Title: SYSTEM AND METHOD FOR COLLECTION, ANALYSIS AND ARCHIVING OF PIPE DEFECT DATA

Abstract: The system utilizes electroscan equipment including a voltage source and current meter with a cable having one end grounded and one end having an electric probe thereon sized to fit within an underground pipe. The probe is able to complete an electric circuit back to ground when the probe is adjacent a defect through which electric currents can pass, thus producing varying electric current. A cable reel is provided with portions of the cable supported thereon and with a cable distance sensor coupled to the reel along with the current meter and voltage source in the form of a battery. The current meter and distance sensor transmit wireless signals to an on-site processor, such as a smartphone, for on-site data evaluation. Such unconditioned data is also transmitted to a remote location for conditioning of the data and retransmission of the conditioned data back to the on-site processor.
SYSTEM AND METHOD FOR COLLECTION, ANALYSIS
AND ARCHIVING OF PIPE DEFECT DATA

Technical Field

The following invention relates to systems and methods for detecting defects in underground pipes, such as sewer pipes or water pipes which have a potential to leak. More particularly, this invention relates to systems and methods which involve establishing if electric current flows between ground adjacent the pipe and an interior of the pipe, which circuit increases in current amplitude when an electric probe passing through a pipe filled with electrically conductive fluid approaches defects in the pipe.

Background Art

Sewer systems and other underground pipes can be difficult to inspect due to their hidden location. Leaks in such pipes can increase costs associated with operating the pipe, and potentially create hazards. Thus, it is beneficial to identify defects in the pipe which can leak (both leaks into and out of the pipe).

One form of defect detection is described in detail in ASTM Standard F2550-06 which describes an electroscan method for defect detection by measuring variations in electric current flow through walls of the pipe as part of a series circuit including a voltage source and an electric current sensor, which collects data as the probe moves through a known position within the pipe.

One such probe beneficial for use in conducting this electroscan is the segmented measuring probe for sewer pipes described in U.S. Patent No. 6,301,954, incorporated herein by reference in its entirety. Such probes effectively concentrate the electric current over a relatively short length of the pipe in which the probe is located, so that electric current amplitude data gathered by the electroscan method can be accurately correlated with the condition of the pipe directly adjacent the probe.

Operation of the electroscan method can be difficult in that there is a challenge associated with accurately correlating the current amplitude data with the probe position. If the probe is not where the operators think it is when current data is
gathered from the current meter, operators will mistakenly associate the current data correlating with pipe defects to the wrong portions of the pipe. Repairs might then be done in the wrong location or further analysis conducted in the wrong location, wasting time, resources and increasing the cost of further analysis and repairs. To precisely correlate probe position with current amplitude data can be a time intensive and laborious process, thus magnifying the resources required to analyze a section of pipe. Accordingly, a need exists for better systems and methods for efficiently gathering and correlating both current amplitude data and probe position data and combining this data into a two-dimensional data array for viewing and meaningful analysis.

Furthermore, raw data gathered from the current meter and probe position often need significant conditioning before it can be most meaningfully evaluated by personnel. Such analysis is beneficially done at a remote location where the most specialized data conditioning software can act on the data, and where the unconditioned and conditioned data can simultaneously be archived and incorporated into a larger data set of overall piping system condition. Data, once conditioned at the remote location, can then be beneficially returned to the site where the operators are located for more precise interpretation of the current amplitude data and correlation to potential pipe defects.

Disclosure of the Invention

With this invention a system and method are provided for operating electroscan type pipe defect detection analysis with equipment and methods to enhance the results achieved thereby. The system includes an electric probe coupled to a distal end of an electrically conductive cable also having a proximal end opposite the distal end. The probe is preferably of a type similar to that disclosed in U.S. Patent No. 6,301,958, incorporated herein by reference in its entirety. A voltage source is provided adjacent to the proximal end of the electrically conductive cable, typically in the form of a battery. An electric meter, typically in the form of a current meter, is also located along the electrically conductive cable, typically near the proximal end thereof.

A ground interface, typically in the form of a ground stake, is penetrated into ground in the general area of the pipe to be inspected and has a ground wire which extends to the proximal end of the electrically conductive cable. Thus, a series
electric circuit is created which is closed by passage of electric current from the probe through a defect in the pipe wall and through ground between this defect and the ground interface.

Amplitude of this current in this circuit is measured by the electric meter. Probe position data is also gathered so that the probe position data is correlated with the electric current amplitude to create an unconditioned two-dimensional data set of current amplitude versus probe position.

A cable reel is provided to assist in storing portions of the electrically conductive cable which are not yet drawn down into the pipe. This cable reel also beneficially includes the voltage source and current meter mounted thereto and most preferably rotating along with portions of the cable adjacent the proximal end thereof. The cable is routed through a cable distance sensor which is preferably fixed to a frame of this cable reel and measures an amount of cable played off of the reel and into the pipe extending toward the probe. This cable distance sensor is correlated with probe position so that the position of the probe is known for the current amplitude data.

As the probe is drawn through the pipe being evaluated, the cable plays off of the reel and passes through the cable position sensor. Electric current data is simultaneously gathered. The cable position sensor and electric meter preferably each include transmitters which transmit to a separate on-site portable electronic device, such as in the form of a smartphone. One form of such transmission can be in the form of Bluetooth signals. Signals are received by the smartphone or other on-site processor which correlates the two signals into a single two-dimensional data set of current amplitude versus probe position.

The reel also facilitates effective grounding of the proximal end of the cable by having the proximal end of the cable first grounded to a rotating hub of the reel and having this hub rotate upon an axle sufficiently closely that a grounded electric connection is maintained therebetween. The stationary axle has an end which can have the ground wire of the ground stake electrically coupled thereto so that a ground connection exists between the ground stake and the hub of the reel. The overall system can thus be readily set up and used to support the cable as it is deployed and the probe is drawn through a pipe being evaluated.
Data is automatically transmitted to the smartphone or other portable on-site processor which can then readily gather an unconditioned data set. This data set can be viewed on site, can trigger alarms when preset limits associated with defects of a preselected magnitude are identified. This unconditioned data set can be viewed through the on-site processor, such as a smartphone. The unconditioned data can also be transmitted, such as by cellular data link associated with a smartphone, to a remote location for archiving and conditioning of the data into more meaningful data which can be transmitted back to the on-site processor for display to personnel in the field in near real time. The conditioned data can be incorporated into a larger overall data set for an overall piping system, of which the evaluated pipe is only a portion.

Consistent with the electroscan method to which this invention is directed, other equipment is also utilized such as to maintain a flooded or substantially flooded state within the pipe being evaluated and to accommodate particular situations such as when the pipe to be analyzed is a lateral pipe or a mainline. Various different equipment are also known in the art for drawing the probe through the pipe while maintaining this submerged state within the pipe, such as utilization of a haul line such as that associated with a jet cleaner hose, as is known in the art.

**Brief Description of Drawings**

Figure 1 is a schematic depiction of the prior art electroscan underground pipe defect detection methodology associated with ASTM Standard F2550-06 to which the details of this invention are directed.

Figure 2 is a schematic generalized depiction of a section of underground pipe which is undergoing the electroscan evaluation associated with Figure 1.

Figure 3 is a graphic depiction of a typical graph of current amplitude versus probe location as it might appear utilizing the electroscan method associated with Figure 1 and with current amplitude spikes shown in Figure 3 correlating with leaks depicted in Figure 2 and illustrating how current spikes plus shape and area under current spikes indicate presence of defects, size and type of defects in the pipe with a propensity for leaking.

Figure 4 is a perspective view of a cable reel for use according to a preferred system and method of this invention to enhance accuracy and convenience of operation of the system and method of this invention.
Figure 5 is a side elevation view of that which is shown in Figure 4.

Figure 6 is a schematic depicting an on-site processor in the form of a smartphone in a preferred embodiment communicating with a remote processing location and illustrating how unconditioned raw data is received by the smartphone, can potentially be displayed and also is transmitted to the remote processing location for conditioning, archiving and potentially retransmission back to the smartphone for further analysis of conditioned data by personnel at the pipe evaluation site.

Best Modes for Carrying Out the Invention

Referring to the drawings, wherein like reference numerals represent like parts throughout the various drawing figures, reference numeral 10 is directed to a system for identification of pipe defects. The system 10 (Figure 1) is consistent with a prior art system described in ASTM (ASTM International, formerly known as "American Society for Testing and Materials") Standard F2550-06 described as "Standard Practice for Locating Leaks in Sewer Pipes Using Electroscan — the Variation of Electric Current Flow Through the Pipe Wall." This system 10 can be utilized in underground pipes such as a sewer S (Figure 2) by passing a probe 60 through the sewer S pipe, such as between adjacent manholes M to detect defects D in the pipe wall W. The system incorporates a reel assembly 110 (Figures 4 and 5) and data handling and processing (Figure 6) with a smartphone 190 or other on-site processor, as well as a remote processing location 200, for efficient and accurate data handling and overall database construction of pipe condition data.

With particular reference to Figures 1-3, basic details of the prior art electroscan pipe defect evaluation system are described. This basic electroscan leak detection system 10 causes a series electric circuit to be formed extending along a cable 50 which extends from a probe end 52 to a proximal end 54. The probe end 52 has an electric probe 60 attached thereto, such as through a connector 62. This probe 60 can be similar to or the same as a probe such as that described in U.S. Patent No. 6,301,954, incorporated herein in its entirety.

The proximal end 54 of the cable 50 is coupled to a ground stake 20. A voltage source 40 is provided along the cable 50. An electric meter, such as in the form of a current meter, is also located along the cable or between the voltage source 40 and the ground stake 20 to measure current within this series circuit. Such location of the
voltage source and/or the electric meter can involve physical connection or non-
physical, such as involving inductance or electromagnetic field forces. A final
portion of the series circuit is in the form of a current path C passing from the ground
stake 20, through the ground G, and through a defect D in the pipe wall W and
through electrically conductive fluid F (typically water with dissolved electrolytes)
contained within the pipe and then to the probe 60.

The current meter 30 detects a small amount of current when the pipe wall W is
free of defects, because the pipe wall is typically formed of a low or non-electrically
conductive material, such as cement pipe, clay pipe, plastic pipe, etc. When there is a
defect in the pipe, and because the pipe is filled with electrically conductive fluid F,
fluid will pass through this crack or other defect in the flooded pipe and a current
pathway is thus provided to enhance an amount of current detected by the current
meter 30 or other electric meter. A size and shape of current spike generally
correlates with an amount, size and/or shape of this defect.

With reference to Figures 2 and 3, examples of different types of defects are
indicated by different sizes, shapes and areas under the curve, and amplitudes of
electric current spikes 78 in the data plot 72 of current versus probe 60 position. For
instance, a longitudinal crack such as defect D, (Figure 2) results in a relatively wide
current amplitude spike which is spaced away from the location of any laterals or
joints between pipe segments. Small and regularly located increases in electric
current amplitude are indicative of pipe joint P locations which under normal
circumstances might still allow sufficient fluid F to pass therethrough to create a small
spike in current.

Point or radial defects such as depicted by D, (Figure 2) tend to provide a
narrower spike in current amplitude with less area under the curve (Figure 3). Defects
adjacent a lateral L in the sewer S are depicted by defect D, (Figure 2) and generally
appear in the graphed data as a wide current amplitude spike which is aligned with a
location of the lateral. Finally, defects 78 which are aligned with joint locations in the
pipe are indicative of a defective joint such as defect D, (Figure 2), and
correspondingly depicted in Figure 3.

In essence, and with particular reference to Figures 4 and 5, basic details of the
reel assembly 110 of the enhanced implementation of the system 10 of this invention
are described, according to a most preferred embodiment. The reel assembly 110
allows for efficiency and accuracy to be improved when implementing the system 10. This reel assembly 110 generally includes a foot 120 which can rest upon the ground. An axle 130 near a center of the reel assembly 110 supports a hub 140 thereon with the axle 130 being stationary and fixed to the foot 120 with the hub 140 rotating upon the axle 130. A cable support cage 150 acts as a form of spool rotating along with the hub upon the axle 130. The cable support cage 150 has a series of turns of the cable 150 adjacent thereto.

A distance module 160 is preferably fixedly mounted to the reel assembly 110, such as to portions of the structure extending up from the foot 120. This distance module 160 is configured to accurately measure an amount of cable 50 played off of the reel assembly 110. A probe module 170 is also mounted to the reel assembly 110, but to a portion thereof which rotates along with the cable support cage 150 and portions of the cable 50 mounted upon the cable support cage 150. This probe module 170 preferably includes the voltage source 40 such as in the form of a battery and the electric meter 30, such as in the form of a current meter thereon. Both the distance module 160 and probe module 170 preferably include transmitters 166, 176 so that data collected thereby can be transmitted to a common smartphone 190 or other on-site processor where these signals can be correlated together into a single unconditioned data set. The smartphone 190 can transmit this unconditioned data to a remote processing location 200 (Figure 6), such as over a cellular data network, where the data can be conditioned, archived and added to an overall piping evaluation database, and also can be transmitted back to the field in near real time for analysis by operators at the pipeline evaluation location.

More specifically, and with continuing reference to Figures 4 and 5, particular details of the reel assembly 110 are described, according to this most preferred embodiment. The reel assembly 110 includes a fixed frame portion and a rotating portion which rotates relative to the fixed portion. The fixed portion includes the foot 120 adapted to rest upon the ground. A handle 125 extends up from the foot 120 and is conveniently located to grip and carry the reel assembly 110 without having to grip rotating portions of the reel assembly 110. Wheels 122 can optionally be provided on portions of the foot 120 to allow for rolling of the reel assembly 110 on the ground, especially when a large amount of cable 150 is supported on the reel assembly 110.
The rigid frame portion of the reel assembly 110 also supports an axle 130 at a
junction between the handle 125 and the foot 120. This axle 130 extends along a
centerline of rotation of rotating portions of the reel assembly 110. The axle 130 acts
as a shaft about which a hub 140 of rotating portions of the reel assembly 110 can be
supported in a rotating fashion. Preferably, the axle 130 has ends 134 which either
extend out from other portions of the fixed frame somewhat or are otherwise
configured to be conveniently accessed for attachment through a ground clip 142.
This ground clip 142 extends to a ground wire 22 which extends to the ground stake
20. In this way, the axle 130 of the reel assembly 110 is grounded effectively to the
ground stake 20.

Rotating portions of the reel assembly 110 are all supported by fixed portions of
the reel assembly 110 through the hub 140. The hub 140 is a hollow cylinder with the
axle 130 passing through a central portion thereof and along a centerline of the hub
140. A cable support cage 150 is oriented circumferentially about the hub 140 with
spokes 155 supporting the cable support cage 150 from the hub 140. This cable
support cage 150 is preferably largely open so that cable 50 supported thereon can be
readily cleaned and can readily dry, but has sufficient support to keep it from falling
off of the cable support cage 150, which acts as a form of spool for the cable 50.

The reel assembly 110 preferably includes a distance module 160 and probe
module 170 affixed thereto to conveniently allow for gathering and collection of
accurate current (or other electric parameter) amplitude and probe position data. The
distance module 160 is preferably mounted to fixed portions of the reel assembly 110,
such as to portions of the handle 125 or foot 120. This distance module 160 is
preferably in the for of a box which is rigidly attached to the reel assembly 110 and
has a cable sleeve 162 with a bore passing therethrough on a portion thereof. The
cable 50 is routed through this bore 164 in the cable sleeve 162.

A detector is located adjacent this bore 164 which can measure an amount of
cable passing through the cable sleeve 162. In one form, this detector is in the form
of a rolling dial which extends sufficiently laterally into the bore 164 so that the cable
50 cannot pass through the bore 164 unless it causes this wheel to rotate. A rotational
transducer is associated with this wheel so that it measures a number of turns of the
wheel and correlates this number of turns with an amount of cable 50 played off of
the reel assembly 110.
Initially, an operator will measure precisely a distance from the distance module 160 to a manhole M and down to a bottom of the manhole M to a start location within the pipe to be evaluated, and can enter this "offset" into the on-site processor if desired. Then, as distance data is collected associated with the cable 50 passing through the bore 164 in the distance module 160, this distance data is correlated with distance away from this start point below the entry manhole for the cable. The distance module 160 can include an input device where this start distance can be entered. As an alternative, the distance module 160 can merely include a zeroing button which can be depressed when the probe 60 is seen to be at the start location and the cable 50 is generally taut between the location of the reel assembly 110 and the input manhole M.

While the reel assembly 110 preferably does not move during pipe evaluation, should the reel assembly 110 move, or should slack develop in the cable 50, which would cause distance data from the distance module 160 to come out of correlation with the position of the probe 60, such potential errors can be corrected during conditioning of the data, such as at the remote processing location 200. One form of such conditioning involves identifying small spikes in current amplitude data correlating with joints in the pipe. When a distance between joints in the pipe is already known, such relatively small errors in distance data and probe location data can be corrected by causing detected current spikes associated with joints to control rather than actual measured distance data from the distance module 160.

The on-site processor is provided for initial collection of data from the distance module 160. This on-site processor is preferably in the form of a smartphone 190. While the distance module 160 could be hard wired to the smartphone 190 or other on-site processor, most preferably a wireless transmitter is associated with the distance module 160. This wireless transmitter 166 transmits distance data to the smartphone 190. The distance data can be given a timestamp or can otherwise be correlated with current amplitude data from the probe module 170. In one form this transmitter 166 is a Bluetooth transmitter and the smartphone 190 is a Bluetooth enabled smartphone.

Preferably, a dedicated frequency is provided for the distance module 160 so that the transmitter 166 avoids interference when communicating with the smartphone 190. A data sample rate can be provided by the distance module 160 and associated
software operating on the smartphone 190 depending on the sensitivity desired for the
operation of the overall system 10.

The probe module 170 includes the electric current meter (or other electric
parameter meter) thereon and preferably also the voltage source 40, such as in the
form of a battery. Most preferably, these elements, including the electric meter 30
and voltage source 40, are located within the probe module 170 which are mounted to
a rotating portion of the reel assembly 110, such as to spokes 155 between the cable
support cage 150 and the hub 140. In this way, the voltage source 40 can be located
with nothing but electric cable 50 extending from the voltage source 40 to the probe
60, and to minimize any distortions which might come from poor connections within
the overall circuit.

The current meter 30 is also preferably provided with this probe module 170
and rotating with the cable support cage 150 and hub 140, so that the current meter
can be intimately coupled to the cable 50 and measure current passing through the
cable 50 and associated portions of the overall series circuit. While this location is
desirable, it is conceivable that other portions of the series circuit could have the
electric meter 30 located thereon. By utilizing a battery for the voltage source 40, no
rotating connection is required, such as brushes to provide electric power to drive the
series circuit associated with the system 10.

The probe module 170 preferably includes a transmitter 176 which can transmit
electric current data from the electric current sensor 30 directly to the smartphone 190
or other on-site processor. This transmitter 176 transmits a current amplitude signal
which correlates with a character of defects located within the pipe wall W adjacent
the probe 60. This current amplitude data is preferably transmitted by Bluetooth to
the smartphone 190. The current amplitude data is transmitted in a manner which
allows it to be correlated with probe location/distance data from the distance module
160, such as by providing a time stamp associated with the current amplitude data.
Other forms of transmission other than Bluetooth could be utilized by the transmitter
176.

The smartphone 190 or other on-site processor analyzes the two signals, one
from the distance module 160 and one from the probe module 170 and correlates each
signal so that a resulting unconditioned two-dimensional data set is created which has
a probe position field and a corresponding current amplitude field. This two-
dimensional data set can be graphed such as in the form of current amplitude versus distance (see Figure 3) and provide an indication of where defects might exist. As an alternative to time stamps, a data set can merely be created in real time from the two signals received by the on-site processor. As the data is typically sent in packets, the elapsed time between packets can also be used to correlate the two data sets together.

Initially, this data is unconditioned data. For instance, it does not take into account the conductivity of the soil. Also, it has not been conditioned to factor in any slack or other irregularities in playing out of the cable 50 which might cause probe position data to require adjustment, such as utilizing joint position data to correct the distance portion of the signal. While this unconditioned data is less precise, there is some benefit in displaying this unconditioned data through the on-site processor, such as a smartphone, such as on the display of the smartphone. For instance, such display can verify that data is being gathered. A skilled technician might be able to tell whether the data will be useful once conditioned or if something is wrong with the operation of the system. Also, when extreme conditions exist such as an exceptionally large defect, even unconditioned data would tend to clearly show such a defect. Alarms can be preset into the smartphone which would indicate to even untrained personnel a high likelihood of a serious defect and the approximate location of the defect, such that further remedial action can immediately be taken if necessary.

With particular reference to Figure 6, further conditioning and other handling of the unconditioned data and later processed and conditioned data are described. The unconditioned or raw data is initially received by the smartphone, typically in the form of two separate transmissions from the distance module and the probe module which are correlated together in a single unconditioned signal. The smartphone preferably communicates with a remote processing location 200, such as through utilizing a cellular data transmission system built into the smartphone 190, or utilizing other transmission techniques for other forms of on-site processors. Once this raw data has been transmitted to the processing location, the raw data can be archived in raw form. The raw data can also be conditioned, such as to normalize the current amplitude data. For instance, different soil conductivity conditions will result in different magnitudes of current being measured by the current sensor 30. Also, the conductivity of the fluid F within the pipe will have an effect on the magnitude of the current measured by the current meter 30. These current amplitude varying effects...
will tend to be constant along the entire length of pipe being examined and so do not totally obscure spikes in current amplitude associated with a defect that could leak. However, without conditioning, these spikes in the data can be somewhat obscured and more difficult to identify and properly interpret.

One form of current amplitude normalization involves finding the highest or near highest reading of current amplitude and giving it an arbitrary value, such as one hundred percent. All other current amplitude data is compared to this greatest amplitude data to identify a percentage that each current amplitude data set bears relative to this highest amplitude. A current amplitude reading that is ninety percent of the maximum would be given a value of "ninety." In this way, the data set would be normalized in a linear fashion. In some instances, non-linear normalization might be more effective such as utilizing a logarithmic scale rather than a linear scale or some other form of normalization. For instance, statistical variation away from a norm, in the form of standard deviations, might be utilized. By utilizing common current amplitude normalization techniques and having field experience in the defects actually exhibited, the best current normalization techniques can be developed and implemented.

Data conditioning can also involve corrections in the distance signal provided from the distance module 160. For instance, and as discussed above, the position of joints P between known segments of pipes can be seen within the current amplitude data as a form of regular small spikes. The expected location of these small spikes can be compared to the actual location that they are plotted utilizing original distance module signal data. If they are out of synch with each other, this can indicate stretching in the cable 160, accumulated distance errors associated with poor calibration of the sensor in the distance module 160, bends in the pipe being evaluated, causing the cable to travel a distance slightly greater than or less than an actual length of the pipe, or excessive or varying slack in portions of the cable 50, and particularly between the reel assembly 110 and a first manhole where the cable 50 enters the pipe. Data conditioning can involve correcting the actual measured distance coordinate to line up with the joint indicative current amplitude spikes, to properly locate the current amplitude spikes that might be indicative of defects in the pipe.
Other conditioning can also occur, such as to eliminate static or noise from the data or to eliminate potential forms of interference from the data. The conditioned data can be archived similar to the way that the unconditioned data is archived. The conditioned data can also be utilized with other conditioned data within a larger overall database of an overall piping network, such as an overall sewer system, so that a sewer operator or other underground pipeline operator can have a characterization of the status of the overall pipeline system, which can act as a benchmark when future testing is performed and to compare the relative health of different portions of the system to each other.

Finally, the conditioned data can be transmitted back to the remote processor, such as a smartphone 190. This conditioned data can be displayed on the smartphone 190 or other display associated with the on-site processor so that field personnel can see the now conditioned data. The conditioning process can be automated and occur quickly so that this retransmission of the conditioned data can occur in near real time. In this way, field personnel can immediately have access to conditioned data which can be viewed and provide the on-site personnel with information such as whether sections of the pipe need to be re-evaluated, or if any serious defects exist which require further inspection by other means, or to provide confidence that accurate data has been gathered before the scanning operation is wrapped up.

This disclosure is provided to reveal a preferred embodiment of the invention and a best mode for practicing the invention. Having thus described the invention in this way, it should be apparent that various different modifications can be made to the preferred embodiment without departing from the scope and spirit of this invention disclosure. When structures are identified as a means to perform a function, the identification is intended to include all structures which can perform the function specified. When structures of this invention are identified as being coupled together, such language should be interpreted broadly to include the structures being coupled directly together or coupled together through intervening structures. Such coupling could be permanent or temporary and either in a rigid fashion or in a fashion which allows pivoting, sliding or other relative motion while still providing some form of attachment, unless specifically restricted.
Industrial Applicability

This invention exhibits industrial applicability in that it provides a system for efficiently and accurately gathering data associated with underground pipe conditions utilizing the electroscan method.

Another object of the present invention is to provide a method and apparatus for gathering, displaying, conditioning and archiving pipe electroscan data for maximum usefulness.

Another object of the present invention is to provide a system and apparatus for evaluating pipe sections in underground locations, such as sewer pipes or water pipes, for defects in the pipe which have the potential to leak.

Another object of the present invention is to minimize leakage of fluids into or out of pipelines by providing an effective method and apparatus for evaluating underground pipe condition.

Another object of the present invention is to provide a system and apparatus for managing cable associated with an electroscan underground pipe evaluation system for convenient and easy operation and to acquire highly precise data.

Another object of the present invention is to provide a system and method for collection, analysis and archiving of pipe defect data which includes both unconditioned data and conditioned data.

Other further objects of this invention which demonstrate its industrial applicability, will become apparent from a careful reading of the included detailed description, from a review of the enclosed drawings and from review of the claims included herein.
CLAIMS

What is claimed is:

Claim 1: A system for collection, analysis and archiving of pipe defect data, comprising in combination:

- an electric probe sized to fit within an underground pipe;
- an electrically conductive cable having a proximal end and a distal end, said distal end electrically attached to said probe;
- a voltage source coupled to said cable and spaced from said probe;
- a ground interface coupled to said proximal end of said cable;
- an electric meter positioned to measure an electric signal in a circuit including said cable, said voltage source and said ground interface, said electric signal correlating with defects in the pipe adjacent to said probe;
- at least two data processors including an on-site processor and a remote processor;
- said on-site processor including a display for unconditioned data and a transmitter coupleable with the remote processor;
- said remote processor including a processor, memory and software adapted to condition said data to enhance data usefulness and a transmitter capable of sending data back to said on-site processor; and
- said on-site processor adapted to display conditioned data.

Claim 2: The system of claim 1 wherein both said unconditioned data and said conditioned data including an at least two-dimensional data set with each entry in said two-dimensional data set including a current amplitude field and a probe location field, suitable for display in a two-dimensional graph depicting current amplitude versus probe position.

Claim 3: The system of claim 2 wherein said conditioned data includes position data correlated with a location of joints in the pipe, the joint position either pre-determined or detected from regular electric amplitude spikes within said unconditioned data.
Claim 4: The system of claim 1 wherein said remote processor is configured to archive both said unconditioned data and said conditioned data created by said remote processor.

Claim 5: The system of claim 1 wherein said remote processor is adapted to combine conditioned data from multiple locations and taken at multiple different times to establish a larger data set of an overall piping system status.

Claim 6: The system of claim 1 wherein said on-site processor includes a smartphone with a display thereon in the form of a smartphone display, the smartphone transmitter for communication with said remote processor including a cellphone data transmission system with which the smartphone is enabled.

Claim 7: The system of claim 6 wherein said on-site processor includes software running on said smartphone adapted to display unconditioned and conditioned data in the form of a two-dimensional array of electric amplitude versus probe position.

Claim 8: The system of claim 6 wherein said on-site processor is adapted to analyze said unconditioned data sufficient to compare it to alarm conditions and trigger an alarm signal if pre-set alarm conditions correlating with a defect of predetermined magnitude is likely to exist.

Claim 9: The system of claim 1 wherein said remote processor includes software to act upon said unconditioned data to perform electric value normalization, such as to accommodate variations in ground soil conductivity.

Claim 10: The system of claim 1 wherein a cable reel is provided with at least a portion of said cable located thereon and with said cable also simultaneously electrically connected to said ground interface through said proximal end of said cable and with said distal end of said cable deployed off of said reel and extending to said probe, said reel including said voltage source in the form of a battery mounted to a rotating portion of said reel, said electric meter coupled to said reel and a cable
position sensor coupled to said reel and adapted to measure an amount of cable played off of said reel and correlating with a position of said probe within the underground pipe.

Claim 11: The system of claim 10 wherein said electric meter and said distance sensor are adapted to transmit signals to the on-site processor for correlation together to create said unconditioned data.

Claim 12: A method for collection, analysis and archiving of pipe defect data, the method including the steps of:

- providing an electric probe sized to fit within an underground pipe, an electrically conductive cable having a proximal end, the distal end electrically attached to the probe, a voltage source coupled to the cable and spaced from the probe, a ground interface coupled to the proximal end of the cable, an electric meter positioned to measure an electric signal in a circuit including the cable the voltage source and the ground interface, the electric signal correlating with defects in the pipe adjacent to the probe;
- providing at least two data processors including an on-site processor and a remote processor;
- configuring the on-site processor to include a display for unconditioned data and a transmitter capable of transmitting the unconditioned data to the remote processor;
- the remote processor including a processor, memory and software adapted to condition the unconditioned data to enhance data usefulness and a transmitter capable of transmitting the conditioned signal back to the on-site processor;
- collecting data with the on-site processor;
- transmitting the unconditioned data to the remote processor;
- conditioning the unconditioned data into conditioned data with the remote processor;
- transmitting the conditioned data back to the on-site processor; and
- displaying the conditioned data with the on-site processor.
Claim 13: The method of claim 12 wherein said display of conditioned data includes a graphic depiction of electric amplitude versus probe location.

Claim 14: The method of claim 13 wherein said conditioning step includes the unconditioned conditioned data being adjusted to align electric amplitude differences associated with pipe joint locations to match predetermined expected pipe locations.

Claim 15: The method of claim 12 including the further step of archiving the conditioned data and the unconditioned data through the remote processor.

Claim 16: The method of claim 12 wherein the conditioned data is combined with conditioned data from other locations and other times to establish a larger data set of overall piping system status.

Claim 17: The method of claim 12 wherein said providing at least two data processors step includes providing said on-site processor as a smartphone including a display and cellphone data transmitter, said cellphone data transmitter adapted to transmit data to the remote location and the display adapted to display conditioned and unconditioned data as a graph of electric current amplitude versus probe position.

Claim 18: The method of claim 17 wherein said on-site processor includes software with alarm parameters programmed therein which are compared to the unconditioned data and produce an alarm when elements of the data are highly likely to correlate with a pipe defect of predetermined sufficient amplitude.

Claim 19: The method of claim 12 wherein said providing step includes providing a cable reel with at least a portion of the electrically conductive cable located thereon and with the cable also simultaneously electrically connected to the ground interface through the proximal end of the cable and with the distal end of the cable electrically connected to the ground interface through the proximal end of the cable and with the distal end of the cable deployed off of the reel and attached to the probe.
Claim 20: The method of claim 19 including the further step of configuring the cable reel to include a distance sensor thereon adapted to measure an amount of cable played off of the cable reel and to transmit cable distance data along with electric current amplitude data to the on-site processor for combination by the on-site processor into the unconditioned data set.
FIG. 6
INTERNATIONAL SEARCH REPORT

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

G01M 3/18 (2006.01)

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)

G0 IN 22/00, 22/02, 29/00, G01 M 3/18, F 17 D 5/02-5/06

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

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

PatSearch (RUPTO internal), Esp@cenet, PAJ, USPTO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US 447 1651 A (MARK TELEPHONE PRODUCTS, INC) 18.09. 1984</td>
<td>1-20</td>
</tr>
<tr>
<td>A</td>
<td>JP 58555853 A (NIPPON STEEL CORP) 02.04. 1983</td>
<td>1-20</td>
</tr>
<tr>
<td>A</td>
<td>JP 60249049 A (NIPPON KOKAN KK) 09.12. 1985</td>
<td>1-20</td>
</tr>
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</table>

Further documents are listed in the continuation of Box C.

(*) Special categories of cited documents:

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"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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

08 May 2013 (08.05.2013)

Date of mailing of the international search report

20 June 2013 (20.06.2013)

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