**

**APPLICATION NUMBER: PCT/US10/61104
FILING DATE: December 17, 2010**

**By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office**

E. Bornett
E. BORNETT
Certifying Officer



Electronic Acknowledgement Receipt	
EFS ID:	9066486
Application Number:	
International Application Number:	PCT/US10/61104
Confirmation Number:	9198
Title of Invention:	MODELING SHOCK PRODUCED BY WELL PERFORATING
First Named Inventor/Applicant Name:	HALLIBURTON ENERGY SERVICES, INC.
Customer Number:	49431
Correspondence Address:	SMITH IP SERVICES, P.C. - PO Box 997 - Rockwall TX 75087 US 972-516-0030 mail@smithipservices.com
Filer:	Marlin Ray Smith/Sally Ann Smith
Filer Authorized By:	Marlin Ray Smith
Attorney Docket Number:	10-031572U1
Receipt Date:	17-DEC-2010
Filing Date:	
Time Stamp:	17:33:47
Application Type:	International Application for filing in the US receiving office

Payment information:

Submitted with Payment	yes
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Payment was successfully received in RAM		\$2709			
RAM confirmation Number		4650			
Deposit Account					
Authorized User					
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		PatentApplication.pdf	93934 c4b93372521360cc87f0dcf688939f8be6e242190	yes	29
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Information:					
Total Files Size (in bytes):			2068700		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PCT**REQUEST**

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

PCT/US10/61104

International Application No.

International Filing Date

17-12-2010**RO/US**

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum) **10-031572U1****Box No. I TITLE OF INVENTION****MODELING SHOCK PRODUCED BY WELL PERFORATING****Box No. II APPLICANT**☐ This person is also inventor

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

HALLIBURTON ENERGY SERVICES, INC.
10200 Bellaire Boulevard
Houston, Texas 77072
US

Telephone No.

Facsimile No.

Applicant's registration No. with the Office

E-mail authorization: Marking one of the check-boxes below authorizes the receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority to use the e-mail address indicated in this Box to send notifications issued in respect of this international application to that e-mail address if those offices are willing to do so.

☐ as advance copies followed by paper notifications; or☐ exclusively in electronic form (no paper notifications will be sent).

E-mail address:

State (that is, country) of nationality:

US

State (that is, country) of residence:

US

This person is applicant for the purposes of:

☐ all designated States☒ all designated States except the United States of America☐ the United States of America only☐ the States indicated in the Supplemental Box**Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)**☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.**Box No. IV AGENT OR COMMON REPRESENTATIVE, OR ADDRESS FOR CORRESPONDENCE**

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:

☒ agent☐ common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

SMITH, Marlin R.
SMITH IP SERVICES, P.C.
P.O. Box 997
Rockwall, Texas 75087
US

Telephone No.

972-516-0030

Facsimile No.

972-516-0608

Agent's registration No. with the Office

38310

E-mail authorization: Marking one of the check-boxes below authorizes the receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority to use the e-mail address indicated in this Box to send notifications issued in respect of this international application to that e-mail address if those offices are willing to do so.

☒ as advance copies followed by paper notifications; or☐ exclusively in electronic form (no paper notifications will be sent).E-mail address: **mail@smithipservices.com**

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Sheet No. 2

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
<i>If none of the following sub-boxes is used, this sheet should not be included in the request.</i>	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) RODGERS, John 1904 Winter Drive Roanoke, Texas 76262 US	This person is: ☐ applicant only ☒ applicant and inventor ☐ inventor only (If this check-box is marked, do not fill in below.) Applicant's registration No. with the Office:
State (that is, country) of nationality: US	State (that is, country) of residence: US
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) SERRA, Marco Jaegerstrasse 2 Winterthur 8406 CH	This person is: ☐ applicant only ☒ applicant and inventor ☐ inventor only (If this check-box is marked, do not fill in below.) Applicant's registration No. with the Office:
State (that is, country) of nationality: IT	State (that is, country) of residence: CH
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) SWENSON, David 2601 Beltline Road Carrollton, Texas 75006 US	This person is: ☐ applicant only ☒ applicant and inventor ☐ inventor only (If this check-box is marked, do not fill in below.) Applicant's registration No. with the Office:
State (that is, country) of nationality: US	State (that is, country) of residence: US
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) GLENN, Timothy S. 1904 Winter Drive Roanoke, Texas 76262 US	This person is: ☐ applicant only ☒ applicant and inventor ☐ inventor only (If this check-box is marked, do not fill in below.) Applicant's registration No. with the Office:
State (that is, country) of nationality: US	State (that is, country) of residence: US
This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box	
☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.	

Box No. V

DESIGNATIONS

The filing of this request constitutes under Rule 4.9(a) the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.

However,

☐

DE Germany is not designated for any kind of national protection

☐

JP Japan is not designated for any kind of national protection

☐

KR Republic of Korea is not designated for any kind of national protection

(The check-boxes above may only be used to exclude (irrevocably) the designations concerned if, at the time of filing or subsequently under Rule 26bis.1, the international application contains in Box No. VI a priority claim to an earlier national application filed in the particular State concerned, in order to avoid the ceasing of the effect, under the national law, of this earlier national application.)

Box No. VI

PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application: regional Office	international application: receiving Office
item (1)				
item (2)				
item (3)				

☐

Further priority claims are indicated in the Supplemental Box.

☐

The International Bureau is requested to obtain from a digital library, a certified copy of the earlier application(s) (if the earlier application(s) is available to it from a digital library) identified above as:*

☐

all items

☐

item (1)

☐

item (2)

☐

item (3)

☐

other, see Supplemental Box

☐

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (if the earlier application(s) was filed with the Office which for the purposes of this international application is the receiving Office) or to obtain a certified copy of the earlier application(s) from a digital library and transmit a copy of it to the International Bureau (if the earlier application(s) is available to the receiving Office from a digital library), identified above as:*

☐

all items

☐

item (1)

☐

item (2)

☐

item (3)

☐

other, see Supplemental Box

*

Where the certified copy of the earlier application(s) is not stored in a digital library under the number of the earlier application indicated above but under the application number of another application which also claims priority from it, indicate that number in the supplemental sheet (item 4).

Restore the right of priority:

the receiving Office is requested to restore the right of priority for the earlier application(s) identified above or in the Supplemental Box as item(s) (). (See also the Notes to Box No. VI; further information must be provided to support a request to restore the right of priority.)

Incorporation by reference:

where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.

Box No. VII

INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) (if more than one International Searching Authority is competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):

ISA/ KR

Sheet No. ...4...

Continuation of Box No. VII USE OF RESULTS OF EARLIER SEARCH, REFERENCE TO THAT SEARCH

- ☐ The ISA indicated in Box No. VII is requested to take into account the results of the earlier search(es) indicated below (see also Notes to Box VII: use of results of more than one earlier search).

Filing date (day/month/year)

Application Number

Country (or regional Office)

- ☐ **Statement (Rule 4.12(ii)):** this international application is the same, or substantially the same, as the application in respect of which the earlier search was carried out except, where applicable, that it is filed in a different language.

- ☐ **Availability of documents:** the following documents are available to the ISA in a form and manner acceptable to it and therefore do not need to be submitted by the applicant to the ISA (Rule 12bis.1(f)):

- ☐ a copy of the results of the earlier search,*
☐ a copy of the earlier application,
☐ a translation of the earlier application into a language which is accepted by the ISA,
☐ a translation of the results of the earlier search into a language which is accepted by the ISA,
☐ a copy of any document cited in the results of the earlier search. (If known, please indicate below the document(s) available to the ISA):

- ☐ **Transmit copy of results of earlier search and other documents (where the earlier search was not carried out by the ISA indicated above but by the same Office as that which is acting as the receiving Office):** the receiving Office is requested to prepare and transmit to the ISA (Rule 12bis.1(c)):

- ☐ a copy of the results of the earlier search,*
☐ a copy of the earlier application,
☐ a copy of any document cited in the results of the earlier search.

* Where the results of the earlier search are neither available from a digital library nor transmitted by the receiving Office, the applicant is required to submit them to the receiving Office (Rule 12bis.1(a)) (See item 11. in the check-list and also Notes to Box No. VII).

Filing date (day/month/year)

Application Number

Country (or regional Office)

- ☐ **Statement (Rule 4.12(ii)):** this international application is the same, or substantially the same, as the application in respect of which the earlier search was carried out except, where applicable, that it is filed in a different language.

- ☐ **Availability of documents:** the following documents are available to the ISA in a form and manner acceptable to it and therefore do not need to be submitted by the applicant to the ISA (Rule 12bis.1(f)):

- ☐ a copy of the results of the earlier search,*
☐ a copy of the earlier application,
☐ a translation of the earlier application into a language which is accepted by the ISA,
☐ a translation of the results of the earlier search into a language which is accepted by the ISA,
☐ a copy of any document cited in the results of the earlier search. (If known, please indicate below the document(s) available to the ISA):

- ☐ **Transmit copy of results of earlier search and other documents (where the earlier search was not carried out by the ISA indicated above but by the same Office as that which is acting as the receiving Office):** the receiving Office is requested to prepare and transmit to the ISA (Rule 12bis.1(c)):

- ☐ a copy of the results of the earlier search,*
☐ a copy of the earlier application,
☐ a copy of any document cited in the results of the earlier search.

* Where the results of the earlier search are neither available from a digital library nor transmitted by the receiving Office, the applicant is required to submit them to the receiving Office (Rule 12bis.1(a)) (See item 11. in the check-list and also Notes to Box No. VII).

- ☐ Further earlier searches are indicated on a continuation sheet.

Box No. VIII: DECLARATIONS

The following declarations are contained in Boxes Nos. VIII (i) to (v) (mark the applicable check-boxes below and indicate in the right column the number of each type of declaration):

Number of declarations

- | | | | |
|---|--|---|---|
| ☐ Box No. VIII (i) | Declaration as to the identity of the inventor | : | |
| ☒ Box No. VIII (ii) | Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent | : | 1 |
| ☐ Box No. VIII (iii) | Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application | : | |
| ☐ Box No. VIII (iv) | Declaration of inventorship (only for the purposes of the designation of the United States of America) | : | |
| ☐ Box No. VIII (v) | Declaration as to non-prejudicial disclosures or exceptions to lack of novelty | : | |

Box No. VIII (II) DECLARATION: ENTITLEMENT TO APPLY FOR AND BE GRANTED A PATENT

The declaration must conform to the standardized wording provided for in Section 212; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (ii). If this Box is not used, this sheet should not be included in the request.

Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent (Rules 4.17(ii) and 51 bis.1(a)(ii)), in a case where the declaration under Rule 4.17(iv) is not appropriate,
in relation to this international application,

HALLIBURTON ENERGY SERVICES, INC., is entitled to apply for and be granted a patent by virtue of the following:

...HALLIBURTON ENERGY SERVICES, INC., is entitled as employer of the inventor,
SWENSON, David.

...HALLIBURTON ENERGY SERVICES, INC., is entitled as assignee of the inventors,
RODGERS, John, SERRA, Marco, and GLENN, Timothy S.

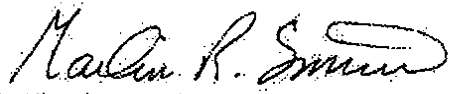
☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (ii)".

Box No. IX CHECK LIST for EFS-Web filings - this sheet is only to be used when filing an international application with RO/US via EFS-Web

This international application contains the following:	Number of sheets	This international application is accompanied by the following item(s) (mark the applicable check-boxes below and indicate in right column the number of each item):	Number of items
(a) request form PCT/RO/101 (including any declarations and supplemental sheets)	6	1. ☒ fee calculation sheet	1
(b) description (excluding any sequence listing part of the description, see (f), below)	23	2. ☐ original separate power of attorney	
(c) claims	5	3. ☐ original general power of attorney	
(d) abstract	1	4. ☐ copy of general power of attorney; reference number:	
(e) drawings (if any)	9	5. ☐ statement explaining lack of signature	
(f) sequence listing part of the description in the form of an image file (e.g. PDF)		6. ☐ priority document(s) identified in Box No. VI as item(s)	
Total number of sheets (including the sequence listing part of the description if filed as an image file)	44	7. ☐ Translation of international application into (language):	
(g) sequence listing part of the description		8. ☐ separate indications concerning deposited microorganism or other biological material	
☐ filed in the form of an Annex C/ST.25 text file		9. ☐ (only where item (f) is marked in the left column) copy of the sequence listing in electronic form (Annex C/ST.25 text file) not forming part of the international application but furnished only for the purposes of international search under Rule 13ter	
☐ WILL BE filed separately on physical data carrier(s), on the same day and in the form of an Annex C/ST.25 text file		10. ☐ (only where item (f) is marked in the left column) a statement confirming that "the information recorded in electronic form submitted under Rule 13ter is identical to the sequence listing as contained in the international application" as filed via EFS-Web:	
Indicate type and number of physical data carrier(s)		11. ☐ copy of results of earlier search(es) (Rule 12bis, 1(a))	
		12. ☒ other (specify): Transmittal, Fee Payment	2

Figure of the drawings which should accompany the abstract:	Language of filing of the international application: English
---	--

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE
 Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).


 Marlin R. Smith
 Agent

For receiving Office use only		2. Drawings: ☐ received: ☐ not received:
1. Date of actual receipt of the purported international application:	17-12-2010	
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:		
4. Date of timely receipt of the required corrections under PCT Article 11(2):		
5. International Searching Authority (if two or more are competent): ISA / KR	6. ☐ Transmittal of search copy delayed until search fee is paid	

For International Bureau use only
Date of receipt of the record copy by the International Bureau:

5

MODELING SHOCK PRODUCED BY WELL PERFORATING

TECHNICAL FIELD

10 The present disclosure relates generally to equipment utilized and operations performed in conjunction with a subterranean well and, in an embodiment described herein, more particularly provides for modeling shock produced by well perforating.

15

BACKGROUND

 Attempts have been made to model the effects of shock due to perforating. It would be desirable to be able to predict shock due to perforating, for example, to prevent
20 unsettling a production packer, to prevent failure of a perforating gun body, and to otherwise prevent or at least reduce damage to various components of a perforating string.

 Unfortunately, past shock models have not been able to predict shock effects in axial, bending and torsional
25 directions, and to apply these shock effects to three dimensional structures, thereby predicting stresses in particular components of the perforating string. One hindrance to the development of such a shock model has been the lack of satisfactory measurements of the strains, loads,

stresses, pressures, and/or accelerations, etc., produced by perforating. Such measurements can be useful in verifying a shock model and refining its output.

Therefore, it will be appreciated that improvements are
5 needed in the art. These improvements can be used, for example, in designing new perforating string components which are properly configured for the conditions they will experience in actual perforating situations, and in preventing damage to any equipment.

10

SUMMARY

In carrying out the principles of the present disclosure, a method is provided which brings improvements to the art of predicting shock produced by well perforating.
15 One example is described below in which the method is used to adjust predictions made by a shock model, in order to make the predictions more precise. Another example is described below in which the shock model is used to optimize a design of a perforating string.

20 A method of utilizing a shock model for prediction of perforating effects is provided by the disclosure below. In one example, the method can include recording measurements of the perforating effects on an actual perforating string in a wellbore; adjusting the shock model so that predictions
25 of the perforating effects output by the shock model substantially match the measurements of the perforating effects; and causing the adjusted shock model to predict the perforating effects for a proposed perforating string.

Also described below is a method of predicting
30 perforating effects on a perforating string in a wellbore. The method can include inputting a three dimensional well

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model and a three dimensional model of the perforating string into a shock model; and causing the shock model to predict the perforating effects on the perforating string.

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 indicated in the various figures using the same reference numbers.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIGS. 2-5 are schematic views of a shock sensing tool which may be used in the system and method of FIG. 1.

FIGS. 6-8 are schematic views of another configuration of the shock sensing tool.

FIG. 9 is a schematic flowchart for the method.

FIG. 10 is a schematic block diagram of a shock model, along with its inputs and outputs.

DETAILED DESCRIPTION

Representatively illustrated in FIG. 1 is a well system 10 and associated method which can embody principles of the present disclosure. In the well system 10, a perforating string 12 is installed in a wellbore 14. The depicted perforating string 12 includes a packer 16, a firing head 18, perforating guns 20 and shock sensing tools 22.

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In other examples, the perforating string 12 may include more or less of these components. For example, well screens and/or gravel packing equipment may be provided, any number (including one) of the perforating guns 20 and shock
5 sensing tools 22 may be provided, etc. Thus, it should be clearly understood that the well system 10 as depicted in FIG. 1 is merely one example of a wide variety of possible well systems which can embody the principles of this disclosure.

10 A shock model can use a three dimensional model of the perforating string 12 and wellbore 14 to realistically model the physical behavior of the system 10 during a perforating event. Preferably, the shock model will predict at least bending, torsional and axial loading, as well as motion in
15 all directions (three dimensional motion). The model can include predictions of casing contact and friction, and the loads that result from it.

In a preferred example, detailed finite element models of the components of the perforating string 12 enable a
20 higher fidelity prediction of stresses in the components. Wellbore pressure dynamics and communication with a formation can also be incorporated into the model.

The shock model is preferably calibrated using actual perforating string loads and accelerations, as well as
25 wellbore pressures, collected from one or more of the shock sensing tools 22. Measurements taken by the shock sensing tools 22 can be used to verify the predictions made by the shock model, and to make adjustments to the shock model, so that future predictions are more accurate.

30 The shock sensing tool 22 can be as described in the International patent application entitled, "Sensing Shock During Well Perforating," filed on even date herewith. That

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patent application discloses that the shock sensing tools 22 can be interconnected in various locations along the perforating string 12.

One advantage of interconnecting the shock sensing tools 22 below the packer 16 and in close proximity to the perforating guns 20 is that more accurate measurements of strain and acceleration at the perforating guns can be obtained. Pressure and temperature sensors of the shock sensing tools 22 can also sense conditions in the wellbore 14 in close proximity to perforations 24 immediately after the perforations are formed, thereby facilitating more accurate analysis of characteristics of an earth formation 26 penetrated by the perforations.

A shock sensing tool 22 interconnected between the packer 16 and the upper perforating gun 20 can record the effects of perforating on the perforating string 12 above the perforating guns. This information can be useful in preventing unsetting or other damage to the packer 16, firing head 18, etc., due to detonation of the perforating guns 20 in future designs.

A shock sensing tool 22 interconnected between perforating guns 20 can record the effects of perforating on the perforating guns themselves. This information can be useful in preventing damage to components of the perforating guns 20 in future designs.

A shock sensing tool 22 can be connected below the lower perforating gun 20, if desired, to record the effects of perforating at this location. In other examples, the perforating string 12 could be stabbed into a lower completion string, connected to a bridge plug or packer at the lower end of the perforating string, etc., in which case the information recorded by the lower shock sensing tool 22

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could be useful in preventing damage to these components in future designs.

Viewed as a complete system, the placement of the shock sensing tools 22 longitudinally spaced apart along the perforating string 12 allows acquisition of data at various points in the system, which can be useful in validating a model of the system. Thus, collecting data above, between and below the guns, for example, can help in an understanding of the overall perforating event and its effects on the system as a whole.

The information obtained by the shock sensing tools 22 is not only useful for future designs, but can also be useful for current designs, for example, in post-job analysis, formation testing, etc. The applications for the information obtained by the shock sensing tools 22 are not limited at all to the specific examples described herein.

Referring additionally now to FIGS. 2-5, one example of the shock sensing tool 22 is representatively illustrated. As depicted in FIG. 2, the shock sensing tool 22 is provided with end connectors 28 (such as, perforating gun connectors, etc.) for interconnecting the tool in the perforating string 12 in the well system 10. However, other types of connectors may be used, and the tool 22 may be used in other perforating strings and in other well systems, in keeping with the principles of this disclosure.

In FIG. 3, a cross-sectional view of the shock sensing tool 22 is representatively illustrated. In this view, it may be seen that the tool 22 includes a variety of sensors, and a detonation train 30 which extends through the interior of the tool.

The detonation train 30 can transfer detonation between perforating guns 20, between a firing head (not shown) and a

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perforating gun, and/or between any other explosive components in the perforating string 12. In the example of FIGS. 2-5, the detonation train 30 includes a detonating cord 32 and explosive boosters 34, but other components may
5 be used, if desired.

One or more pressure sensors 36 may be used to sense pressure in perforating guns, firing heads, etc., attached to the connectors 28. Such pressure sensors 36 are preferably ruggedized (e.g., to withstand ~20000 g
10 acceleration) and capable of high bandwidth (e.g., >20 kHz). The pressure sensors 36 are preferably capable of sensing up to ~60 ksi (~414 MPa) and withstanding ~175 degrees C. Of course, pressure sensors having other specifications may be used, if desired.

15 Strain sensors 38 are attached to an inner surface of a generally tubular structure 40 interconnected between the connectors 28. The structure 40 is preferably pressure balanced, i.e., with substantially no pressure differential being applied across the structure.

20 In particular, ports 42 are provided to equalize pressure between an interior and an exterior of the structure 40. By equalizing pressure across the structure 40, the strain sensor 38 measurements are not influenced by any differential pressure across the structure before,
25 during or after detonation of the perforating guns 20.

The strain sensors 38 are preferably resistance wire-type strain gauges, although other types of strain sensors (e.g., piezoelectric, piezoresistive, fiber optic, etc.) may be used, if desired. In this example, the strain sensors 38
30 are mounted to a strip (such as a KAPTON(TM) strip) for precise alignment, and then are adhered to the interior of the structure 40.

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Preferably, four full Wheatstone bridges are used, with opposing 0 and 90 degree oriented strain sensors being used for sensing axial and bending strain, and +/- 45 degree gauges being used for sensing torsional strain.

5 The strain sensors 38 can be made of a material (such as a KARMA(TM) alloy) which provides thermal compensation, and allows for operation up to ~150 degrees C. Of course, any type or number of strain sensors may be used in keeping with the principles of this disclosure.

10 The strain sensors 38 are preferably used in a manner similar to that of a load cell or load sensor. A goal is to have all of the loads in the perforating string 12 passing through the structure 40 which is instrumented with the sensors 38.

15 Having the structure 40 fluid pressure balanced enables the loads (e.g., axial, bending and torsional) to be measured by the sensors 38, without influence of a pressure differential across the structure. In addition, the detonating cord 32 is housed in a tube 33 which is not
20 rigidly secured at one or both of its ends, so that it does not share loads with, or impart any loading to, the structure 40.

 A temperature sensor 44 (such as a thermistor, thermocouple, etc.) can be used to monitor temperature
25 external to the tool. Temperature measurements can be useful in evaluating characteristics of the formation 26, and any fluid produced from the formation, immediately following detonation of the perforating guns 20. Preferably, the temperature sensor 44 is capable of accurate
30 high resolution measurements of temperatures up to ~170 degrees C.

Another temperature sensor (not shown) may be included with an electronics package 46 positioned in an isolated chamber 48 of the tool 22. In this manner, temperature within the tool 22 can be monitored, e.g., for diagnostic purposes or for thermal compensation of other sensors (for example, to correct for errors in sensor performance related to temperature change). Such a temperature sensor in the chamber 48 would not necessarily need the high resolution, responsiveness or ability to track changes in temperature quickly in wellbore fluid of the other temperature sensor 44.

The electronics package 46 is connected to at least the strain sensors 38 via pressure isolating feed-throughs or bulkhead connectors 50. Similar connectors may also be used for connecting other sensors to the electronics package 46. Batteries 52 and/or another power source may be used to provide electrical power to the electronics package 46.

The electronics package 46 and batteries 52 are preferably ruggedized and shock mounted in a manner enabling them to withstand shock loads with up to ~10000 g acceleration. For example, the electronics package 46 and batteries 52 could be potted after assembly, etc.

In FIG. 4 it may be seen that four of the connectors 50 are installed in a bulkhead 54 at one end of the structure 40. In addition, a pressure sensor 56, a temperature sensor 58 and an accelerometer 60 are preferably mounted to the bulkhead 54.

The pressure sensor 56 is used to monitor pressure external to the tool 22, for example, in an annulus 62 formed radially between the perforating string 12 and the wellbore 14 (see FIG. 1). The pressure sensor 56 may be

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similar to the pressure sensors 36 described above. A suitable pressure transducer is the Kulite model HKM-15-500.

The temperature sensor 58 may be used for monitoring temperature within the tool 22. This temperature sensor 58
5 may be used in place of, or in addition to, the temperature sensor described above as being included with the electronics package 46.

The accelerometer 60 is preferably a piezoresistive type accelerometer, although other types of accelerometers
10 may be used, if desired. Suitable accelerometers are available from Endevco and PCB (such as the PCB 3501A series, which is available in single axis or triaxial packages, capable of sensing up to ~60000 g acceleration).

In FIG. 5, another cross-sectional view of the tool 22
15 is representatively illustrated. In this view, the manner in which the pressure transducer 56 is ported to the exterior of the tool 22 can be clearly seen. Preferably, the pressure transducer 56 is close to an outer surface of the tool, so that distortion of measured pressure resulting
20 from transmission of pressure waves through a long narrow passage is prevented.

Also visible in FIG. 5 is a side port connector 64 which can be used for communication with the electronics package 46 after assembly. For example, a computer can be
25 connected to the connector 64 for powering the electronics package 46, extracting recorded sensor measurements from the electronics package, programming the electronics package to respond to a particular signal or to "wake up" after a selected time, otherwise communicating with or exchanging
30 data with the electronics package, etc.

Note that it can be many hours or even days between assembly of the tool 22 and detonation of the perforating

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guns 20. In order to preserve battery power, the electronics package 46 is preferably programmed to "sleep" (i.e., maintain a low power usage state), until a particular signal is received, or until a particular time period has
5 elapsed.

The signal which "wakes" the electronics package 46 could be any type of pressure, temperature, acoustic, electromagnetic or other signal which can be detected by one or more of the sensors 36, 38, 44, 56, 58, 60. For example,
10 the pressure sensor 56 could detect when a certain pressure level has been achieved or applied external to the tool 22, or when a particular series of pressure levels has been applied, etc. In response to the signal, the electronics package 46 can be activated to a higher measurement
15 recording frequency, measurements from additional sensors can be recorded, etc.

As another example, the temperature sensor 58 could sense an elevated temperature resulting from installation of the tool 22 in the wellbore 14. In response to this
20 detection of elevated temperature, the electronics package 46 could "wake" to record measurements from more sensors and/or higher frequency sensor measurements.

As yet another example, the strain sensors 38 could detect a predetermined pattern of manipulations of the
25 perforating string 12 (such as particular manipulations used to set the packer 16). In response to this detection of pipe manipulations, the electronics package 46 could "wake" to record measurements from more sensors and/or higher frequency sensor measurements.

30 The electronics package 46 depicted in FIG. 3 preferably includes a non-volatile memory 66 so that, even if electrical power is no longer available (e.g., the

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batteries 52 are discharged), the previously recorded sensor measurements can still be downloaded when the tool 22 is later retrieved from the well. The non-volatile memory 66 may be any type of memory which retains stored information when powered off. This memory 66 could be electrically erasable programmable read only memory, flash memory, or any other type of non-volatile memory. The electronics package 46 is preferably able to collect and store data in the memory 66 at >100 kHz sampling rate.

Referring additionally now to FIGS. 6-8, another configuration of the shock sensing tool 22 is representatively illustrated. In this configuration, a flow passage 68 (see FIG. 7) extends longitudinally through the tool 22. Thus, the tool 22 may be especially useful for interconnection between the packer 16 and the upper perforating gun 20, although the tool 22 could be used in other positions and in other well systems in keeping with the principles of this disclosure.

In FIG. 6 it may be seen that a removable cover 70 is used to house the electronics package 46, batteries 52, etc. In FIG. 8, the cover 70 is removed, and it may be seen that the temperature sensor 58 is included with the electronics package 46 in this example. The accelerometer 60 could also be part of the electronics package 46, or could otherwise be located in the chamber 48 under the cover 70.

A relatively thin protective sleeve 72 is used to prevent damage to the strain sensors 38, which are attached to an exterior of the structure 40 (see FIG. 8, in which the sleeve is removed, so that the strain sensors are visible). Although in this example the structure 40 is not pressure balanced, another pressure sensor 74 (see FIG. 7) can be used to monitor pressure in the passage 68, so that any

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contribution of the pressure differential across the structure 40 to the strain sensed by the strain sensors 38 can be readily determined (e.g., the effective strain due to the pressure differential across the structure 40 is subtracted from the measured strain, to yield the strain due to structural loading alone).

Note that there is preferably no pressure differential across the sleeve 72, and a suitable substance (such as silicone oil, etc.) is preferably used to fill the annular space between the sleeve and the structure 40. The sleeve 72 is not rigidly secured at one or both of its ends, so that it does not share loads with, or impart loads to, the structure 40.

Any of the sensors described above for use with the tool 22 configuration of FIGS. 2-5 may also be used with the tool configuration of FIGS. 6-8.

In general, it is preferable for the structure 40 (in which loading is measured by the strain sensors 38) to experience dynamic loading due only to structural shock by way of being pressure balanced, as in the configuration of FIGS. 2-5. However, other configurations are possible in which this condition can be satisfied. For example, a pair of pressure isolating sleeves could be used, one external to, and the other internal to, the load bearing structure 40 of the FIGS. 6-8 configuration. The sleeves could encapsulate air at atmospheric pressure on both sides of the structure 40, effectively isolating the structure from the loading effects of differential pressure. The sleeves should be strong enough to withstand the pressure in the well, and may be sealed with o-rings or other seals on both ends. The sleeves may be structurally connected to the tool

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at no more than one end, so that a secondary load path around the strain sensors 38 is prevented.

Although the perforating string 12 described above is of the type used in tubing-conveyed perforating, it should be clearly understood that the principles of this disclosure are not limited to tubing-conveyed perforating. Other types of perforating (such as, perforating via coiled tubing, wireline or slickline, etc.) may incorporate the principles described herein. Note that the packer 16 is not necessarily a part of the perforating string 12.

With measurements obtained by use of shock sensing tools 22, a shock model can be precisely calibrated, so that it can be applied to proposed perforating system designs, in order to improve those designs (e.g., by preventing failure of, or damage to, any perforating system components, etc.), to optimize the designs in terms of performance, efficiency, effectiveness, etc., and/or to generate optimized designs.

In FIG. 9, a flowchart for the method 80 is representatively illustrated. The method 80 depicted in flowchart form in FIG. 9 can be used with the system 10 described above, or it may be used with a variety of other systems.

In step 82, a planned or proposed perforating job is modeled. Preferably, at least the perforating string 12 and wellbore 14 are modeled geometrically in three dimensions, including material types of each component, expected wellbore communication with the formation 26 upon perforating, etc. Finite element models can be used for the structural elements of the system 10.

Suitable finite element modeling software is LS-DYNA(TM) available from Livermore Software Technology Corporation. This software can utilize shaped charge

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models, multiple shaped charge interaction models, flow through permeable rock models, etc.

5 In steps 90, 84, 86, 87, 88, the perforating string 12 is optimized using the shock model. Various metrics may be used for this optimization process. For example, performance, cost-effectiveness, efficiency, reliability, and/or any other metric may be maximized by use of the shock model.

10 Optimization may also include improving the safety margins for failure as a trade-off with other performance metrics. In one example, it may be desired to have tubing above the perforating guns 20 as short as practical, but failure risks may require that the tubing be longer. So there is a trade-off, and an accurate shock model can help
15 in selecting an appropriate length for the tubing.

Optimization is an iterative process of running shock model simulations and modifying the perforating job design as needed to improve upon a valued performance metric. Each iteration of modifying the design influences the response of
20 the system to shock and, thus, requires that the failure criteria be checked every iteration of the optimization process.

In step 90, the shock produced by the perforating string 12 and its effects on the various components of the
25 perforating string are predicted by running a shock model simulation of the perforating job. For example, the perforating system can be input to the shock model to obtain a prediction of stresses, strains, pressures, loading, motion, etc., in the perforating string 12.

30 Based on the outcome of applying failure criteria to these predictions in step 84 and the desire to optimize the design further, the perforating string 12 can be modified in

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step 88 as needed to enhance the performance, cost-effectiveness, efficiency, reliability, etc., of the perforating system.

5 The modified perforating string 12 can then be input into the shock model to obtain another prediction, and another modification of the perforation string can be made based on the prediction. This process can be repeated as many times as needed to obtain an acceptable level of performance, cost-effectiveness, efficiency, reliability,
10 etc., for the perforating system.

Once the perforating string 12 and overall perforating system are optimized, in step 92 an actual perforating string is installed in the wellbore 14. The actual perforating string 12 should be the same as the perforating
15 string model, the actual wellbore 14 should be the same as the modeled wellbore, etc., used in the shock model to produce the prediction in step 90.

In step 94, the shock sensing tool(s) 22 wait for a trigger signal to start recording measurements. As
20 described above, the trigger signal can be any signal which can be detected by the shock sensing tool 22 (e.g., a certain pressure level, a certain pattern of pressure levels, pipe manipulation, a telemetry signal, etc.).

In step 96, the perforating event occurs, with the
25 perforating guns 20 being detonated, thereby forming the perforations 24 and initiating fluid communication between the formation 26 and the wellbore 14. Concurrently with the perforating event, the shock sensing tool(s) 22 in step 98 record various measurements, such as, strains, pressures,
30 temperatures, accelerations, etc. Any measurements or combination of measurements may be taken in this step.

In step 100, the shock sensing tools 22 are retrieved from the wellbore 14. This enables the recorded measurement data to be downloaded to a database in step 102. In other examples, the data could be retrieved by telemetry, by a
5 wireline sonde, etc., without retrieving the shock sensing tools 22 themselves, or the remainder of the perforating string 12, from the wellbore.

In step 104, the measurement data is compared to the predictions made by the shock model in step 90. If the
10 predictions made by the shock model do not acceptably match the measurement data, appropriate adjustments can be made to the shock model in step 106 and a new set of predictions generated by running a simulation of the adjusted shock model. If the predictions made by the adjusted shock model
15 still do not acceptably match the measurement data, further adjustments can be made to the shock model, and this process can be repeated until an acceptable match is obtained.

Once an acceptable match is obtained, the shock model can be considered calibrated and ready for use with the next
20 perforating job. Each time the method 80 is performed, the shock model should become more adept at predicting loads, stresses, pressures, motions, etc., for a perforating system, and so should be more useful in optimizing the perforating string to be used in the system.

25 Over the long term, a database of many sets of measurement data and predictions can be used in a more complex comparison and adjustment process, whereby the shock model adjustments benefit from the accumulated experience represented by the database. Thus, adjustments to the shock
30 model can be made based on multiple sets of measurement data and predictions.

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Referring additionally now to FIG. 10, a block diagram of the shock model 110 and associated well model 112, perforating string model 114 and output predictions 116 are representatively illustrated. As described above, the shock
5 model 110 utilizes the model 112 of the well (including, for example, the geometry of the wellbore 14, the characteristics of the formation 26, the fluid in the wellbore, flow through permeable rock models, etc.) and the model 114 of the perforating string 12 (including, for
10 example, the geometries of the various perforating string components, shaped charge models, shaped charge interaction models, etc.), in order to produce the predictions 116 of loads, stresses, pressures, motions, etc. in the well system 10.

15 The perforating string 12, wellbore 14 (including, e.g., casing and cement lining the wellbore), fluid in the wellbore, formation 26, and other well components are preferably precisely modeled in three dimensions in high resolution using finite element modeling techniques. For
20 example, the perforating guns 20 can be modeled along with their associated gun body scallops, thread reliefs, etc.

Deviation of the wellbore 14 can be modeled. This is used in predicting contact loads, friction and other interactions between the perforating string 12 and the
25 wellbore 14.

The fluid in the wellbore 14 can be modeled. The modeled wellbore fluid is the link between the pressures generated by the shaped charges, formation communication, and the perforating string 12 structural model. The
30 wellbore fluid can be modeled in one dimension or, preferably, in three dimensions. Modeling of the wellbore fluid can also be described as a fluid-structure interaction

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model, a term that refers to the loads applied to the structure by the fluid.

Failures can also occur as a result of high pressures or pressure waves. So it is important for the model to
5 predict the fluid behavior for the reasons that the fluid loads the structure and the fluid itself can damage the packer or casing directly.

A three dimensional shaped charge model can be used for predicting internal gun pressures and distributions, impact
10 loads of charge cases on interiors of the gun bodies, charge interaction effects, etc.

The shock model 110 can include neural networks, genetic algorithms, and/or any combination of numerical methods to produce the predictions. One particular benefit
15 of the method 80 described above is that the accuracy of the predictions 116 produced by the shock model 110 can be improved by utilizing the actual measurements of the effects of shock taken by the shock sensing tool(s) 22 during a perforating event. The shock model 110 is preferably
20 validated and calibrated using the measurements of actual perforating effects by the shock sensing tool(s) 22 in the perforating string 12.

The shock model 110 and/or shock sensing tool 22 can be useful in failure investigation, that is, to determine why
25 damage or failure occurred on a particular perforating job.

The shock model 110 can be used to optimize the perforating string 12 design, for example, to maximize performance, to minimize stresses, motion, etc., in the perforating string, to provide an acceptable margin of
30 safety against structural damage or failure, etc.

- 20 -

In the application of failure criteria to the predictions generated by the shock model 110, typical metrics, such as material static yield strength, may be used and/or more complex parameters that relate to strain rate-
5 dependent effects that affect crack growth may be used. Dynamic fracture toughness is a measure of crack growth under dynamic loading. Stress reversals result when loading shifts between compression and tension. Repeated load cycles can result in fatigue. Thus, the application of
10 failure criteria may involve more than simply a stress versus strength metric.

The shock model 110 can incorporate other tools that may have more complex behavior that can affect the model's predictions. For example, advanced gun connectors have been
15 modeled specifically because they exhibit a nonlinear behavior that has a large effect on predictions.

It may now be fully appreciated that the above disclosure provides several advancements to the art. The shock model 110 can be used to predict the effects of a
20 perforating event on various components of the perforating string 14, and to investigate a failure of, or damage to, an actual perforating string. In the method 80 described above, the shock model 110 can also be used to optimize the design of the perforating string 14.

25 The above disclosure provides to the art a method 80 of utilizing a shock model 110 for prediction of perforating effects. The method 80 can include recording measurements of the perforating effects on an actual perforating string 12 in a wellbore 14; adjusting the shock model 110 so that
30 predictions of the perforating effects output by the shock model 110 substantially match the measurements of the perforating effects; and causing the adjusted shock model

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110 to predict the perforating effects for a proposed perforating string 12.

The recorded measurements may include axial, bending and torsional strain in the actual perforating string 12.

5 The recorded measurements may also include pressure external to, internal to, and/or in a perforating gun 20 of, the actual perforating string 12.

Adjusting the shock model can include repeatedly: a) receiving a comparison of the predictions of the perforating effects to the measurements of the perforating effects, and
10 b) adjusting the shock model 110 to reduce differences between the predictions of the perforating effects and the measurements of the perforating effects, until the differences are acceptably reduced.

15 The method may include, prior to the recording step, inputting a three dimensional geometrical model 114 of the actual perforating string 12 into the shock model 110.

The method may include, after the adjusting step and prior to the causing step, inputting a three dimensional
20 model 114 of the proposed perforating string 12 into the shock model 110.

The predictions of the perforating effects can include stresses along the actual perforating string 12, motions along the actual perforating string 12, and/or interactions
25 between the actual perforating string 12 and the wellbore 14. The interactions between the actual perforating string 12 and the wellbore 14 may include contact loads and friction between the actual perforating string 12 and the wellbore 14.

30 The above disclosure also describes a method 80 of predicting perforating effects on a perforating string 12 in

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a wellbore 14. The method 80 can include inputting a three dimensional well model 112 and a three dimensional model 114 of the perforating string 12 into a shock model 110; and causing the shock model 110 to predict the perforating effects on the perforating string 12.

The three dimensional model 114 of the perforating string 12 may include a model of one or more shock sensing tools 22 interconnected in the perforating string 12.

The three dimensional model 114 of the perforating string 12 may include material properties of components of the perforating string 12.

The method 80 can include measuring the perforating effects on the perforating string 12 caused by detonation of perforating guns 20.

The method 80 may include adjusting the shock model 110 so that the predicted perforating effects output by the shock model 110 substantially match the measurements of the perforating effects.

The perforating effects can include at least axial, bending and torsional strain in the perforating string 12. The perforating effects may include stresses along the perforating string 12, motions along the perforating string 12, and/or interactions between the perforating string 12 and the wellbore 14. The interactions between the perforating string 12 and the wellbore 14 can include contact loads and friction between the perforating string 12 and the wellbore 14.

It is to be understood that the various embodiments described herein may be utilized in 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, which is not limited to any specific details of these embodiments.

5 In the above description of the representative
embodiments, directional terms, such as "above," "below,"
"upper," "lower," etc., are used for convenience in
referring to the accompanying drawings. In general,
"above," "upper," "upward" and similar terms refer to a
10 direction toward the earth's surface along a wellbore, and
"below," "lower," "downward" and similar terms refer to a
direction away from the earth's surface along the wellbore.

 Of course, a person skilled in the art would, upon a
careful consideration of the above description of
15 representative embodiments of the disclosure, readily
appreciate that many modifications, additions,
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,
20 the foregoing detailed description is to be clearly
understood as being given by way of illustration and example
only, the spirit and scope of the present invention being
limited solely by the appended claims and their equivalents.

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TRANSMITTAL LETTER TO THE UNITED STATES RECEIVING OFFICE

Express Mail mailing number:	Date of deposit:
File reference no.: 10-031572U1	International application no. (if known):
Customer Number ¹ : 49431	Earliest priority date claimed (Day/Month/Year):
Title of the invention: MODELING SHOCK PRODUCED BY WELL PERFORATING	

¹ Customer Number will allow access to the application in Private PAIR but cannot be used to establish or change the correspondence address.☒ This is a new International Application**SCREENING DISCLOSURE INFORMATION:**

In order to assist in screening the accompanying international application for purposes of determining whether a license for foreign transmittal should and could be granted and for other purposes, the following information is supplied. (check as boxes as apply):

- ☐ The invention disclosed was not made in the United States of America.
- ☒ There is no prior U.S. application relating to this invention.
- ☐ The following prior U.S. application(s) contain subject matter which is related to the invention disclosed in the attached international application. (NOTE: priority to these applications may or may not be claimed on the Request (form PCT/RO/101) and this listing does not constitute a claim for priority.)

application no.		filed on	
application no.		filed on	

- ☐ The present international application contains additional subject matter not found in the prior U.S. application(s) identified above. The additional subject matter is found on pages: _____ and ☐ DOES NOT ALTER ☐ MIGHT BE CONSIDERED TO ALTER the general nature of the invention in a manner which would require the U.S. application to have been made available for inspection by the appropriate defense agencies under 35 U.S.C. 181 and 37 C.F.R. 5.15.

Itemized list of contents

Sheets of Request form: 6	Check no.:
Sheets of description (excluding sequence listing): 23	Return receipt postcard:
Sheets of claims: 5	Power of attorney:
Sheets of abstract: 1	Certified copy of priority document (specify):
Sheets of drawings: 9	Other (specify): Fee Calculation Sheet
Sheets of sequence listing:	
Sequence listing diskette/CD:	

The person signing this form is:	☐ Applicant	Marlin R. Smith
	☒ Attorney/Agent (Reg. No.) 38310	Name of person signing /Marlin R. Smith/
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WHAT IS CLAIMED IS:

1. A method of utilizing a shock model for prediction of perforating effects, the method comprising:

5 recording measurements of the perforating effects on an actual perforating string in a wellbore;

adjusting the shock model so that predictions of the perforating effects output by the shock model substantially match the measurements of the perforating effects; and

10 causing the adjusted shock model to predict the perforating effects for a proposed perforating string.

2. The method of claim 1, wherein the recorded measurements include axial, bending and torsional strain in
15 the actual perforating string.

3. The method of claim 1, wherein the recorded measurements include pressure external to the actual perforating string.

20

4. The method of claim 1, wherein the recorded measurements include pressure internal to the actual perforating string.

25 5. The method of claim 1, wherein the recorded measurements include pressure internal to a perforating gun of the actual perforating string.

- 25 -

6. The method of claim 1, wherein adjusting the shock model further comprises repeatedly: a) receiving a comparison of the predictions of the perforating effects to the measurements of the perforating effects, and b) adjusting the shock model to reduce differences between the predictions of the perforating effects and the measurements of the perforating effects, until the differences are acceptably reduced.

7. The method of claim 1, further comprising, prior to the recording step, inputting a three dimensional geometrical model of the actual perforating string into the shock model.

8. The method of claim 1, further comprising, after the adjusting step and prior to the causing step, inputting a three dimensional model of the proposed perforating string into the shock model.

9. The method of claim 1, wherein the predictions of the perforating effects include stresses along the actual perforating string.

10. The method of claim 1, wherein the predictions of the perforating effects include motions along the actual perforating string.

11. The method of claim 1, wherein the predictions of the perforating effects include interactions between the actual perforating string and the wellbore.

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12. The method of claim 11, wherein the interactions
between the actual perforating string and the wellbore
include contact loads and friction between the actual
5 perforating string and the wellbore.

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13. A method of predicting perforating effects on a perforating string in a wellbore, the method comprising:

inputting a three dimensional well model and a three
5 dimensional model of the perforating string into a shock
model; and

causing the shock model to predict the perforating
effects on the perforating string.

10 14. The method of claim 13, wherein the three
dimensional model of the perforating string includes a model
of a shock sensing tool interconnected in the perforating
string.

15 15. The method of claim 13, wherein the three
dimensional model of the perforating string includes a model
of multiple shock sensing tools interconnected in the
perforating string.

20 16. The method of claim 13, wherein the three
dimensional model of the perforating string includes
material properties of components of the perforating string.

25 17. The method of claim 13, further comprising
measuring the perforating effects on the perforating string
caused by detonation of perforating guns.

18. The method of claim 17, further comprising
adjusting the shock model so that the predicted perforating

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effects output by the shock model substantially match the measurements of the perforating effects.

19. The method of claim 13, wherein the perforating
5 effects include at least axial loads in the perforating string.

20. The method of claim 19, wherein the perforating
effects further include bending loads in the perforating
10 string.

21. The method of claim 20, wherein the perforating
effects further include torsional loads in the perforating
string.

15

22. The method of claim 13, wherein the perforating
effects include stresses along the perforating string.

23. The method of claim 13, wherein the perforating
20 effects include motions along the perforating string.

24. The method of claim 13, wherein the perforating
effects include interactions between the perforating string
and the wellbore.

25

25. The method of claim 24, wherein the interactions
between the perforating string and the wellbore include
contact loads and friction between the perforating string
and the wellbore.

30

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ABSTRACT

A method of utilizing a shock model for prediction of perforating effects can include recording measurements of the perforating effects on an actual perforating string in a wellbore, adjusting the shock model so that predictions of the perforating effects output by the shock model substantially match the measurements of the perforating effects, and causing the adjusted shock model to predict the perforating effects for a proposed perforating string. A method of predicting perforating effects on a perforating string in a wellbore can include inputting a three dimensional well model and a three dimensional model of the perforating string into a shock model, and causing the shock model to predict the perforating effects on the perforating string.

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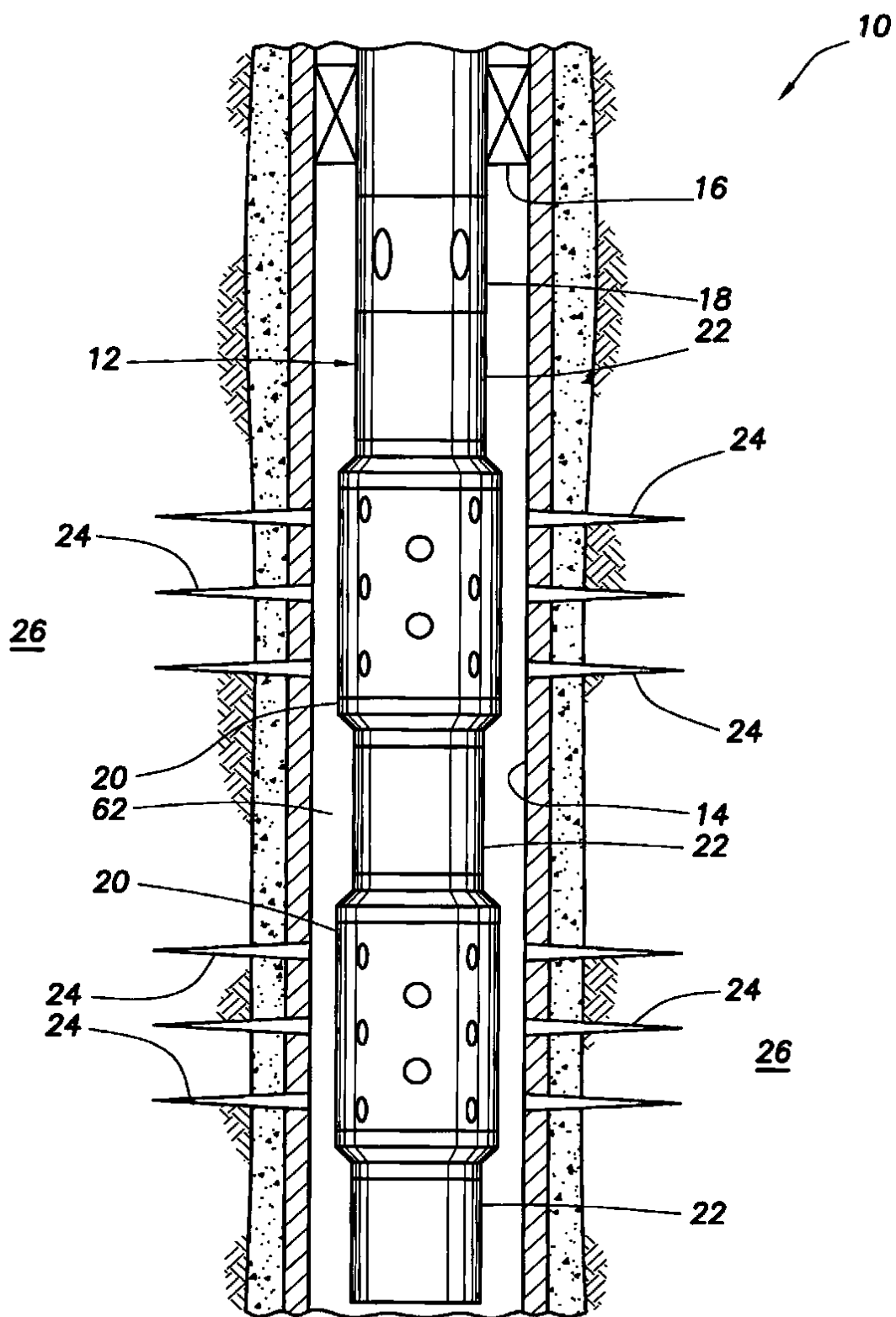
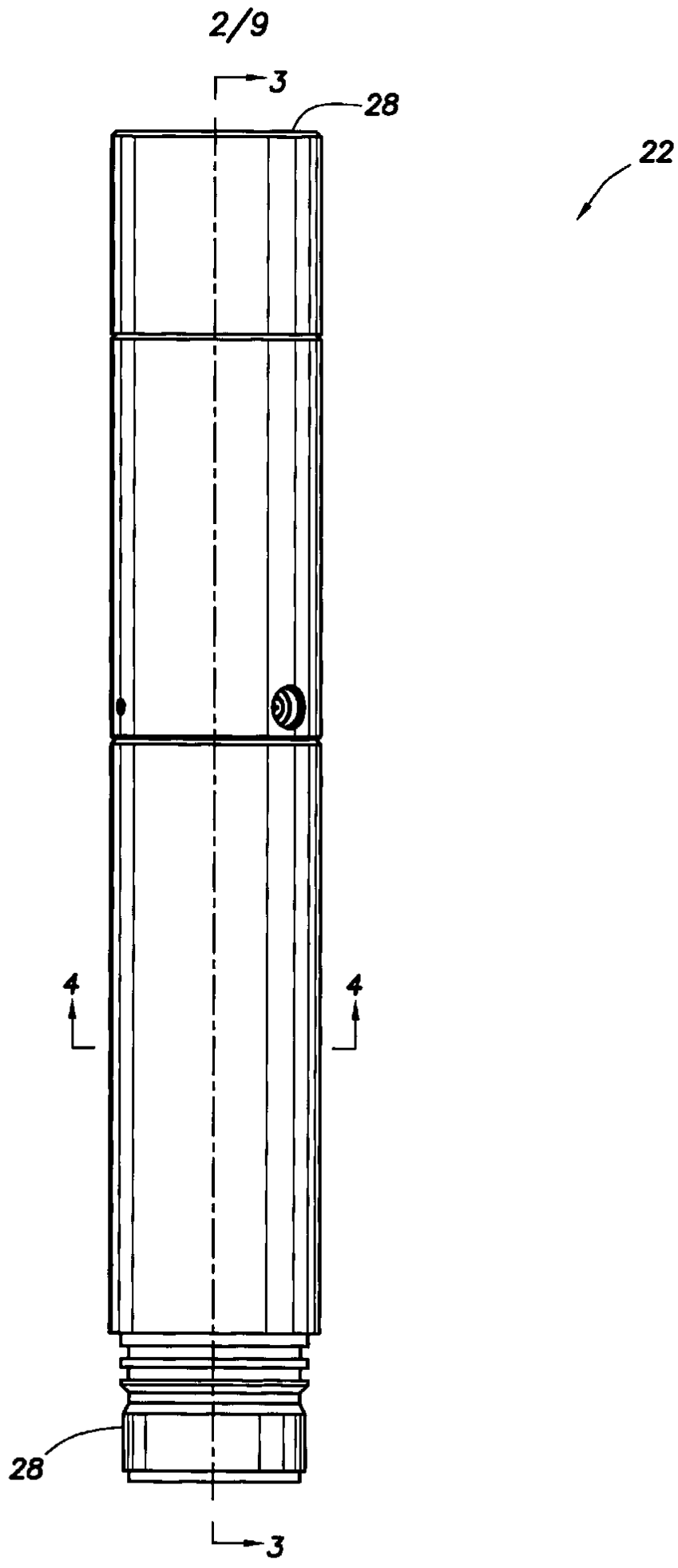


FIG. 1

FIG.2



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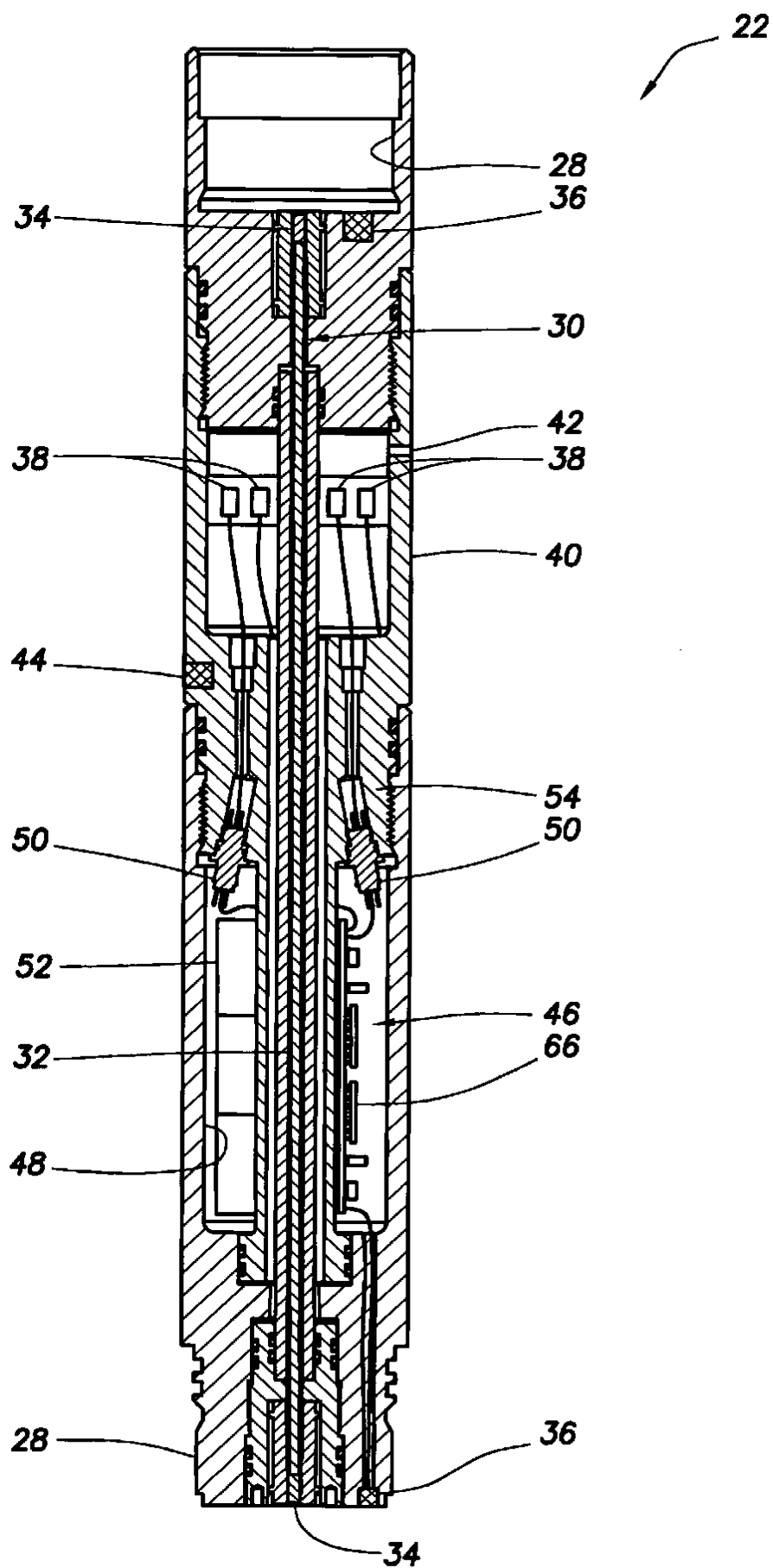


FIG. 3

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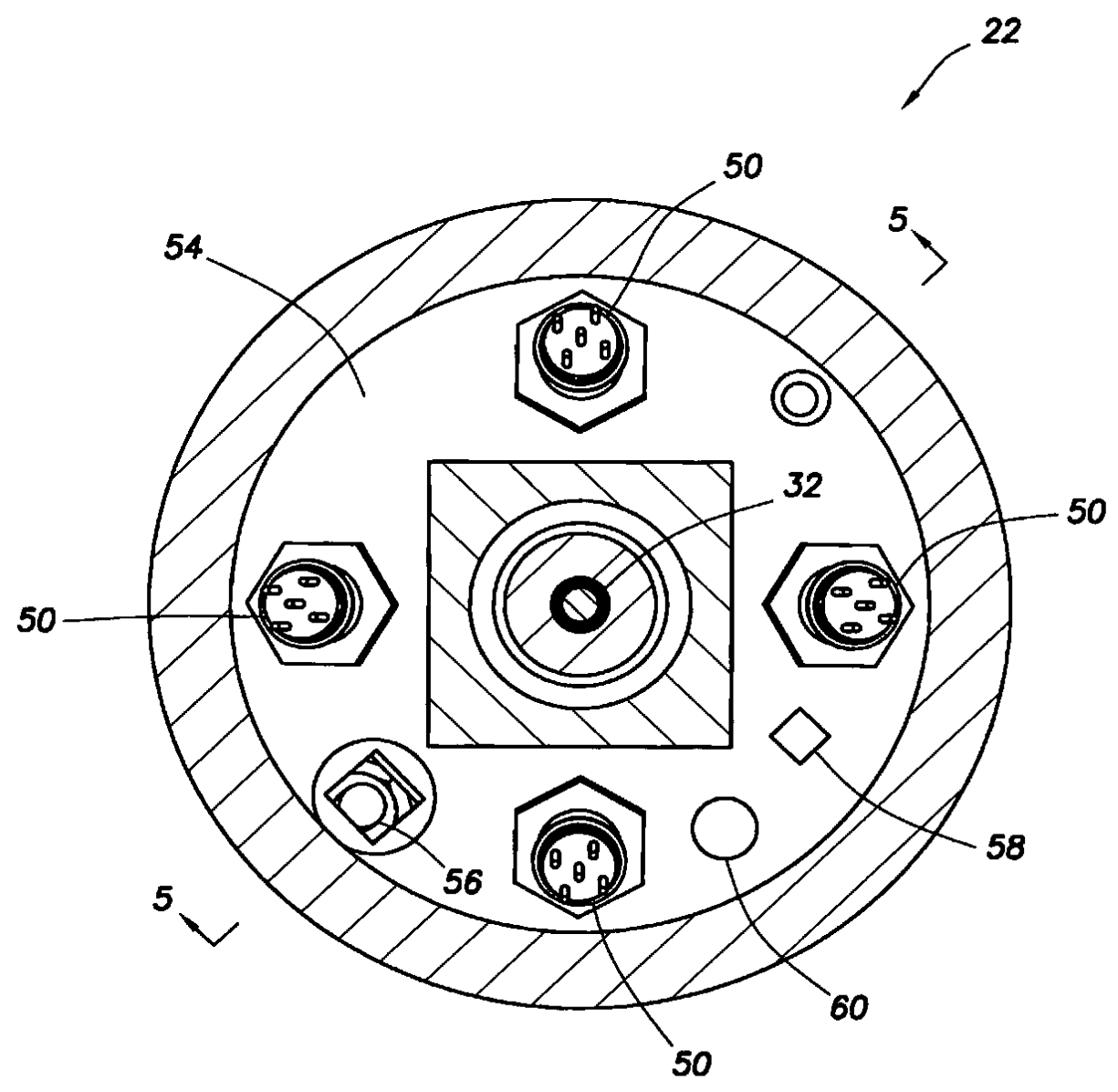


FIG. 4

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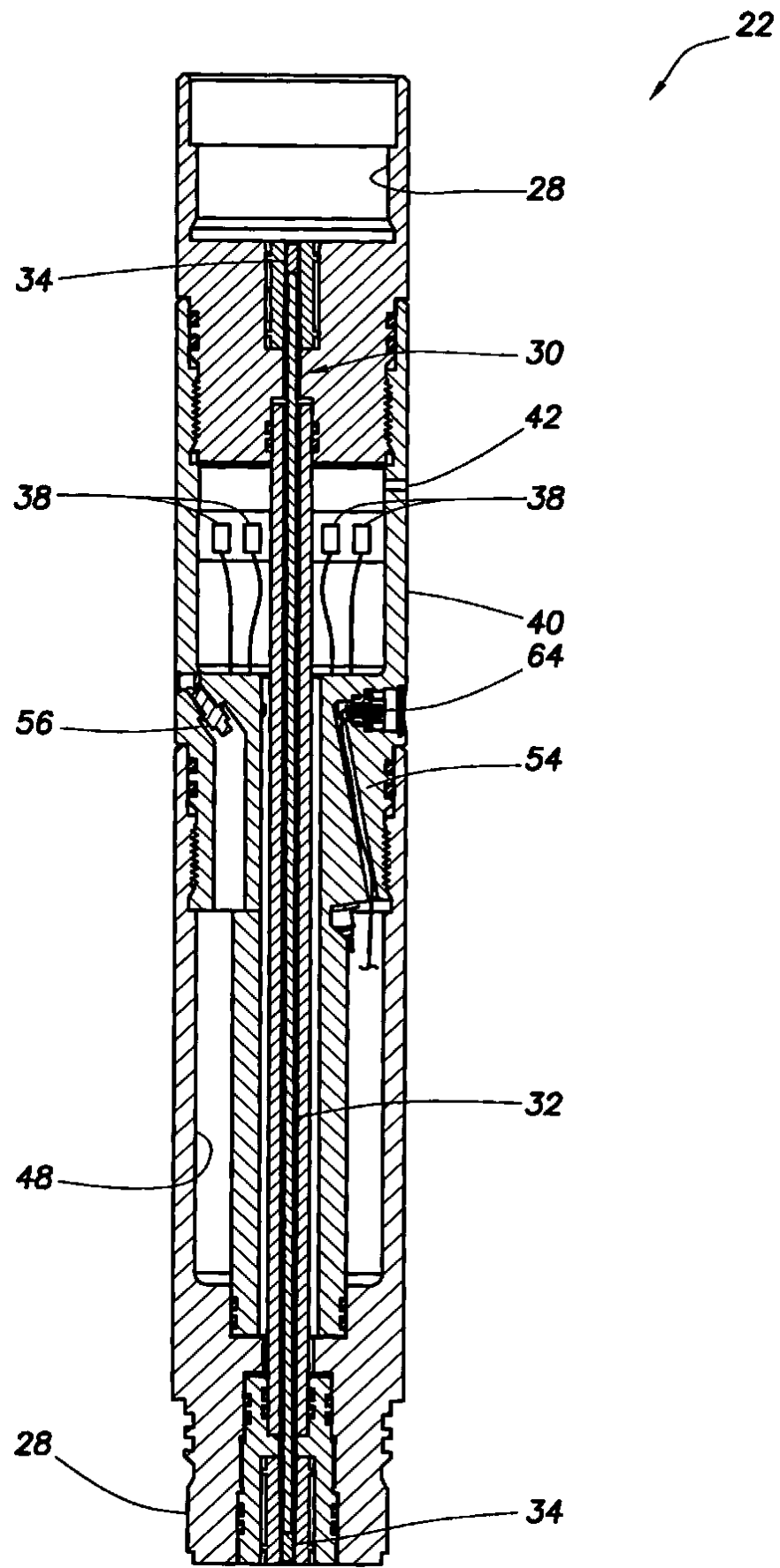


FIG.5

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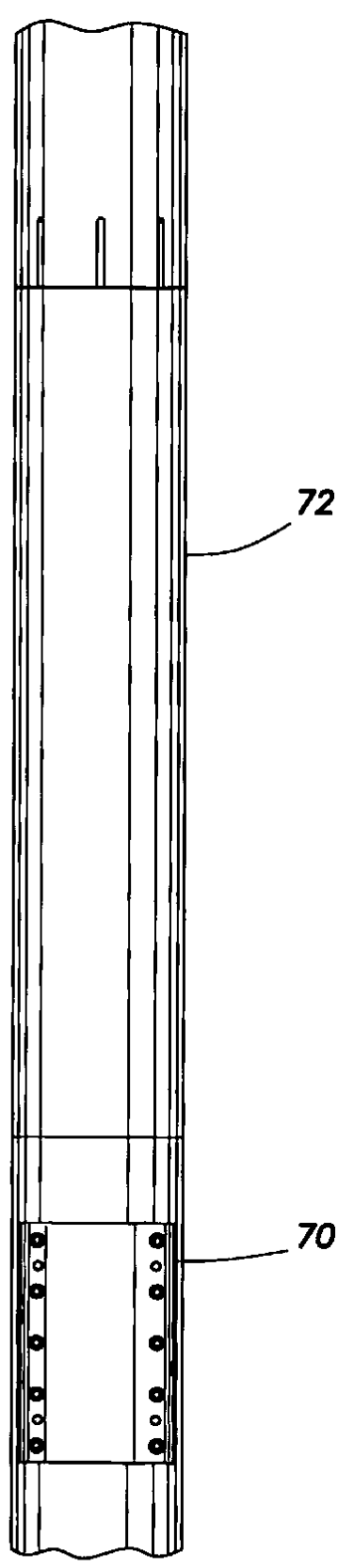


FIG. 6

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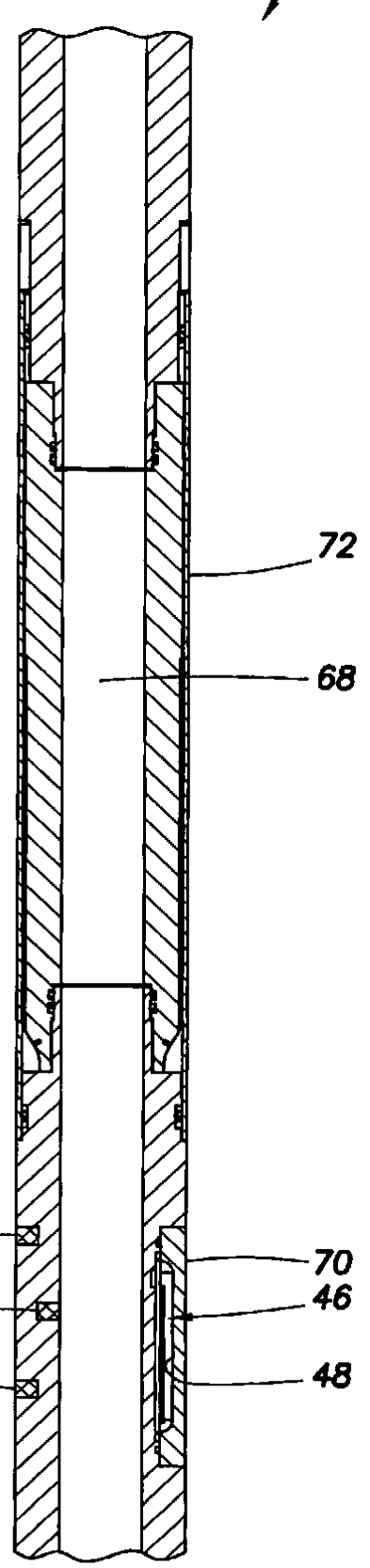
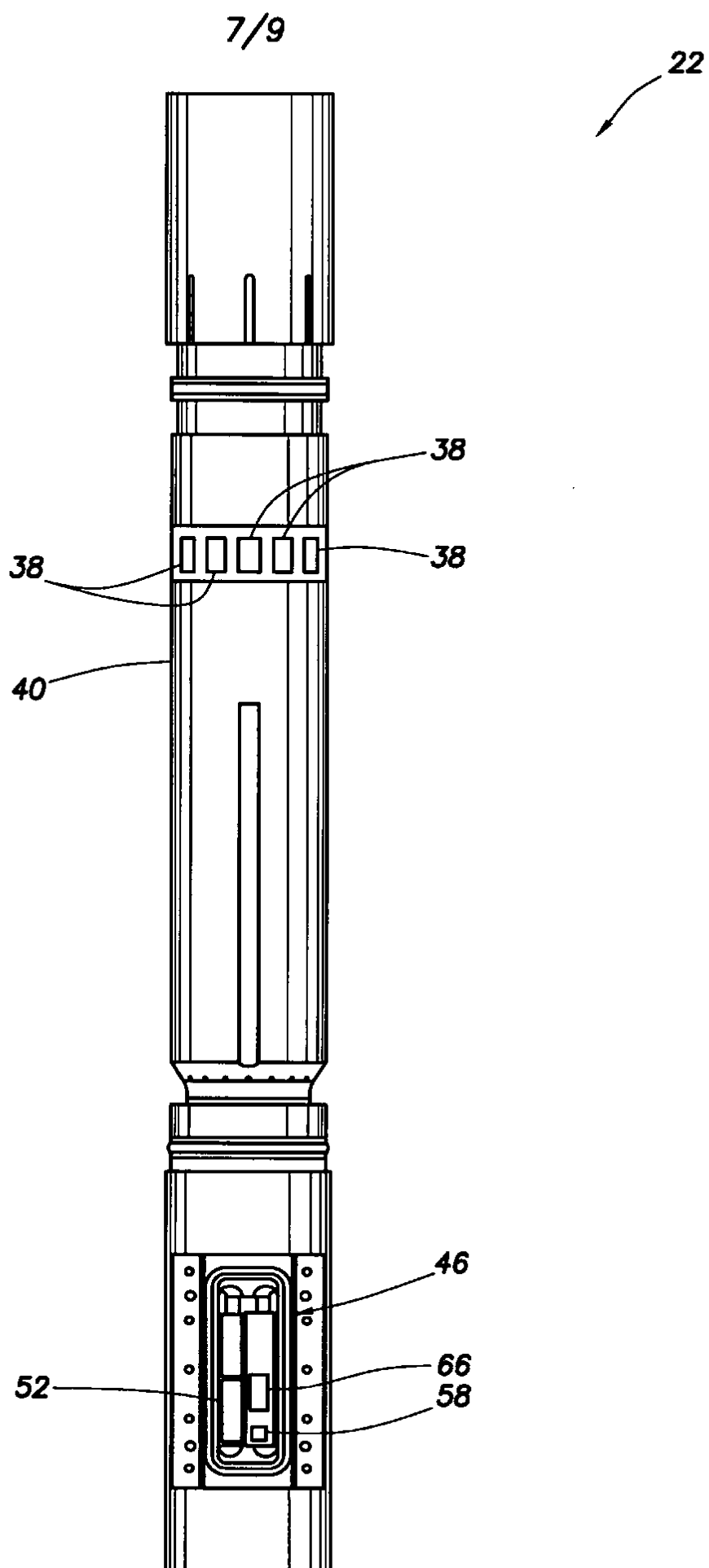


FIG. 7

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FIG. 8



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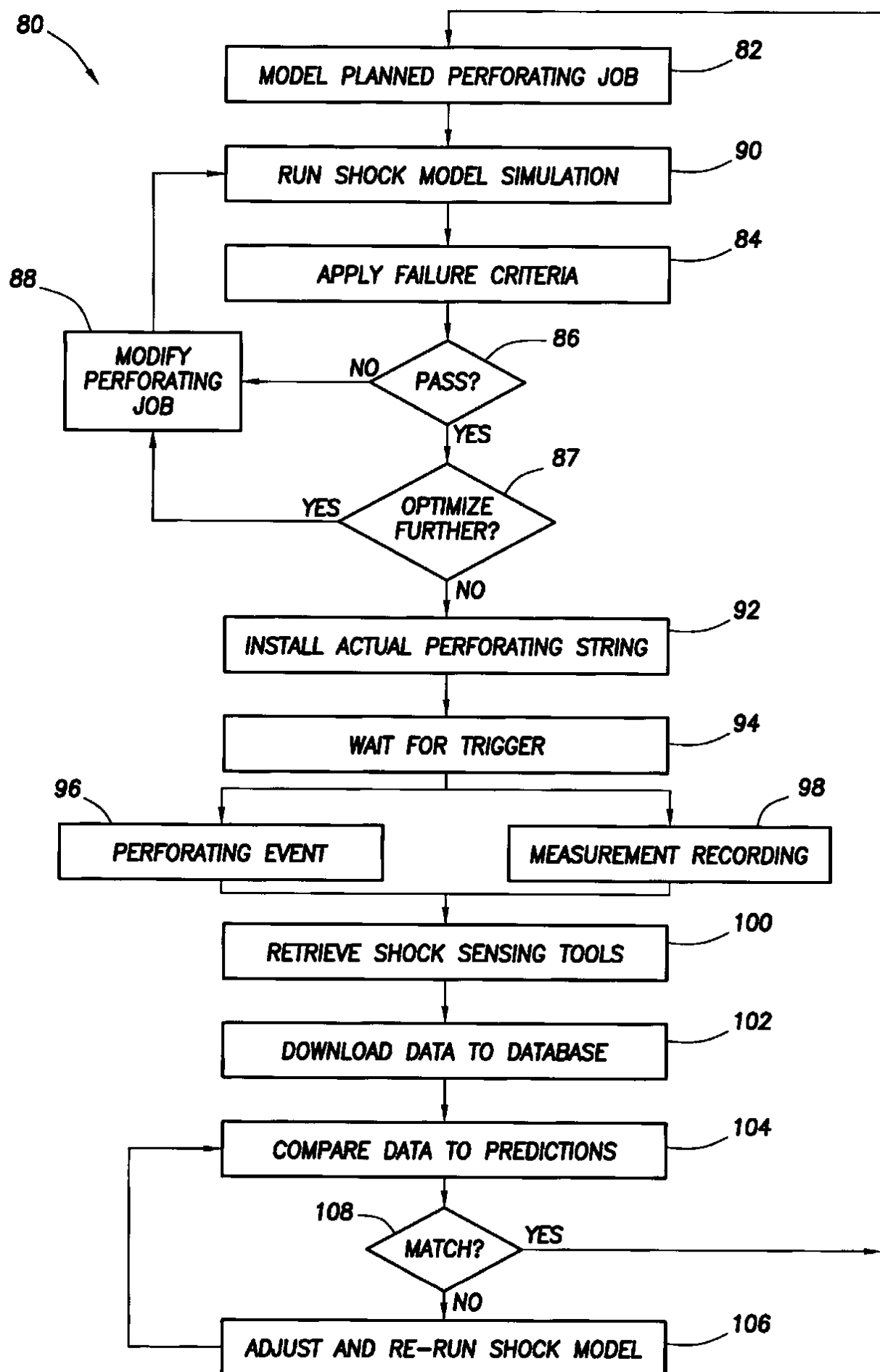


FIG.9

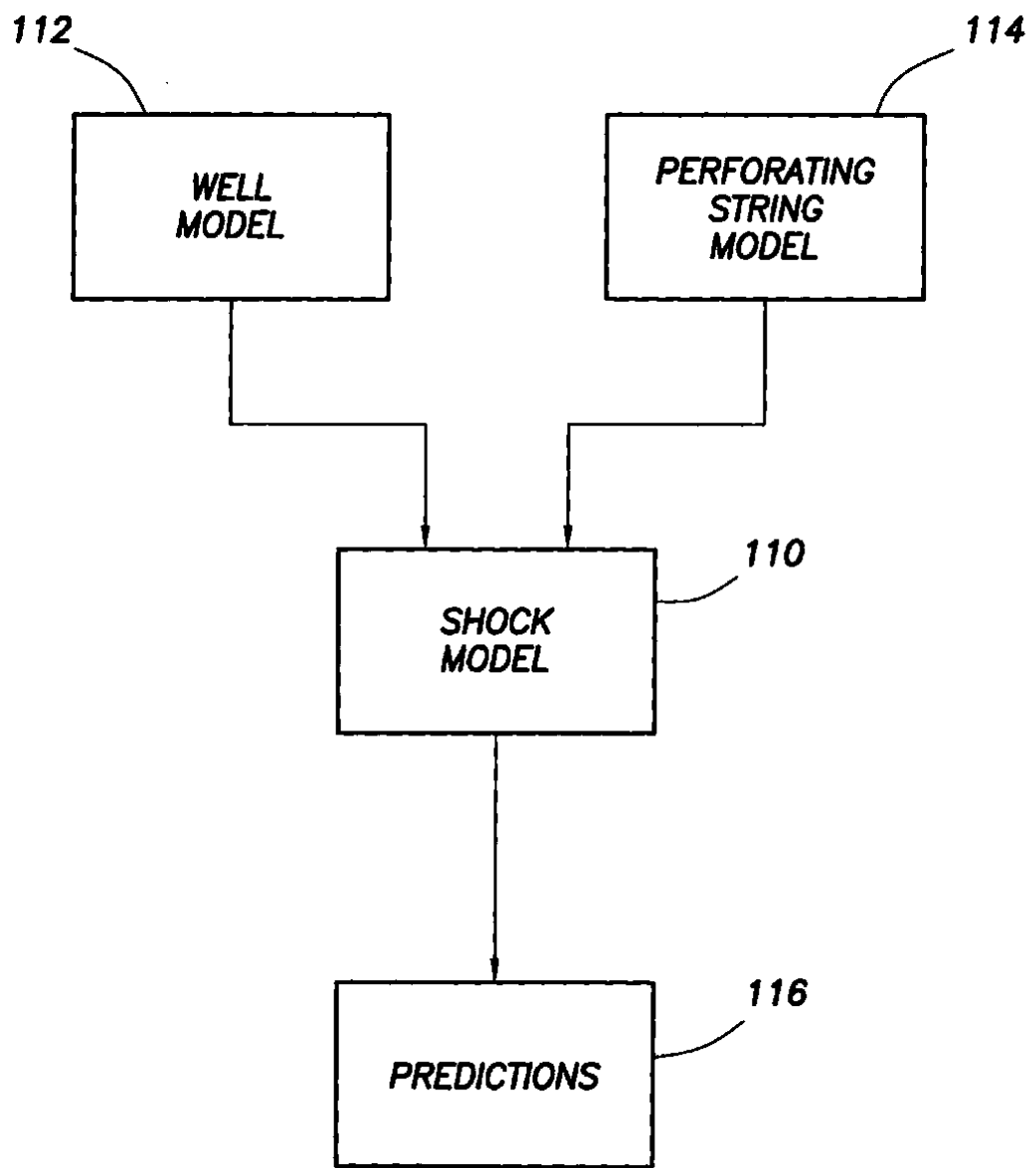


FIG.10

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Versión Electrónica v1.1

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TIPO DE PRESENTACION	NUEVA CESION
NATURALEZA DE LA OPERACION	CESION

DATOS DE LA PARTE QUE TRANSFIERE

Nombre	Fecha de Firma
John RODGERS	12/30/2010
Marco SERRA	01/14/2011
David SWENSON	01/05/2011
Timothy S. GLENN	01/10/2011

NOMBRE DE LA PARTE RECEPTORA

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Ciudad:	Houston
Estado/País	TEXAS
Código Postal	77072

NUMERO DE PROPIEDADES Total: 1

Tipo de Propiedad	Número
Número PCT	US1061104

DATOS DE CORRESPONDENCIA

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Línea de Dirección 1: P.O. Box 997
Línea de Dirección 4: Rockwall, TEXAS 75087

NUMERO DE CARPETA DEL ABOGADO: 10-031572U1
NOMBRE DEL REMITENTE: Sally Ann Smith

Total de Anexos; 5

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PATENTE
ROLLO: 025714 CUADRO: 0919

Solicitud PCT

10-031572U1

CESION

EN CONSIDERACION de que me ha sido pagado UN DOLAR (\$1.00) En efectivo a la mano por HALLIBURTON ENERGY SERVICES, INC., y otras valiosas consideraciones el recibo y cantidad suficiente la cual reconozco por medio de la presente, nosotros, los abajo firmantes **John RODGERS, Marco SERRA, David SWENSON, y Timothy S. GLENN**, habiendo realizado una invención de un **"MODELADO DE IMPACTO PRODUCIDO POR LA PERFORACION DE UN POZO"** que se encuentra en el empleo de HALLIBURTON ENERGY SERVICES, INC., una corporación organizada y existente bajo las leyes del Estado de Delaware, que tiene negocios en 10200 Bellaire Boulevard, Houston, Texas 77072, (algunas veces llamado en adelante **"CESIONARIO"**), por medio de la presente CEDO, VENDO y CONVENDO con dicho CESIONARIO, sus sucesores y cesionarios, la totalidad de mi derecho, título e interés alrededor del mundo en y para:

1. La mencionada invención de un **"MODELADO DE IMPACTO PRODUCIDO POR LA PERFORACION DE UN POZO"**;
2. La Solicitud Internacional de Patente sobre la invención mencionada, Referencia del Archivo del Agente No. 10-031572U1 Serial No. PCT/US10/61104 presentado en Diciembre 17, 2010, que lleva por nombre **"MODELADO DE IMPACTO PRODUCIDO POR LA PERFORACION DE UN POZO"**;
3. Todas las solicitudes de patentes o protecciones similares sobre la invención mencionada que han sido ahora o puedan ser hechas en el futuro

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(ilegible)

John RODGERS

ESTADO DE TEXAS]

]

CONDADO DE TARRANT]

ANTE MÍ, la autoridad abajo firmante, en este día compareció ante mí personalmente John RODGERS , reconocido por mí como la persona cuyo nombre se encuentra suscrito en el anterior documento, y reconoció ante mí que el firmó el mismo para los propósitos y consideraciones expresadas allí.

BAJO MI FIRMA Y SELLO DE OFICINA, este 30 de Diciembre de 2010.

(Sello)

MUHAMMED A. PIRACHA

NOTARIO PUBLICO

ESTADO DE TEXAS

LA COMISION EXPIRA 20-Septiembre-2014

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REGISTRADO: 04/16/2009

PATENTE

ROLLO: 025714 CUADRO: 0921

FIRMADO EN el Condado de WINTERTHUR, Suiza, el 14 de Enero de 2011.

(ilegible)

Marco SERRA

RECONOCIMIENTO

ANTE MI, El testigo abajo firmante, en este día compareció Marco SERRA, a quien conozco como la persona cuyo nombre está suscrito en el anterior documento, y quien reconoció ante mí que firmó el mismo para los propósitos y consideraciones allí expresados, este 14 de Enero de 2011.

(ilegible)

Firma del Testigo

KAI DETZNER

Nombre del Testigo

Edi Meier + Partner AG

Geophysik Geotechnik

Jägerstrasse 2

8406 Winterthur

PATENTE

ROLLO: 025714 CUADRO: 0922

FIRMADO EN el Condado de Dallas, Texas, el 5 de Enero de 2011.

(ilegible)
David SWENSON

ESTADO DE TEXAS]
]
CONDADO DE DALLAS]

ANTE MÍ, la autoridad abajo firmante, en este día compareció ante mí personalmente David SWENSON, reconocido por mí como la persona cuyo nombre se encuentra suscrito en el anterior documento, y reconoció ante mí que el firmó el mismo para los propósitos y consideraciones expresadas allí.

BAJO MI FIRMA Y SELLO DE OFICINA, este 5 de Enero de 2011.

(Sello)
CYNTHIA A. GONZALEZ
NOTARIO PUBLICO
ESTADO DE TEXAS
LA COMISION EXPIRA 10-29-2011

(Firma Ilegible)
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FIRMADO EN el Condado de MIDDLE SEX, Massachusetts TSG, el 10 de Enero de 2011.

(illegible)

Timothy S. GLENN

ESTADO DE MASSACHUSETTS

I

CONDADO DE MIDDLESEX

ANTE MÍ, la autoridad abajo firmante, en este día compareció ante mí personalmente Timothy S. GLENN , reconocido por mí como la persona cuyo nombre se encuentra suscrito en el anterior documento, y reconoció ante mí que el firmó el mismo para los propósitos y consideraciones expresadas allí.

BAJO MI FIRMA Y SELLO DE OFICINA, este 10 de Enero de 2011.

(Sello)

(Firma Ilegible)

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PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: SMITH MARLIN R. SMITH IP SERVICES, P.C. P.O. BOX 997 ROCKWALL TX 75087 USA

PCT

 NOTIFICATION OF TRANSMITTAL OF
 THE INTERNATIONAL SEARCH REPORT AND
 THE WRITTEN OPINION OF THE INTERNATIONAL
 SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 10-031572U1	Date of mailing (day/month/year) 28 JULY 2011 (28.07.2011)
International application No. PCT/US2010/061104	International filing date (day/month/year) 17 DECEMBER 2010 (17.12.2010)
Applicant HALLIBURTON ENERGY SERVICES, INC. et al	

1. ☐ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes
 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 - 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.
3. ☐ With regard to any protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:
- ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.
- ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

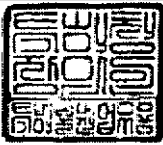
4. Reminders

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

Shortly after the expiration of 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90bis.1 and 90bis.3).

Within 19 months from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later); otherwise, the applicant must, within 20 months from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices. In respect of other designated Offices, the time limit of 30 months (or later) will apply even if no demand is filed within 19 months.

For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the PCT Applicant's Guide, National Chapters.

Name and mailing address of the ISA/KR  Korean Intellectual Property Office Government Complex-Daejeon, 189 Cheongsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer COMMISSIONER Telephone No. 82-42-481-8754	
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Form PCT/ISA/220 (July 2010)

• Attention

Copies of the documents cited in the international search report can be searched in the following Korean Intellectual Property Office English website for three months from the date of mailing of the international search report.

<http://www.kipo.go.kr/en/> => PCT Services => PCT Services

ID : PCT international application number

PW : **G0W7SM5P**

Inquiries related to PCT International Search Report or Written Opinion prepared by KIPO as an International Searching Authority can be answered not only by KIPO but also through IPKC (Intellectual Property Korea Center), located in Vienna, VA, which functions as a PCT Help Desk for PCT applicants.

Homepage: <http://www.ipkcenter.com>

Email: ipkc@ipkcenter.com

Phone: +1 703 388 1066

Fax: +1 703 388 1084

PCT/US2010/061104

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 10-031572U1	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/US2010/061104	International filing date (<i>day/month/year</i>) 17 DECEMBER 2010 (17.12.2010)	(Earliest) Priority Date (<i>day/month/year</i>)
Applicant HALLIBURTON ENERGY SERVICES, INC. et al		

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

- Basis of the report**
 - With regard to the language, the international search was carried out on the basis of:
 - ☐ the international application in the language in which it was filed
 - ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
 - ☐ This international search report has been established taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rule 43.6bis(a)).
 - ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, see Box No. I.
- ☐ Certain claims were found unsearchable (See Box No. II)
- ☐ Unity of invention is lacking (See Box No. III)
- With regard to the title,
 - ☐ the text is approved as submitted by the applicant.
 - ☐ the text has been established by this Authority to read as follows:
- With regard to the abstract,
 - ☐ the text is approved as submitted by the applicant.
 - ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
- With regard to the drawings,
 - the figure of the drawings to be published with the abstract is Figure No. 5
 - ☐ as suggested by the applicant.
 - ☐ as selected by this Authority, because the applicant failed to suggest a figure.
 - ☐ as selected by this Authority, because this figure better characterizes the invention.
 - ☐ none of the figure is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/061104**A. CLASSIFICATION OF SUBJECT MATTER****E21B 47/00(2006.01)i, E21B 47/01(2006.01)i, E21B 47/06(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 47/00; E21B 43/116; E21B 41/00; E21B 43/11

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:perforating effect, perforating string, a shock model, perforating gun, strain

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010-0230105 A1 (VAYNSHTEYN VLADIMIR) 16 September 2010 See paragraphs 23, 52 and figures 1-3.	1-25
A	GB 2406870 A (SCHLIMBERGER HOLDINGS LIMITED)) 13 April 2005 See abstract, pages 3-5 and figures 3, 17.	1-25
A	W0 2007-056121 A1 (SHELL OIL COMPANY et al.) 18 May 2007 See page 7 and figure 4.	1-25

☐ 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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

28 JULY 2011 (28.07.2011)

Date of mailing of the international search report

28 JULY 2011 (28.07.2011)

Name and mailing address of the ISA/KR

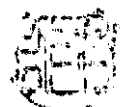
Korean Intellectual Property Office
Government Complex-Daejeon, 189 Cheongsu-ro,
Seo-gu, Daejeon 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KANG, Min Sug

Telephone No 82-42-481-5860



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2010/061104

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010-0230105 A1	16.09.2010	US 2010-230105 A1	16.09.2010
GB 2406870 A	13.04.2005	CA 2451822 C	10.11.2009
		GB 0426979 D0	12.01.2005
		GB 0426981 D0	12.01.2005
		GB 2406870 B	12.04.2006
		GB 2406871 A	13.04.2005
		GB 2406871 B	12.04.2006
		US 2004-0104029 A1	03.06.2004
		US 6837310 B2	04.01.2005
WO 2007-056121 A1	18.05.2007	AT 489535 T	15.12.2010
		AU 2006-311880 A1	18.05.2007
		AU 2006-311880 B2	03.06.2010
		AU 2006-311880 B2	03.06.2010
		CA 2627431 A1	18.05.2007
		CN 101300402 A	05.11.2008
		CN 101300402 A	05.11.2008
		CN 101300402 C0	05.11.2008
		DE 602006018508 D1	05.01.2011
		EA200801260A1	27.02.2009
		EP 1945905 A1	23.07.2008
		EP 1945905 B1	24.11.2010
		N020082490A	04.08.2008
		US 2007-193740 A1	23.08.2007

PCT/US2010/061104

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: SMITH MARLIN R. SMITH IP SERVICES, P.C. P.O. BOX 997 ROCKWALL TX 75087 USA

PCTWRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing
(day/month/year) **28 JULY 2011 (28.07.2011)**

Applicant's or agent's file reference 10-031572U1		FOR FURTHER ACTION See paragraph 2 below	
International application No. PCT/US2010/061104	International filing date (day/month/year) 17 DECEMBER 2010 (17.12.2010)	Priority date(day/month/year)	
International Patent Classification (IPC) or both national classification and IPC E21B 47/00(2006.01)i, E21B 47/01(2006.01)i, E21B 47/06(2006.01)i			
Applicant HALLIBURTON ENERGY SERVICES, INC. et al			

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☐ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

 Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 189 Cheongsu-ro, Seo-gu, Daejeon 302- 701, Republic of Korea Facsimile No. 82-42-472-7140	Date of completion of this opinion 28 JULY 2011 (28.07.2011)	Authorized officer KANG, Min Sug
	Telephone No. 82-42-481-5860	

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.

PCT/US2010/061104

Box No. 1 Basis of this opinion

1. With regard to the language, this opinion has been established on the basis of:

- ☐ the international application in the language in which it was filed
- ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this opinion has been established on the basis of:

a. a sequence listing filed or furnished

- ☐ on paper
- ☐ in electronic form

b. time of filing or furnishing

- ☐ contained in the international application as filed.
- ☐ filed together with the international application in electronic form.
- ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/US2010/061104

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-25	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	1-25	YES
	Claims	NONE	NO
Industrial applicability (IA)	Claims	1-25	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 2010-0230105 A1 (VAYNSHTEYN VLADIMIR) 16 September 2010
D2: GB 2406870 A (SCHLUMBERGER HOLDINGS LIMITED)) 13 April 2005
D3: WO 2007-056121 A1 (SHELL OIL COMPANY et al.) 18 May 2007

1. Novelty and Inventive Step

1.1 Claims 1-12

1.1.1 Independent Claim 1

The subject matter of claim 1 differs from these prior art documents in that a method of utilizing a shock model for prediction of perforating effects in claim 1 comprises the steps of adjusting the shock model and causing the adjusted shock model to predict the perforating effects. And these are not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 1 meets the requirements of PCT Article 33(2) and (3) with respect to novelty and inventive step.

1.1.2 Dependent Claims 2-12

Claims 2-12 are dependent on claim 1 and therefore meet the requirements of PCT Article 33(2) and (3).

1.2 Claims 13-25

1.2.1 Independent Claim 13

The subject matter of claim 13 differs from these prior art documents in that a method of prediction of perforating effects on a perforating string in a wellbore in claim 13 comprises the steps of inputting a three dimensional model into a shock model and causing the shock model to predict the perforating effects. And these are not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 13 meets the requirements of PCT Article 33(2) and (3) with respect to novelty and inventive step.

1.1.2 Dependent Claims 14-25

Claims 15-25 are dependent on claim 13 and therefore meet the requirements of PCT Article 33(2) and (3).

2. Industrial Applicability

Claims 1-25 are industrially applicable under PCT Article 33(4).

Sheet No.

Box No. VIII (iv) DECLARATION: INVENTORSHIP (only for the purposes of the designation of the United States of America)
The declaration must conform to the following standardized wording provided for in Section 214, see Notes to Boxes Nos. VIII, VII (i) to (v) (in general) and the specific Notes to Box No. VIII (iv). If this box is not used, this sheet should not be included in the request.

**Declaration of inventorship (Rules 4.17(iv) and 51bis.1(a)(iv))
 for the purposes of the designation of the United States of America:**

I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/US10/61104 (if furnishing declaration pursuant to Rule 26ter).

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications:

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

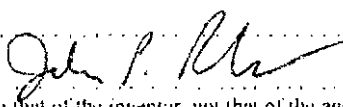
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name: RODGERS, John

Residence: Roanoke, Texas
 (city and either US state, if applicable, or country)

Mailing Address: 1904 Winter Drive
Roanoke, Texas 76262
US

Citizenship: US

Inventor's Signature:  Date: 12/30/2010
 (The signature must be that of the inventor, not that of the agent)

Name: SERRA, Marco

Residence: Winterthur, CH
 (city and either US state, if applicable, or country)

Mailing Address: Jaegerstrasse 2
Winterthur 8406
CH

Citizenship: IT

Inventor's Signature: Date:
 (The signature must be that of the inventor, not that of the agent)

☒ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)"

Sheet No.

Continuation of Box No. VIII (i) to (v) **DECLARATION**

If the space is insufficient in any of Boxes Nos. VIII (i) to (v) to furnish all the information, including in the case where more than two inventors are to be named in Box No. VIII (vi), in such case, write "Continuation of Box No. VIII ..." indicate the item number of the Box and furnish the information in the same manner as required for the purposes of the Box in which the space was insufficient. If additional space is needed in respect of two or more declarations, a separate continuation box must be used for each such declaration. If this Box is not used, this sheet should not be included in the request.

"Continuation of Box No. VIII (iv)".

Name: . SWENSON, David.
Residence: . Crossroads, Texas . US.
(city and either US state, if applicable, or country)
Mailing Address: . 2601 Belt Line Road.
..... Carrollton, Texas 75006
Citizenship: . US

Inventor's Signature: Date:
(The signature must be that of the inventor, not that of the agent)

Name: . GLENN, Timothy S.
Residence: . Dracut, Massachusetts . US.
(city and either US state, if applicable, or country)
Mailing Address: . 1904 Winter Drive
..... Roanoke, Texas 77032
Citizenship: . US

Inventor's Signature: Date:
(The signature must be that of the inventor, not that of the agent)

Sheet No.

Box No. VIII (iv) DECLARATION: INVENTORSHIP (only for the purposes of the designation of the United States of America)
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This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/US10/61104 (if furnishing declaration pursuant to Rule 26ter).

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications:

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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 (city and either US state, if applicable, or country)

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 Roanoke, Texas 76262
 US

Citizenship: US

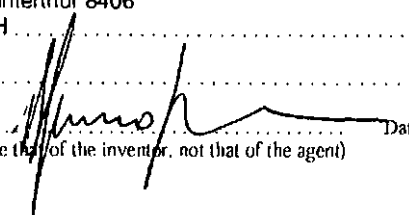
Inventor's Signature: Date:
 (The signature must be that of the inventor, not that of the agent)

Name: SERRA, Marco

Residence: Winterthur, CH
 (city and either US state, if applicable, or country)

Mailing Address: Jaegerstrasse 2
 Winterthur 8406
 CH

Citizenship: IT

Inventor's Signature:  Date: 14 January 2011
 (The signature must be that of the inventor, not that of the agent)

☒ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

Sheet No.

Continuation of Box No. VIII (i) to (v) DECLARATION

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..... Carrollton, Texas 75006
Citizenship: . US

Inventor's Signature: Date:
(The signature must be that of the inventor, not that of the agent)

Name: . GLENN, Timothy S.
Residence: . Dracut, Massachusetts . US.
(city and either US state, if applicable, or country)
Mailing Address: . 1904 Winter Drive
..... Roanoke, Texas 77032.
Citizenship: . US

Inventor's Signature: Date:
(The signature must be that of the inventor, not that of the agent)

Sheet No.

Box No. VIII (iv) DECLARATION: INVENTORSHIP (only for the purposes of the designation of the United States of America)
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**Declaration of inventorship (Rules 4.17(iv) and 51b/s.1(a)(iv))
 for the purposes of the designation of the United States of America:**

I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/US10/61104..... (if furnishing declaration pursuant to Rule 26ter).

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

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I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name: RODGERS, John

Residence: Roanoke, Texas

Mailing Address: 1904 Winter Drive

Roanoke, Texas 76262

US

Citizenship: US

Inventor's Signature: Date:

(The signature must be that of the inventor, not that of the agent)

Name: SERRA, Marco

Residence: Winterthur, CH

Mailing Address: Jaegerstrasse 2

Winterthur 8406

CH

Citizenship: IT

Inventor's Signature: Date:

(The signature must be that of the inventor, not that of the agent)

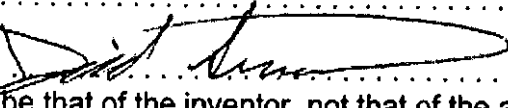
☒ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

Sheet No.

Continuation of Box No. VIII (i) to (v) DECLARATION

If the space is insufficient in any of Boxes Nos. VIII (i) to (v) to furnish all the information, including in the case where more than two inventors are to be named in Box No. VIII (iv), in such case, write "Continuation of Box No. VIII ..." (indicate the item number of the Box) and furnish the information in the same manner as required for the purposes of the Box in which the space was insufficient. If additional space is needed in respect of two or more declarations, a separate continuation box must be used for each such declaration. If this Box is not used, this sheet should not be included in the request.

"Continuation of Box No. VIII (iv)".

Name: . SWENSON, David.
Residence: . Crossroads, Texas . US.
(city and either US state, if applicable, or country)
Mailing Address: .2601 Belt Line Road.
.....Carrollton, Texas 75006
Citizenship: . US
Inventor's Signature:  Date: 1/5/11
(The signature must be that of the inventor, not that of the agent)

Name: . GLENN, Timothy S.
Residence: . Dracut, Massachusetts . US.
(city and either US state, if applicable, or country)
Mailing Address: . 1904 Winter Drive
.....Roanoke, Texas 77032
Citizenship: . US
Inventor's Signature: Date:
(The signature must be that of the inventor, not that of the agent)

Sheet No.

Box No. VIII (iv) DECLARATION: INVENTORSHIP (only for the purposes of the designation of the United States of America)
The declaration must conform to the following standardized wording provided for in Section 214; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (iv). If this Box is not used, this sheet should not be included in the request.

**Declaration of inventorship (Rules 4.17(iv) and 51bis.1(a)(iv))
 for the purposes of the designation of the United States of America:**

I hereby declare that I believe I am the original, first and sole (if only one inventor is listed below) or joint (if more than one inventor is listed below) inventor of the subject matter which is claimed and for which a patent is sought.

This declaration is directed to the international application of which it forms a part (if filing declaration with application).

This declaration is directed to international application No. PCT/US10/61104..... (if furnishing declaration pursuant to Rule 26ter).

I hereby declare that my residence, mailing address, and citizenship are as stated next to my name.

I hereby state that I have reviewed and understand the contents of the above-identified international application, including the claims of said application. I have identified in the request of said application, in compliance with PCT Rule 4.10, any claim to foreign priority, and I have identified below, under the heading "Prior Applications," by application number, country or Member of the World Trade Organization, day, month and year of filing, any application for a patent or inventor's certificate filed in a country other than the United States of America, including any PCT international application designating at least one country other than the United States of America, having a filing date before that of the application on which foreign priority is claimed.

Prior Applications:

I hereby acknowledge the duty to disclose information that is known by me to be material to patentability as defined by 37 C.F.R. § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the PCT international filing date of the continuation-in-part application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name: RODGERS, John

Residence: Roanoke, Texas

Mailing Address: 1904 Winter Drive

Roanoke, Texas 76262

US

Citizenship: US

Inventor's Signature: Date:

(The signature must be that of the inventor, not that of the agent)

Name: SERRA, Marco

Residence: Winterthur, CH

(city and either US state, if applicable, or country)

Mailing Address: Jaegerstrasse 2

Winterthur 8406

CH

Citizenship: IT

Inventor's Signature: Date:

(The signature must be that of the inventor, not that of the agent)

☒ This declaration is continued on the following sheet, "Continuation of Box No. VIII (iv)".

Sheet No.

Continuation of Box No. VIII (i) to (v) **DECLARATION**

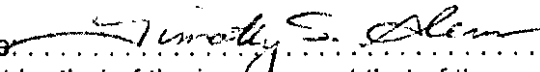
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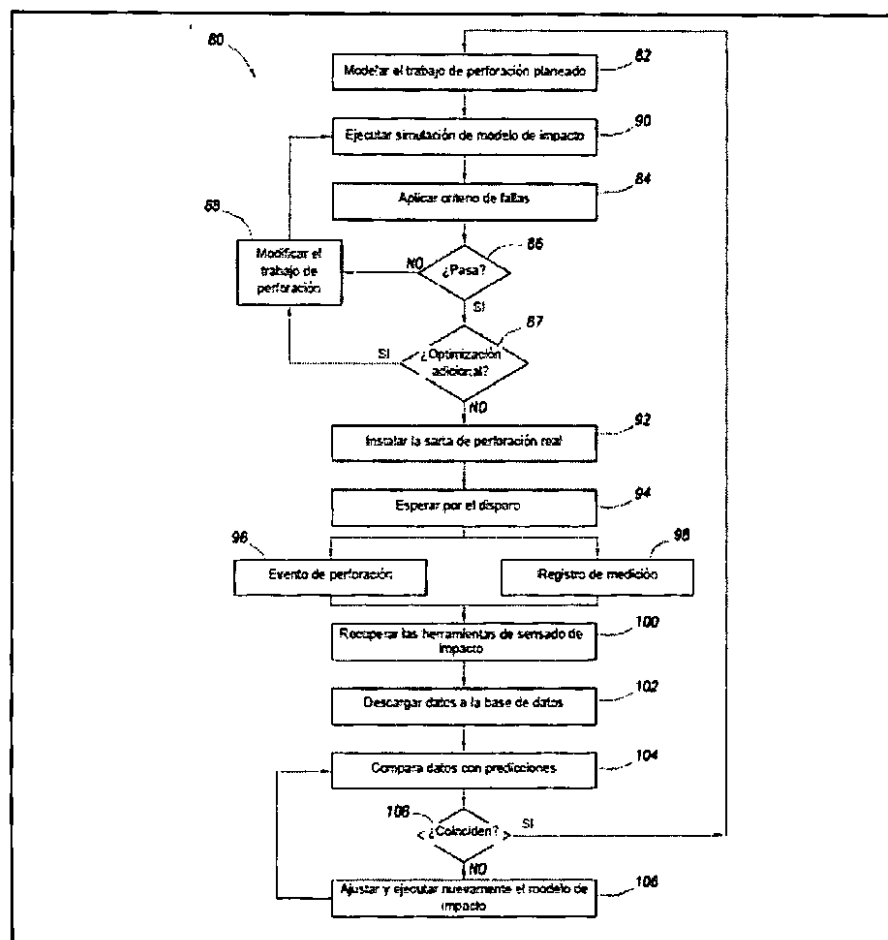
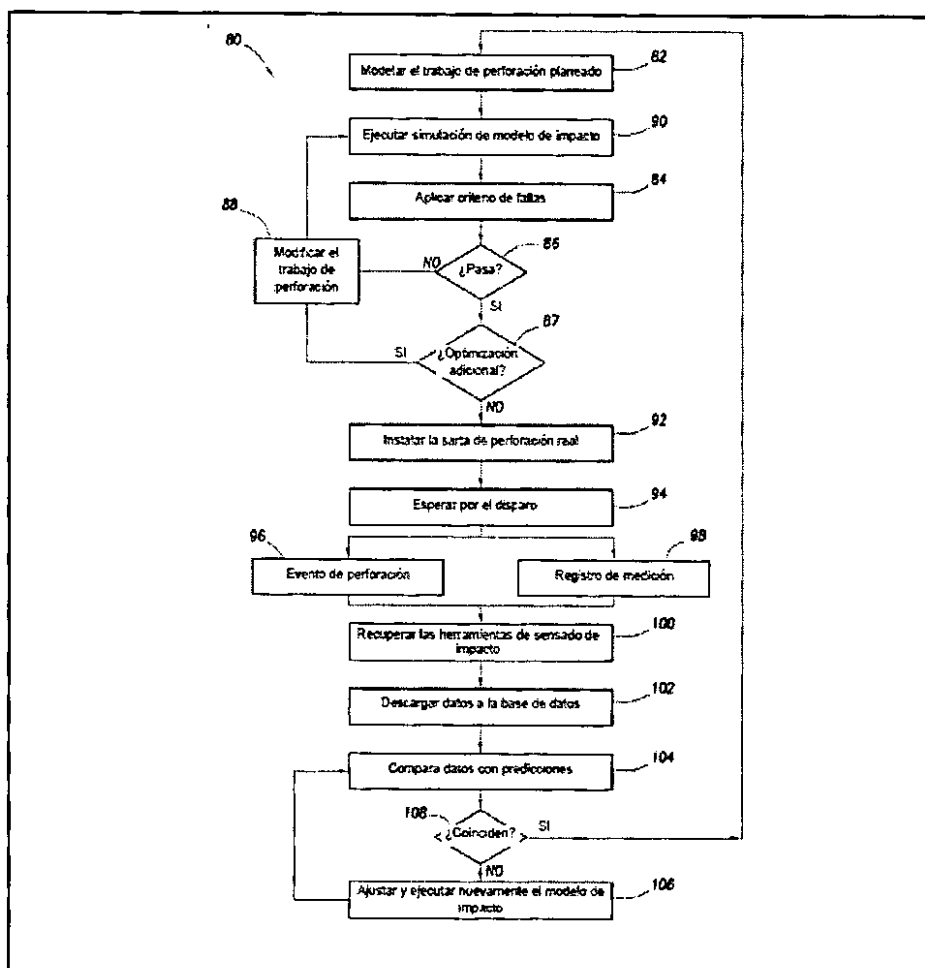
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..... Roanoke, Texas 77032.
Citizenship: . . US

Inventor's Signature:  Date: 01/10/11
(The signature must be that of the inventor, not that of the agent)





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Act. 411 PRESENTACION

Folios: 171

PATENTE DE INVENCION ☐

MODELO DE UTILI. ☐

☐	Indicación que se solicita una patente.
☐	Datos de identificación del solicitante o de la persona que presenta la solicitud
☐	Descripción de la invención
☐	Dibujos de ser estos pertinentes
☐	Comprobante de pago de las tasas establecidas (De ser el caso formato de descuento)
Completa ☐	Incompleta ☐

PATENTE DE INVENCION PCT ☒ MODELO DE UTILIDAD PCT ☐ Art.33 Decisión 486/00, Circular Única

☒	Indicación que se solicita una PCT
☒	Copia de la solicitud en español, tal como fue presentada inicialmente (capítulo descriptivo, reivindicatorio, resumen)
☒	Dibujos de ser estos pertinentes
☒	Comprobante de pago de las tasas establecidas (de ser el caso formato de descuento)
Completa ☒	Incompleta ☐

DISEÑO INDUSTRIAL ☐

(Art. 119 Decisión 486/00)

☐	Indicación que se solicita Diseño industrial
☐	Datos de identificación del solicitante o de la persona que presenta la solicitud
☐	Representación gráfica y fotográfica del Diseño industrial o muestra del material que incorpora el diseño
☐	Comprobante de pago de las tasas establecidas
Completa ☐	Incompleta ☐

ESQUEMA DE TRAZADO ☐

(Art. 92 Decisión 486/00)

☐	Indicación que se solicita un esquema de trazado
☐	Datos de identificación del solicitante o de la persona que presenta la solicitud
☐	Representación gráfica de un esquema de trazado
☐	Comprobante de pago de las tasas establecidas
Completa ☐	Incompleta ☐