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(54) **LOCATING PIPE EXTERNAL EQUIPMENT IN A WELLBORE**

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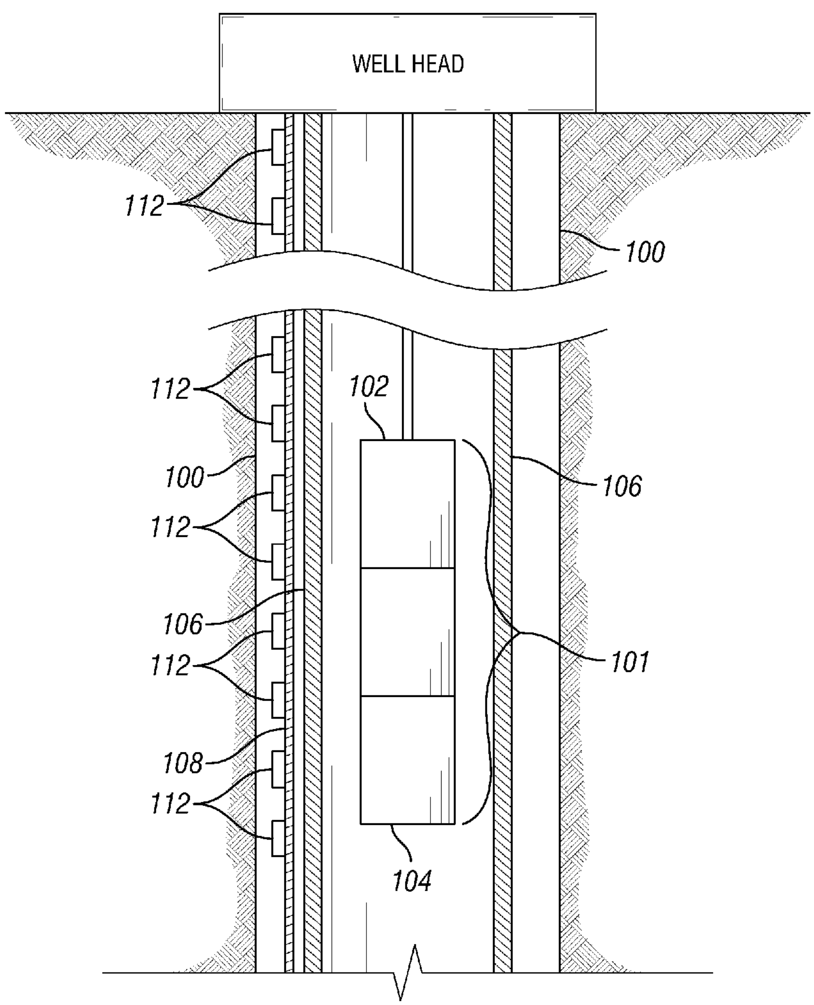
(57) **ABSTRACT**

A method for providing a location of equipment external to a downhole pipe within a wellbore by detecting or generating magnetic or electromagnetic fields within the downhole pipe and measuring the magnetic/electromagnetic field disturbances caused from one or more magnetic generating entities. The magnetic generating entities are detected from the magnetic/electromagnetic field disturbances and the location of the pipe external equipment is determined based upon the magnetic/electromagnetic field disturbances caused from the magnetic generating entities. In another embodiment, an apparatus that comprises at least one pipe external equipment coupled to a downhole pipe within the wellbore, and at least one magnetic field generating entities coupled relatively close or at a known geometric distance to the at least one pipe external equipment. The magnetic field generating entities are coupled to at least one pipe external equipment using a fastening component or installed in the downhole pipe or pipe mandrel.



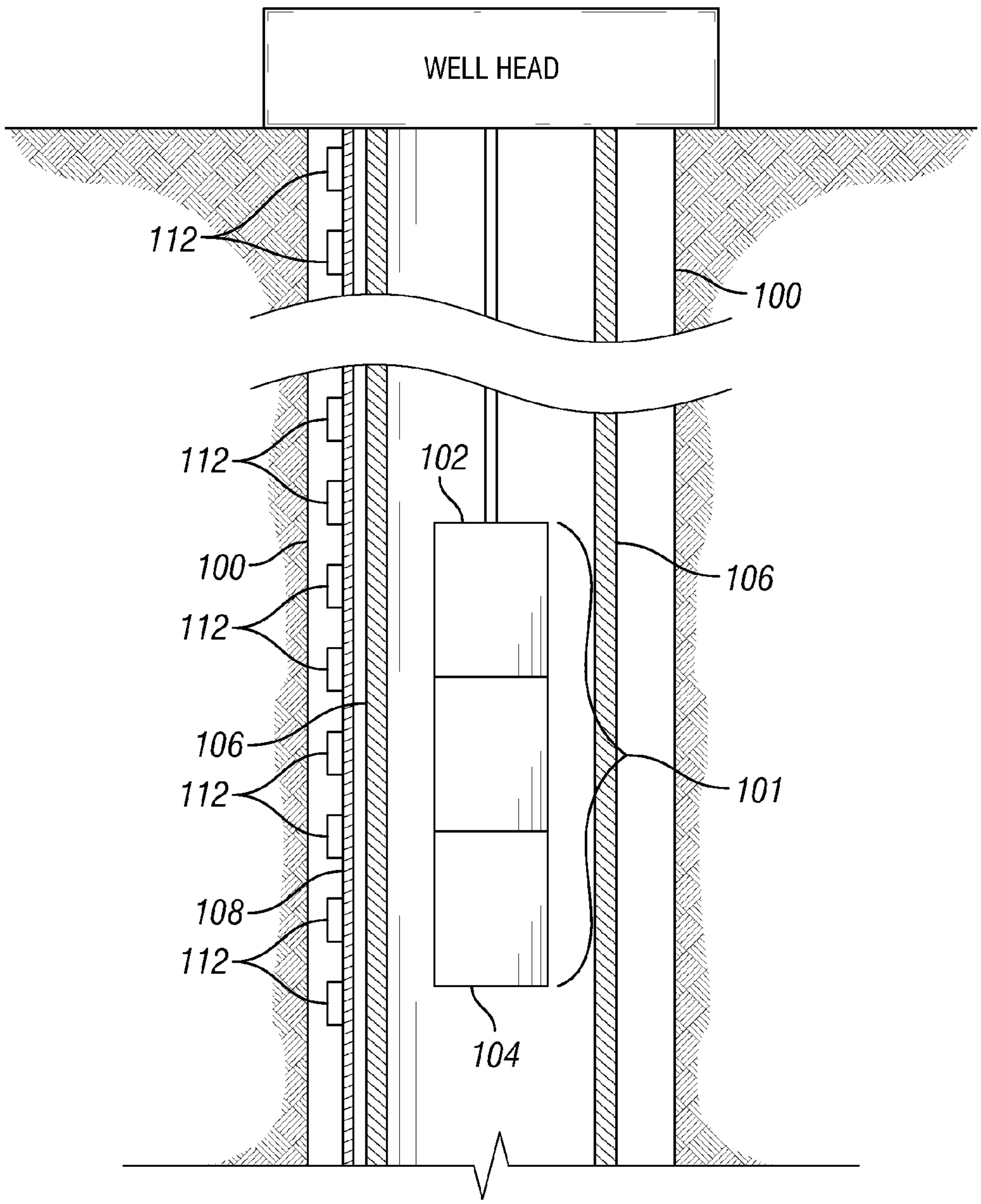


FIG. 1

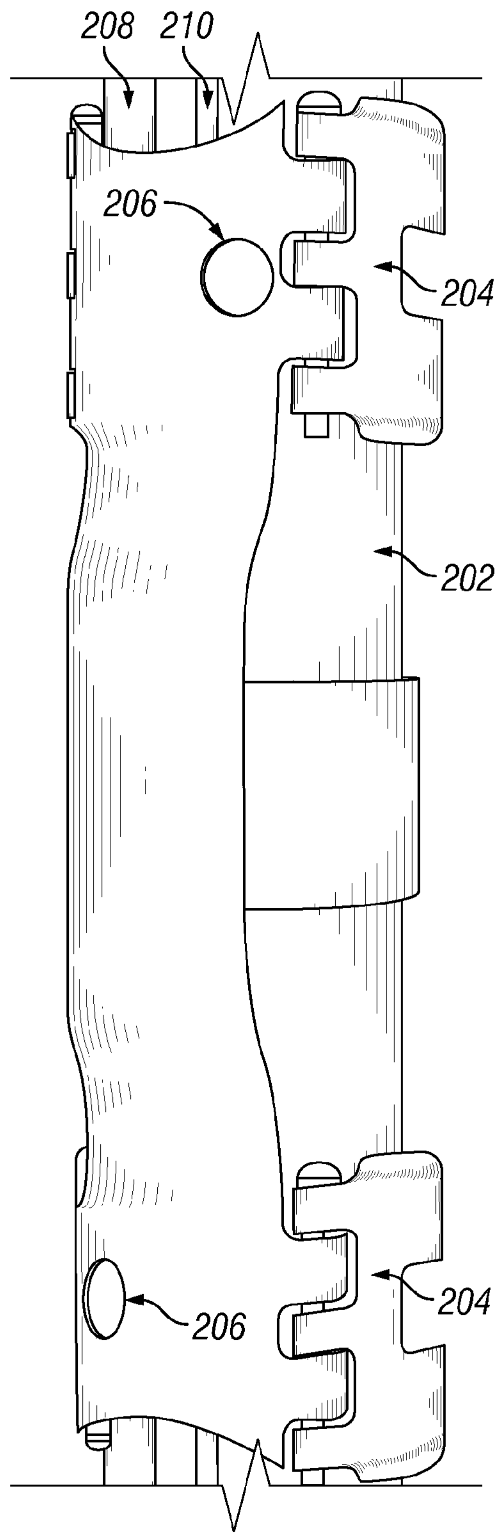


FIG. 2

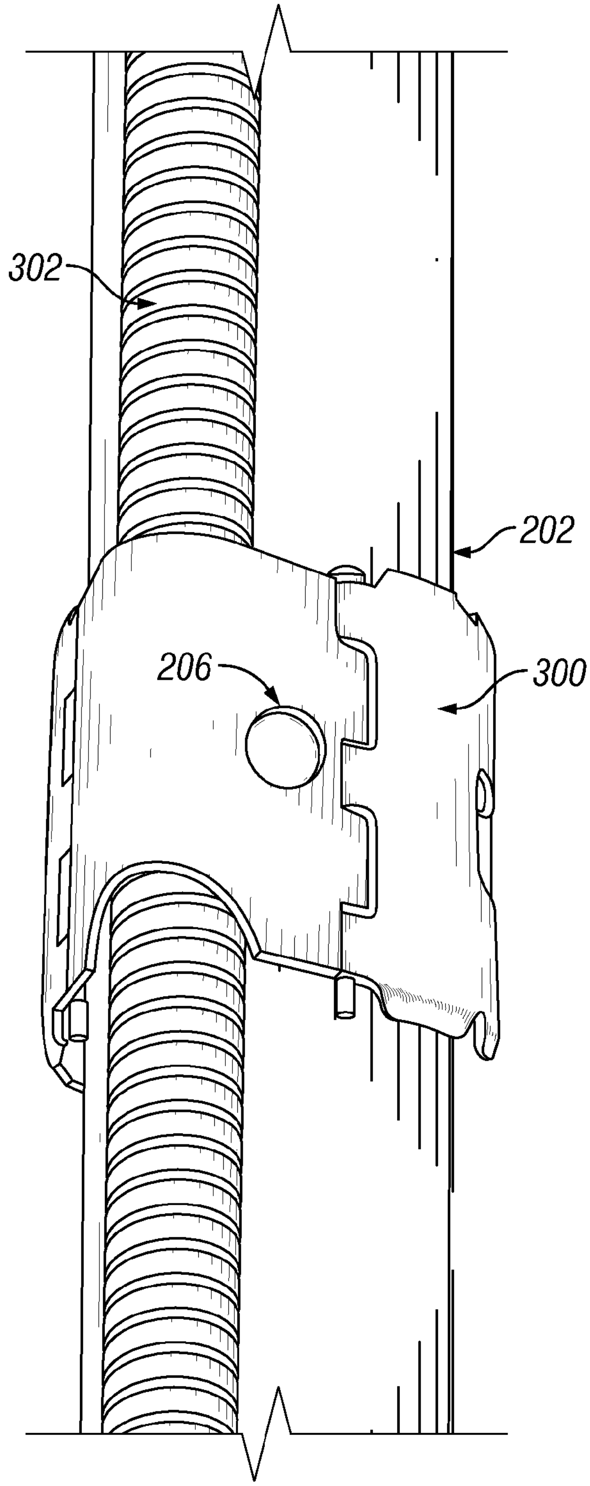


FIG. 3

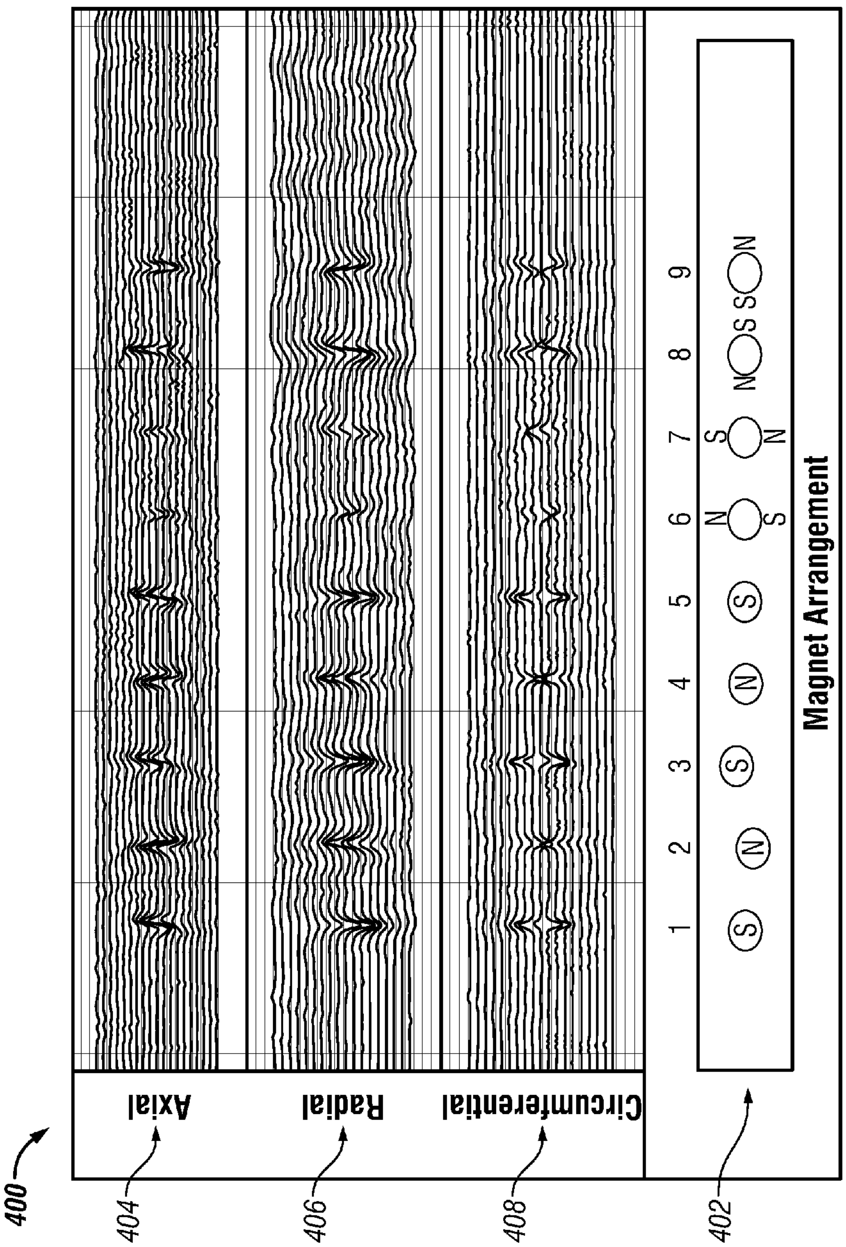

400
Axial
Radial
Circumferential
404
406
408
402
1
2
3
4
5
6
7
8
9
Magnet Arrangement

FIG. 4

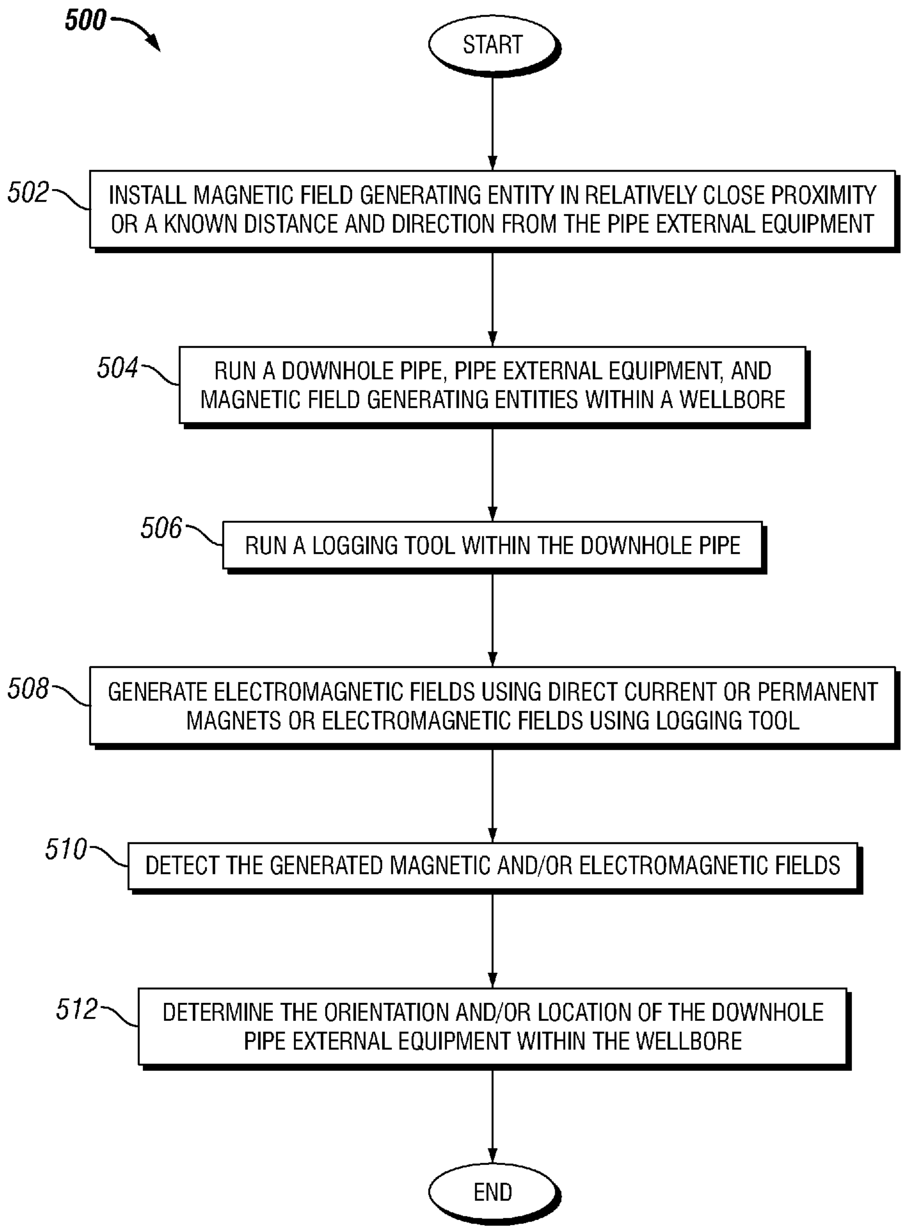

500
START
502
INSTALL MAGNETIC FIELD GENERATING ENTITY IN RELATIVELY CLOSE PROXIMITY OR A KNOWN DISTANCE AND DIRECTION FROM THE PIPE EXTERNAL EQUIPMENT
504
RUN A DOWNHOLE PIPE, PIPE EXTERNAL EQUIPMENT, AND MAGNETIC FIELD GENERATING ENTITIES WITHIN A WELLBORE
506
RUN A LOGGING TOOL WITHIN THE DOWNHOLE PIPE
508
GENERATE ELECTROMAGNETIC FIELDS USING DIRECT CURRENT OR PERMANENT MAGNETS OR ELECTROMAGNETIC FIELDS USING LOGGING TOOL
510
DETECT THE GENERATED MAGNETIC AND/OR ELECTROMAGNETIC FIELDS
512
DETERMINE THE ORIENTATION AND/OR LOCATION OF THE DOWNHOLE PIPE EXTERNAL EQUIPMENT WITHIN THE WELLBORE
END

FIG. 5

LOCATING PIPE EXTERNAL EQUIPMENT IN A WELLBORE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

FIELD OF THE INVENTION

[0003] The present invention relates generally to magnetically detecting equipment external to a downhole pipe prior to performing certain well operations, such as perforating a hydrocarbon well. More particularly, but not by way of limitation, embodiments of the present invention include one or more magnetic field generating entities installed at various distances along the downhole pipe and in close proximity to the pipe external equipment. An electromagnetic logging tool may be used to detect and locate the pipe external equipment from the resultant magnetic field disturbances to prevent damage to the pipe external equipment.

BACKGROUND OF THE INVENTION

[0004] When completing a hydrocarbon well, operators typically run downhole equipment on the outside of downhole pipe within the wellbore to improve well completion effectiveness and profitably. For instance, operators may run pipe external equipment that include capillary tubing for downhole equipment operation or chemical injection, electric lines for various gauges or devices, and/or other external pipes, power cables, and/or fiber optic lines that improve the understanding of completion activities and production flexibility. However, upon subterranean installation, the end location of the pipe external equipment relative to the downhole pipe may be unknown. During certain well operations, such as perforating a well or cutting a "window," determining the location and orientation relative to a reference, such as gravity, may be desirable in order to avoid damaging the pipe external equipment. Accurately sensing the location of the pipe external equipment, however, may present some challenges. Thus, implementing solutions that produce a relatively high degree of accuracy in locating pipe external equipment may avoid costs and problems associated with damaging the pipe external equipment within a wellbore.

BRIEF SUMMARY

[0005] The following presents a simplified summary of the disclosed subject matter in order to provide a basic understanding of some aspects of the subject matter disclosed herein. This summary is not an exhaustive overview of the technology disclosed herein. It is not intended to identify key or critical elements of the invention or to delineate the scope of the invention. Its sole purpose is to present some concepts in a simplified form as a prelude to the more detailed description that is discussed later.

[0006] In one embodiment, a method for providing a location of downhole equipment external to a downhole pipe within a wellbore. To determine the location of the downhole equipment, an electromagnetic logging tool generates an electromagnetic field within the downhole pipe and measures the electromagnetic field disturbances caused from one or more magnetic generating entities. The electromagnetic logging tool detects the position of the one or more magnetic generating entities from the electromagnetic field disturbances and determines the location of one or more pipe external equipment based upon the electromagnetic field disturbances caused from the one or more magnetic generating entities. Additionally, the one or more magnetic generating entities are installed in close proximity to the one or more pipe external equipment.

[0007] In another embodiment, a system for determining the locations of at least one pipe external equipment that comprises a downhole pipe running within a wellbore, at least one pipe external equipment running outside the downhole pipe within the wellbore, an electromagnetic logging tool running within the downhole pipe, and at least one magnetic field generating entities located relatively close to the at least one pipe external equipment. The electromagnetic logging tool may be configured to generate an electromagnetic field and detect one or more electromagnetic field disturbances that correspond to the one magnetic field generating entities.

[0008] In another embodiment, an apparatus that comprises a downhole pipe, at least one pipe external equipment coupled to the exterior of the downhole pipe within the wellbore, and at least one magnetic field generating entities coupled relatively close to the pipe external equipment. The magnetic field generating entities are coupled to the downhole pipe and the pipe external equipment using a fastening component.

BRIEF DESCRIPTION OF THE DRAWING

[0009] For a more complete understanding of this disclosure, reference is now made to the following brief description, taken in connection with the accompanying drawings and detailed description, wherein like reference numerals represent like parts.

[0010] FIG. **1** is a cross-sectional view schematic diagram of an embodiment of a wellbore, where various embodiments may operate within;

[0011] FIG. **2** is a schematic diagram of an embodiment of a clamping component used to secure the magnetic field generating entities in close proximity to the pipe external equipment;

[0012] FIG. **3** is a schematic diagram of another embodiment of a clamping component used to secure the magnetic field generating entities in close proximity to the pipe external equipment;

[0013] FIG. **4** is a diagram of an output from an electromagnetic logging tool assembly when detecting an array of magnetic field generating entities; and

[0014] FIG. **5** is flow chart of an embodiment of method used to locate the pipe external equipment using the magnetic field generating entities.

[0015] While certain embodiments will be described in connection with the preferred illustrative embodiments shown herein, it will be understood that it is not intended to limit the invention to those embodiments. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by claims to be filed in a subsequent non-provisional patent application. In the drawing figures, which are not to scale, the same reference numerals are used throughout the description and in the drawing figures for components and elements having the same structure, and primed reference numerals are used for components and elements having a similar function and construction to those components and elements having the same unprimed reference numerals.

DETAILED DESCRIPTION

[0016] It should be understood that, although an illustrative implementation of one or more embodiments are provided below, the various specific embodiments may be implemented using any number of techniques known by persons of ordinary skill in the art. The disclosure should in no way be limited to the illustrative embodiments, drawings, and/or techniques illustrated below, including the exemplary designs and implementations illustrated and described herein. Furthermore, the disclosure may be modified within the scope of the appended claims along with their full scope of equivalents.

[0017] Disclosed herein are various example embodiments that include magnetic field generating entities that generate local magnetic fields used for detecting and locating pipe external equipment outside of a downhole pipe within a wellbore. In one embodiment, the magnetic field generating entities may be magnets or strips of magnets distributed along the length of the downhole pipe and within close proximity to the pipe external equipment. The pipe external equipment may be externally fastened to the downhole pipe using clamps, encapsulation, and/or any other fastening component configured to secure the pipe external equipment. Electromagnetic logging tools may be commonly configured to locate pits or voids in pipes by effectively locating variances in magnetic fields may be used to detect the magnetic field generating entities along the downhole pipe. The electromagnetic logging tool, which also may generate a magnetic field, may detect resultant magnetic field disturbances generated from the field generating entities and produce data that can be used to locate the pipe external equipment. Operations, such as operating a perforating gun within the downhole pipe, may subsequently proceed, without damaging pipe external equipment, once locating the pipe external equipment.

[0018] FIG. **1** is a cross-sectional view schematic diagram of an embodiment of a wellbore **100**, where various embodiments may operate within. A well site may comprise a wellbore **100**, that include, but are not limited to an injection well, a monitoring well, and/or a producing well used to extract one or more hydrocarbon resources that include carbon-based combustible fuels, such as petroleum products and natural gas. As shown in FIG. **1**, an operator may initially run a downhole pipe **106** within the wellbore **100** to construct a hydrocarbon well. Typically, the operator assembles and subsequently inserts the downhole pipe **106** into a drilled section of the wellbore **100**. In one embodiment, after running the downhole pipe **106** within the wellbore **100**, the operator may cement the downhole pipe **106** to hold it in place. A cemented downhole pipe **106** may serve a variety of functions for a hydrocarbon well that include, but are not limited to zonal isolation, preventing contamination, providing foundation for drilling, sealing high pressure zones from the surface, and/or producing a relatively smooth surface within the internal wellbore **100** for installing production equipment or tool string. In another embodiment, the downhole pipe **106** may be a conduit that is not cemented within the wellbore, such as production tubing or a tubing assembly. For purposes of this disclosure, the term "downhole pipe" throughout this disclosure refers to casing tubing, and/or any other type of conduit used to construct, operate, and/or complete a well.

[0019] FIG. **1** illustrates that pipe external equipment **108** runs on the left side of the downhole pipe **106**. The term "pipe external equipment" throughout this disclosure refers to any type of device and/or equipment external to the downhole pipe that is configured to support a variety of downhole oil and gas operations, such as supporting an injection well, monitoring downhole events, and/or the construction, production, and/or operation of a hydrocarbon well. For example, the pipe external equipment **108** may be monitoring tools, such as sensors and gauges, active flow controls, and/or lift options used in completion and production operations of the hydrocarbon well. Additionally, the pipe external equipment **108** may be capillary tubing, wireline, power cables, fiber optic lines, and/or other hydraulic conduits used to communicate (e.g., transmit and receive data) and control other pipe external equipment (e.g., sensors) and/or other wellbore hardware, such as sub-surface safety values and/or other smart well valves. In one embodiment, the pipe external equipment **108** may be fixed to the exterior of the downhole pipe **106** by using clamps, specific in line—use as part of the piping-anchoring points, placing them in casing collars, molding them on, and/or securing them using any other fastening component. The pipe external equipment **108** may be enclosed in cement for embodiments where an operator cements the downhole pipe **106**.

[0020] Magnetic field generating entities **112** may be installed in close proximity to the pipe external equipment **108**. The magnetic field generating entities **112** may be any material or object configured to produce a local magnetic field and may not be radioactive materials used to tag the pipe external equipment **108**. For instance, the magnetic field generating entities **112** may be permanent magnets, magnetized sections of the wireline, coils, and/or magnetic lines that run in close proximity to the pipe external equipment **108**. In other words, the magnetic field generating entities **112** may be any component capable of generating a magnetic field downhole. Operators may install the magnetic field generating entities **112** by securing the magnetic field generating entities **112** to the downhole pipe **106**, installing the magnetic field generating entities **112** along and/or within the pipe external equipment **108**, and/or incorporating the magnetic field generating entities **112** into the downhole pipe **106**, pipe collars, and/or specific mandrels that run within the downhole pipe **106**. For example, in embodiments where the magnetic field generating entities **112** are permanent magnets, the permanent magnets may be located within and/or on clamps and/or other mechanisms that secure the pipe external equipment **108** to the downhole pipe **106**. In another embodiment, the magnetic field generating entities **112** may be located on and/or within the pipe external equipment **108**. When the magnetic field generating entities **112** are located on the clamps, operators may secure the magnetic field generating entities **112** to the downhole pipe **106** using encapsulation and/or other bonding material. In embodiments where the magnetic field generating entities **112** are magnetic lines, operators may install the magnetic lines along with at least some of the pipe external equipment **108**, such as external capillary tubing, wiring, and/or casing external pipe. In yet another embodiment, the magnetic field generating entities may also be molded into encapsulation often known to those practicing the art to protect lines or wires.

[0021] A logging tool assembly **101** may be configured to detect distortions of a magnetic field caused from one or more magnetic field generating entities **112**. Operators may typically use the logging tool assembly **101** to determine well integrity by running the logging tool assembly **101** within the downhole pipe **106**. For instance, during the lifetime of the well, downhole pipe **106** may erode over time because of corrosion and/or mechanical defects. In order to prevent pipe-string failures, operators may regularly inspect the downhole pipe **106** to detect excessive wear or any other potential infrastructure problems. Operators may detect potential issues in the downhole pipe **106** by running a wireline **114** coupled to an electromagnetic logging tool assembly **101** to locate pits and/or voids in downhole pipe **106** by locating variances in the electromagnetic fields produced by the logging tools to 'saturate' the pipe with magnetic flux. From the distortions in the magnetic fields, the logging tool assembly **101** may be able to determine the location of the pipe external equipment relative to a reference, and thereby enable operators to perform other downhole operations in the downhole pipe **106** without damaging the pipe external equipment **108**. Embodiments of the logging tool assembly **101** include any casing inspection logging tool that uses magnetic flux leakage to locate pits and/or voids in downhole pipe **106**, such as the Baker Hughes Vertilog™ and the Spartek Casing Inspection Tool.

[0022] As illustrated in FIG. **1**, the logging tool assembly **101** may comprise an electromagnetic/magnetic field generation unit **102** and a detection unit **104**. Other embodiments of the logging tool assembly **101** may not comprise the electromagnetic/magnetic field generation unit **102** to induce a magnetic field if relatively strong magnetic generating entities, such as rare Earth magnets, already exist. The electromagnetic/magnetic field generation unit **102** may be configured to generate magnetic and/or electromagnetic fields that are transmitted to the surrounding area of the logging tool assembly **101**. In one embodiment, the electromagnetic/magnetic field generation unit **102** may be an exciter coil that generates alternating current (AC) electromagnetic fields using alternating current (AC). In another embodiment, the electromagnetic field generation unit **102** may generate low frequency or high frequency radio frequency (RF) electromagnetic fields using RF power. In another embodiment, the magnetic field generation unit **102** may be an electromagnet that creates a relatively low-frequency and/or a direct-current magnetic field, or a permanent magnet as used in the Baker Vertilog. Other embodiments may generate electromagnetic and/or magnetic fields using other methods well-known in the art. The generated fields may be static or alternating that penetrate or are transmitted into the surrounding, downhole pipe **106**, cement, pipe external equipment **108**, and/or surrounding rock formations.

[0023] The detecting unit **104**, which may be housed within the logging tool assembly **101** and coupled to the electromagnetic/magnetic field generation unit **102**, may comprise one or more electromagnetic/magnetic field sensors configured to detect the varying electromagnetic/magnetic fields by measuring one or more electromagnetic and/or magnetic properties that include induced voltages, eddy-currents, magnetic flux, and/or electromagnetic phase-shifts. In one embodiment, a motor may directionally rotate the detecting unit **104** to detect variations in the electromagnetic and/or magnetic field and simultaneously and/or successively transmit detected data to output, display, record, and/or store the detected data at equipment or devices located on the surface. In another embodiment, a plurality of electromagnetic and/or magnetic field sensors, such as hall-effect sensors may be constructed to form a ring. Other embodiments may employ other types of electromagnetic field sensors well-known in the art.

[0024] The detection unit **104** may implement a relatively high speed logging process that provides data to locate the external orientation of the pipe external equipment. During the logging process, when the pipe external equipment **108** and/or magnetic generating entities **112** are present, the detecting unit **104** may detect distorted magnetic fields. Without the pipe external equipment **108** and/or magnetic generating entities **112**, the detecting unit **104** may output a constant electromagnetic and/or magnetic field within the downhole pipe **106**. The detection unit **104** may not be configured for gamma ray logging that detects tagged pipe external equipment with radioactive materials. The output of the detecting unit **104** will be discussed in more detail in FIG. **4**.

[0025] As persons of ordinary skill in the art are aware, although FIG. **1** illustrates an embodiment of a logging tool assembly **101** used to determine the location of pipe external equipment **108** relative to the downhole pipe **106**, the disclosure is not limited this particular embodiment as illustrated in FIG. **1**. For instance, although FIG. **1** illustrates that the pipe external equipment **108** is located to the left of the downhole pipe **106**, persons of ordinary skill in the art are aware that depending on the location of the cross section, the pipe external equipment **108** may be located to the right of the downhole pipe **106** or on both sides of the downhole pipe **106**. Moreover, the logging tool assembly **101** may include other components that are not depicted in FIG. **1**, such as electronics, batteries, and/or components of a tool string attached to the logging tool assembly **101**. The use and discussion of FIG. **1** is only an example that facilitates ease of description and explanation.

[0026] For purposes of this disclosure, the term "magnetic" and "electromagnetic" can be interchanged throughout this disclosure. Persons of ordinary skill in the art are aware that electromagnetic fields include electric fields, magnetic fields, and electromagnetic radiation that include light, radio waves, x-rays, and gamma rays. Electric fields are present around charged bodies and magnetic fields exist when electric current is moving. Magnetic files also exist in permanent magnets because of the spin of subatomic particles that are locked into alignment to form a fixed static-magnetic field.

[0027] FIG. **2** is a schematic diagram of an embodiment of a clamping component **204** used to secure the magnetic field generating entities **206** in close proximity to the pipe external equipment **208** and **210**. The pipe external equipment **208** and **210** (e.g., capillary tubing) may be attached to the downhole pipe **202** using one or more clamping components **204** and/or other fastening components. The clamping components **204** may be distributed and attached along the length of the downhole pipe to properly secure the pipe external equipment **208** and **210**. The pipe external equipment **208** and **210** may be substantially similar sizes or may also vary in sizes when attached to the downhole pipe **202**.

[0028] In one embodiment, the clamping component **204** may be a cross coupling clamp that secures and protects the capillary tubing **208** and **210** to the downhole pipe **206**. The clamping component **204** may include channels that shield cables and/or wires that traverse across the clamping component **204** to prevent damage. The clamping component **204** may also be adjustable such that the clamping component **204** may accommodate a variety of sizes for the downhole pipes **202** while securing the pipe external equipment **208** and **210**. Using FIG. **2** as an example, the clamping component **204** may be installed by compressing the clamping component **204** using a hydraulic tool to secure the pipe external equipment **208** and **210** with the downhole pipe **202**.

[0029] As shown in FIG. **2**, the magnetic field generating entities **206** may be held in place with the clamping component **204**. The clamping component **204** may be configured with profiles that accept and/or hold the magnetic field generating entities **206** on either side of the pipe external equipment. For example, if the magnetic field generating entities **206** are permanent magnets or strips of magnets, the permanent magnets or strips of magnets may be located within the clamping component **204** such that an operator may be unable to remove the permanent magnets or strips of magnets without removing or damaging the clamping component **204** (e.g., breaking the clamping component). Conversely, the permanent magnets or strips of magnets may be attached to the clamping component **204** by inserting the permanent magnets or strips of magnets into designated slots or groves incorporated into the clamping component **204**. In other words, the permanent magnets may be inserted or removed from the clamping component **204** without damaging the clamping component **204**. In another embodiment, the permanent magnets or strips of magnets may be located on the clamping component **204** by securely attaching the permanent magnets or strips of magnets onto the clamping component **204** using encapsulation.

[0030] Additionally, in certain embodiments, the operators may install the magnetic field generating entities **206** along with the pipe external equipment **208** and **210**. Recall, that the clamping component **204** may secure the pipe external equipment **208** and **210** to the downhole pipe **202**. In this instance, the magnetic field generating entities **206** may be located in close proximity to the pipe external equipment **208** and held in place using a the clamping component **204**. Prior to installing the clamping component **204**, an operator may place magnetic field generating entities **206** relatively close to the pipe external equipment **208** and **210**. After installing the clamping component **204**, the magnetic field generating entities **206** may maintain the close proximity with the pipe external equipment **208** and **210**, or at any desired distance in known configuration. Example of embodiments of magnetic field generating entities **206** that are installed along with the pipe external equipment **208** and **210** include permanent magnetized sections of wireline or magnetic wire that are located in close proximity to the pipe external equipment **208** and **210**. The magnetic field generating entities **206** may also be placed any radial or longitudinal distance away from the pipe external equipment **208** and **210**.

[0031] Persons of ordinary skill in the art are aware that distances for "close proximity" and/or "any desired distance in known configuration" are dependent on the type of pipe external equipment. In some instances, persons of ordinary skill in the art are aware that the magnetic field generating entities **206** will affect (e.g., noise) one or more sensors of the pipe external equipment **208** and **210**. In these instances, close proximity" and/or "any desired distance in known configuration" will be the determined distance where the magnetic field generating entities **206** will not affect the readings from one or more sensors of the pipe external equipment **208** and **210**. For example, if the magnetic field generating entities **206** are distorting the reading for the sensors of the pipe external equipment **208**, the magnetic field generating entities **206** may be clamped to the pipe or installed on the opposite of the sensor. For applications where the magnetic field generating entities **206** (e.g., permanent magnet) do not affect the pipe external component **208** and **201**, such as an hydraulic umbilical, the distance for close proximity" and/or "any desired distance in known configuration" may be relatively closer. Persons of ordinary skill in the art are aware that a variety of known geometric relationships may be used to determine "close proximity" and/or "any desired distance in known configuration" for the distances between the magnetic field generating entities **206** and pipe external equipment **208** and **210**.

[0032] FIG. **3** is a schematic diagram of another embodiment of a clamping component **300** used to secure the magnetic field generating entities **206** in close proximity to the pipe external equipment **306**. Specifically, FIG. **3** depicts that the pipe external equipment **306** is a conduit that is held against the downhole pipe **202**. In FIG. **3**, the clamping component **300** is mid joint clamp configured to provide protection at the mid joint of the downhole pipe **202**. Similar to the clamping component **204**, the clamping component **300** may be configured to accommodate variety of downhole pipe sizes and any combination of pipe external equipment. An operator may compress/install the clamping component **300** using one or more hydraulic tools. Similar to FIG. **2**, the magnetic field generating entities **206** may be installed in and/or on clamping component **300** or installed along with the pipe external equipment **302**. Although FIGS. **2** and **3** illustrate that clamps are used to secure the pipe external equipment **208**, **210**, and **302**, to the downhole pipe **202**, other fastening devices, such as a casing collar, may be used to secure the downhole pipe **202**, the pipe external equipment **208**, **210**, and **302**, and the magnetic field generating entities **206**.

[0033] FIG. **4** is a diagram of an output **400** from a logging tool assembly when detecting an array of magnetic field generating entities. In one embodiment, the electromagnetic logging tool may employ magnetic flux leakage to detect and locate the array of magnetic field generating entities. The output **400** comprises an axial magnetic field output **404**, a radial magnetic field output **406**, and a circumferential magnetic field output **408**. The axial magnetic field output **404** generates the magnetic disturbances in the axial direction or the direction parallel to the axis of symmetry for the downhole pipe; the radial magnetic field output **406** generates the magnetic disturbances in the radial direction or the direction perpendicular to the axis of symmetry for the downhole pipe; and the circumferential magnetic field output **408** generates magnetic disturbances in the circumferential direction or in the tangential direction

[0034] The array of the magnetic field generating entities may be distributed along the length of a downhole pipe as shown in the arrangement **402** in FIG. **4**. As shown in FIG. **4**, the installed magnetic field generating entities vary in the direction of the magnetic field poles. FIG. **4** illustrates that for the axial magnetic field output **404**, radial magnetic field output **406**, and the circumferential magnetic field output **408**, magnetic disturbances appear in the form of peaks and/or valleys and that correspond to the location of the magnets and the pole of the magnetic field generating entity. The "N" and "S" indicators within FIG. **4** represent the orientation of the magnetic field. In particular, the magnetic field flux lines are described to exit the N and enter the S ends. FIG. **4** illustrates the response of the logging tool assembly to the various orientations of the magnetic field generating entities on the downhole pipe, which is shown in FIG. **4** as laying horizontal.

[0035] FIG. **5** is flow chart of an embodiment of method **500** used to locate the pipe external equipment using the magnetic field generating entities. In one embodiment, method **500** may be implemented using an operator and a logging tool as described above. The logging tool may be configured to locate pits or voids in downhole pipes by effectively locating variances in magnetic fields may be used to detect the magnetic field generating entities along the downhole pipe. The magnetic field generating entities register or detect electromagnetic and/or magnetic field disturbances within the downhole pipe. The measured magnetic field and data may be transmitted to the surface to determine the location of the pipe external equipment from a reference point. For a perforation operation, the perforating gun within the downhole pipe may subsequently be directed away from the pipe external equipment to avoid damaging the pipe external equipment.

[0036] Method **500** may start at step **502** with the install of the magnetic field generating entities in relatively close proximity or a known distance and direction from of the pipe external equipment. Recall that the magnetic field generating entities may be installed in and/or on fastening components that hold the pipe external equipment against the downhole pipe or along with the pipe external equipment (e.g., as a magnetic wire) in the downhole pipe and/or a mandrel or connector of the pipe. After method **500** completes step **502**, method **500** moves to step **504** where the method runs the downhole pipe and pipe external equipment within the wellbore. The downhole pipe may or may not be cemented during construction of the hydrocarbon well. Method **500** may subsequently move to step **506** and run a logging tool within the downhole pipe.

[0037] Method **500** continues to step **508** to log the magnetic/electromagnetic fields using the logging tool. The logging tool may generate magnetic fields using direct current or permanent magnets, or electromagnetic fields using AC current, and/or RF power within the downhole pipe. Method **500** may then continue to step **510** to detect the generated magnetic and/or electromagnetic fields. Without the magnetic field generating entities, the generated magnetic and/or electromagnetic fields may be substantially symmetrical about the downhole pipe to produce about a constant electromagnetic field. However, method **500** may detect magnetic field generating entities based upon detecting the magnetic disturbances and produce an output similar to FIG. **4**. In one embodiment, the detection of the magnetic field generating entities may be measured by detecting the magnetic flux leakage at any known distance along the wellbore. Based on the magnetic field disturbance data, method **500** may proceed to step **512** and determine the orientation and/or location of the pipe external equipment within a wellbore at any distance along the wellbore. The orientation may be based on a reference point, such as gravity. Afterwards, method **500** may move to step **514** and perform a well operation based on the orientation of pipe external equipment along the length of the wellbore.

[0038] Programming and/or loading executable instructions onto surface control equipment is well known in the art in order to transform surface equipment and/or components located on the logging tool that process data in part into a particular machine or apparatus, e.g., an logging tool system. Implementing instructions, real-time monitoring, and other functions by loading executable software into a computer can be converted to a hardware implementation by well-known design rules. For example, decisions between implementing a concept in software versus hardware may depend on a number of design choices that include stability of the design and numbers of units to be produced and issues involved in translating from the software domain to the hardware domain. Often a design may be developed and tested in a software form and subsequently transformed, by well-known design rules, to an equivalent hardware implementation in an ASIC or application specific hardware that hardwires the instructions of the software. In the same manner as a machine controlled by a new ASIC is a particular machine or apparatus, likewise a computer that has been programmed and/or loaded with executable instructions may be viewed as a particular machine or apparatus.

[0039] At least one embodiment is disclosed and variations, combinations, and/or modifications of the embodiment(s) and/or features of the embodiment(s) made by a person having ordinary skill in the art are within the scope of the disclosure. Alternative embodiments that result from combining, integrating, and/or omitting features of the embodiment(s) are also within the scope of the disclosure. Where numerical ranges or limitations are expressly stated, such express ranges or limitations may be understood to include iterative ranges or limitations of like magnitude falling within the expressly stated ranges or limitations (e.g., from about 1 to about 10 includes, 2, 3, 4, etc.; greater than 0.10 includes 0.11, 0.12, 0.13, etc.). The use of the term "about" means ±10% of the subsequent number, unless otherwise stated.

[0040] Use of the term "optionally" with respect to any element of a claim means that the element is required, or alternatively, the element is not required, both alternatives being within the scope of the claim. Use of broader terms such as comprises, includes, and having may be understood to provide support for narrower terms such as consisting of, consisting essentially of, and comprised substantially of. Accordingly, the scope of protection is not limited by the description set out above but is defined by the claims that follow, that scope including all equivalents of the subject matter of the claims. Each and every claim is incorporated as further disclosure into the specification and the claims are embodiment(s) of the present disclosure.

[0041] While several embodiments have been provided in the present disclosure, it may be understood that the disclosed embodiments might be embodied in many other specific forms without departing from the spirit or scope of the present disclosure. The present examples are to be considered as illustrative and not restrictive, and the intention is not to be limited to the details given herein. For example, the various elements or components may be combined or integrated in another system or certain features may be omitted, or not implemented.

[0042] In addition, the various embodiments described and illustrated in the various embodiments as discrete or separate may be combined or integrated with other systems, modules, techniques, or methods without departing from the scope of the present disclosure. Other items shown or discussed as coupled or directly coupled or communicating with each other may be indirectly coupled or communicating through some interface, device, or intermediate component whether electrically, mechanically, or otherwise. Other examples of changes, substitutions, and alterations are ascertainable by one skilled in the art and may be made without departing from the spirit and scope disclosed herein.

[0043] All of the references cited herein are expressly incorporated by reference. The discussion of any reference is not an admission that it is prior art to the present invention, especially any reference that may have a publication data after the priority date of this application.

What is claimed is:

1. A method for providing a location of downhole equipment external to a downhole pipe within a wellbore, comprising:

generating a magnetic or an electromagnetic field within the downhole pipe using a logging tool;

measuring one or more at least one of the following: magnetic field disturbances and electromagnetic field disturbances caused from one or more magnetic generating entities;

detecting the positions of the one or more magnetic generating entities from at least one of the following: magnetic field disturbances and electromagnetic field disturbances; and

determining the location of one or more pipe external equipment based upon at least one of the following: magnetic field disturbances and electromagnetic field disturbances caused from the one or more magnetic generating entities,

wherein the one or more magnetic generating entities are located in close proximity to the one or more pipe external equipment.

2. The method of claim **1**, further comprising securing the one or more pipe external equipment to the downhole pipe using one or more fastening components.

3. The method of claim **2**, wherein the one or more magnetic generating entities are permanent magnets located on the one or more fastening components.

4. The method of claim **2**, wherein the one or more magnetic generating entities are permanent magnets located in the pipe or pipe couplings

5. The method of claim **2**, wherein the one or more magnetic generating entities are permanent magnets located in a mandrel in the pipe string.

6. The method of claim **2**, wherein the one or more magnetic generating entities are permanent magnets located in encapsulation.

7. The method of claim **2**, wherein at least one of the one or more fastening components is a cross coupling clamp.

8. The method of claim **1**, further comprising securing the one or more pipe external equipment and the one or more magnetic generating entities to the downhole pipe using one or more fastening components.

9. The method of claim **1**, wherein detecting the position of the one or more magnetic generating entities from at least one of the following: magnetic field disturbances and electromagnetic field disturbances comprise determining a magnetic flux leakage.

10. The method of claim **1**, wherein the magnetic field is generated using a permanent magnet within the logging tool.

11. The method of claim **1**, wherein the one or more magnetic generating entities is an array of magnets with different magnetic field pole orientations relative to the axis of the downhole pipe.

12. The method of claim **1**, wherein the one or more magnetic generating entities are a magnetic wire.

13. A system for determining the locations of at least one pipe external equipment, the system comprising:

a downhole pipe running within a wellbore;

at least one pipe external equipment running outside or within the downhole pipe within the wellbore;

a logging tool running within the downhole pipe; and

at least one magnetic field generating entities located at a determined distance to the at least one pipe external equipment,

wherein the logging tool is configured to:

generate a magnetic, an electromagnetic field, or both; and

detect one or more magnetic field disturbances, electromagnetic field disturbances, or both that correspond to the location of at least one magnetic field generating entities.

14. The system of claim **13**, wherein the at least one magnetic field generating entities are located outside of the downhole pipe.

15. The system of claim **14**, wherein the at least one pipe external equipment is coupled to the downhole pipe via one or more fastening components.

16. The system of claim **15**, wherein at least one of the fastening component is a cross coupling clamp.

17. The system of claim **15**, wherein the at least one magnetic generating entities are permanent magnets attached to the cross coupling clamp.

18. The system of claim **13**, wherein the logging tool is further configured to detect pits and voids within the downhole pipe by detecting the magnetic flux leakage of the downhole pipe.

19. The system of claim **13**, wherein the logging tool is further configured to generate an magnetic field using a permanent magnet.

20. An apparatus comprising:

at least one pipe external equipment coupled to the exterior of a downhole pipe configured to be run down a wellbore; and

at least one magnetic field generating entity coupled at a determined distance to the at least one pipe external equipment,

wherein the at least one magnetic field generating entity is coupled to the at least one pipe external equipment using a fastening component.

21. The apparatus of claim **18**, wherein the least one magnetic generating entities are permanent magnets attached to the fastening component.

22. The apparatus of claim **18**, wherein the least one magnetic generating entities is a magnetic wire.

23. A method, system, and apparatus magnetically detecting equipment external to a downhole pipe prior to performing certain well operations as shown and described.

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