

Description

This invention relates to detection of blockages, holes, discontinuities and surface qualities in ducts or tubes.

Lightweight transmission line packages can be installed in a duct by a procedure known as 'fibre blowing'. The technique involves blowing compressed gas along the duct into which the transmission line is to be installed and feeding the transmission line package into the duct at the same time so that the package is urged along the duct by viscous drag of the gas flow. The technique is of particular importance to optical fibre transmission lines which can be damaged by the tension that is produced in pulled installation techniques. In new installations ducts for transmission lines are usually underground or incorporated into the structure of a building and it is difficult and/or costly to install new ducting at a subsequent date to cope with increased demand for lines or for replacement lines. Therefore when ducts are first installed additional ducts for future use will be laid, and it may be several years after the duct installation that fibre packages are actually blown through some of these ducts. A degree of over capacity may also mean that there is a choice of which duct to use. A problem that arises with this system is that during the time between duct laying and installation of fibre, damage may occur to one or more of the ducts which renders them temporarily or permanently unsuitable for use. For example, a complete blockage caused by the duct being crushed would make it impossible for the fibre to be installed, a partial blockage may make installation very difficult and puncture may cause such a loss of the blowing gas that installation is slow or impossible and also exposes any installed fibre to potential damage from water flooding into the duct. Thus it is desirable to be able to ascertain the state of a duct prior to installation, and in the event of a fault to know its type and location. There are also occasions when the continuity or state of a duct containing an installed transmission line may require monitoring.

Accordingly the invention provides a method of testing a duct having first and second ends, the method comprising the steps of introducing a pulse of compressed gas into the duct to establish a pressure wavefront advancing through the duct, wherein the pulse is introduced at or adjacent said first end, determining after at least one time interval following said introduction and during travel of the wavefront along the duct, a value indicative of pressure decay at a particular location to give an indication of a characteristic of the duct that influences the rate of pressure decay at a given location of the duct intermediate said first and second ends as the wavefront advances therethrough, and

comparing said value with stored reference values.

The invention also provides apparatus for testing a duct, the apparatus comprising means to introduce a pulse of compressed gas into the duct to establish a pressure wavefront advancing through the duct, a sensor for establishing a set of values indicative of pressure variation at a particular location as the wavefront travels along the duct, characterised by storage means to store a set of values indicative of a reference pressure variation, means to compare said pressure variation with said set of values from said storage means and to determine whether there is a significant difference between the monitored and reference variations and means to establish the time interval between the introduction of the pulse and the onset of any significant differences between the monitored and reference pressure variations.

In Patent Abstracts of Japan, Vol II, No 162, (P-579) [2609], and the corresponding Japanese patent application 61-294326 (Tokyo Gas Co), there is described a pipeline-leak location system. The system relies on filling the pipeline under test with a test gas having a large pressure propagation velocity difference from air. A shock wave is propagated along the pipe and its transit time between two pressure sensors either side of the leak is recorded. Then air is drawn into the pipe through the leak to be located so that the pipeline contains a zone of test gas and a zone of air, the boundary between the two zones being located at the leak site. Next a shock wave is again propagated along the pipe and the transit time recorded.

From the pressure propagation velocities of the test gas and air, and from the different transit times, it is possible to calculate the location of the interface between the two zones, which location should be the location of the leak.

This system requires access to the pipeline on each side of the leak for gas supply and/or suction, and similarly requires access at both sides of the leak for pressure sensing. The method does not detect blockages, nor can it detect and locate multiple leaks in a single test section.

The invention is now described by way of example with reference to the accompanying drawings in which:

Figure 1 illustrates a prototype embodiment of the invention;

Figure 2 shows a pressure decay trace for perfect and blocked ducts;

Figure 3 shows a pressure decay trace for perfect and perforated ducts;

Figure 4 shows a pressure decay trace for perfect and perforated ducts with the far end of the duct closed;

Figures 5 and 6 show pressure decay traces for perfect and doubly faulted ducts, and

Figure 7 is a block diagram of a preferred embodiment of the invention.

The operation principle of the invention is the injection of a pulse of compressed gas into a duct which creates a pressure wavefront and then monitoring of the pressure decay as the wavefront travels along the duct away from a transducer. If the duct has neither a blockage nor leakage through a hole then the pressure decay monitored by the transducer follows a negative curve similar to, but not exactly, an exponential curve. If the duct has a blockage then the blockage impedes the pressure pulse wavefront and the pressure monitored by the transducer does not decay as rapidly as when there is no blockage. In the event that there is a hole in the duct then the pressure pulse is provided with an additional escape route and so the pressure decays more rapidly. In both cases the monitored decay of the pressure pulse follows the expected negative curve until the pressure pulse wavefront reaches the fault, at which point the decay deviation to a higher or lower than expected pressure is detected. From a knowledge of the velocity of the pulse wavefront, the time interval from the pulse launch to the onset of decay deviation gives an indication of the distance along the duct that the fault occurs. The velocity of wavefront travel may vary between ducts (for example as a result of different levels of air friction) and is not constant along the length of a duct and therefore it has to be generated or predicted for the tube under test. The generation of the velocity value may be made by comparison with stored values for different tubes and/or from the early decay trace obtained prior to a fault together with an approximation function of the velocity valuation.

A prototype test system was used to evaluate the performance of the testing method, the apparatus being shown in Figure 1 and comprising a compressor 1, solenoid valve 2, injection nozzle 3, pressure transducer 4 and storage oscilloscope 5. The nozzle 3 and transducer assembly 4 are inserted into the end of the duct 6 to be tested. Typical ducts for use in fibre blowing are made of polyethylene with an external diameter of 8mm and an internal bore diameter of 6mm, although ducts with external diameters in the range of 5 to 12 mm and internal diameters in the range of 3 to 10 mm are also envisaged. The ducts are fabricated in lengths of 500 metres and then joined in lengths of, typically, one or two kilometres for interbuilding connections. Typical blowing installation lengths are of the order of 500 metres (or more using tandem blowing) and so an experimental length of 500m of duct was used with closable apertures and pinch clips at intervals by means of which holes and blockages could be made. A control circuit (not shown) opens and closes the valve in response to

a push button operation to let a burst of air into the duct. The burst of air causes an increase in pressure that is sensed by the pressure transducer and input to the oscilloscope on the Y axis against a time base X axis. Initially the duct was tested with neither blockages nor holes and a negative decay curve of pressure was displayed on the oscilloscope. A blockage was then created by pinching the duct, a further burst of air introduced and the new pressure decay displayed superimposed on the trace obtained for the unblocked duct. The result of the superimposition is shown in Figure 2, the blocked duct curve deviating from the perfect duct curve after time t . This experiment was repeated with the duct blocked at different locations and similar results obtained, the time taken for deviation to higher pressure being related to the distance of the blockage along the duct from the transducer. A similar set of tests was carried out for holes at different locations and similar results obtained except that the deviation observed was to a lower pressure. Figure 3 shows a typical trace for a perfect duct and a duct with a hole.

It was found that the superimposed early exponential decay portions, prior to deviation, and sometimes repeated traces taken under similar conditions of duct (i.e. perfect/blocked/perforated) did not always lie exactly on top of one another. This could result from a variety of causes including drift in the transducer output, drift in the oscilloscope amplifier, from the starting (pre air burst injection) pressure in the duct being different and also from different velocities of the pulse wavefront in different tubes. However, the information required from the test is the shape of the trace at the deviation point, not a pressure value, and so all that is needed to be repeatable is the time (distance) measurement of the deviation. Further, in use on installed ducts only the duct under test is available and it can not be blocked and unblocked as was possible in the experiment. Therefore for field use the first portion of the decay monitored by the transducer may be used as a trigger to generate a reference decay expected for a perfect duct and the actual decay is compared with the generated reference. Alternatively a family of curve values may be stored and the appropriate reference curve automatically selected for comparison. This system is described in more detail later.

The sensitivity of the system is improved if the deviation from the reference decay is increased, and this can be achieved by blocking off the far end of the duct. Figure 4 shows the effect on the decay of blocking off the far end of a perforated duct, and from comparison with Figure 3 it can be seen that the deviation is more noticeable. Of course in the event of a totally blocked duct there is no benefit in blocking off the far end. The send

(transducer) end of the duct is generally blocked so that decay in a single direction is monitored. For correlation purposes or to identify blockages close to the send end, the duct may be tested from each end.

If a duct has more than one fault these may also be detected, but only faults up to and including the first total blockage. Thus two holes can be detected, the trace undergoing two deviations as shown in Figure 5, and a hole followed by a blockage is also detectable as shown in Figure 6.

The system may be arranged to provide a visual output of the trace, either on a chart recorder or a screen from which the installation engineer can analyse the result, or the decay and reference values may be electronically compared and deviation in excess of a given value logged out as a fault with the sign of the difference value indicating the type of fault. Some faults such as partial blockages and multiple faults may be easier to interpret from a trace than by electronic means.

Monitoring of pressure pulse decay also enables comparison of ducts or assessment of air friction values and may be utilised in other aspects of quality control, and in particular for indicating 'blowability' or potential blown installation speed of ducts.

Figure 7 shows a block diagram of a practical embodiment of the invention for field use. In moving from a laboratory prototype to a practical embodiment that may be used in different temperature environments, it becomes necessary to compensate for temperature variation otherwise the temperature dependent drift in the circuit (especially in the pressure transducer) can distort readings. Also, the ducts under test may vary not only in internal surface finish but the air temperature within them may vary giving rise to a different wavefront velocity: the faster the wavefront velocity the more rapid the pressure decay, and therefore a curve from a 'faster' duct compared with a 'slower' duct may show a deviation that is of the same order of magnitude as that for a holed duct. In order to overcome this the apparatus is provided with a memory in which decay traces from a family of ducts of varying types and at various temperatures may be stored for retrieval as references depending upon the conditions encountered. The circuit itself is also temperature dependent and in order to prevent drift in the pressure transducer the temperature within the circuit box is monitored and controlled, and in the event that the temperature moves out of the controllable range an indication is given to address a different stored set of values for comparison, relevant to the circuit operation at the new temperature conditions. It would be possible to have a complete range of values for all possible temperatures or to have a wider range of tempera-

ture control, but it is preferable in terms of size and memory capacity to have the system described.

Referring specifically to Figure 7, the duct 6 under test is connected to a branched connection duct 8 connected to the output of a solenoid valve 7 which controls the duration of an air (or other fluid) burst into the duct. The air may be supplied from a compressed air line, generally via a pressure regulator, or from another source and is stored in a discharge chamber connected to the solenoid. It has been found satisfactory to utilise a one litre discharge chamber at a pressure of about 2 bar. The solenoid valve operates to connect the discharge chamber to the duct for a selected period of time, intervals of the order of 500 to 800 milliseconds having been found satisfactory. The discharge chamber is then recharged for the next test. It would be possible to substitute a mechanically loaded discharge chamber (eg. a chamber with a piston and compression spring held on a trigger) to generate the air burst. With the compressed air loaded discharge chamber it has been found desirable to load the chamber via a restricted orifice of .5mm in order to limit the effect of the air pressure regulator recharging the chamber during the discharge period.

The branch from connection duct 8 is connected to a pressure transducer 9, which is preferably an a.c. bridge with its a.c. supply generated from an oscillator 10. The output of the oscillator is input to an automatic gain control 11 which adjusts the signal to a predetermined level and thereby compensates for variations such as fluctuation in discharge chamber pressure or pulse duration. The signal then passes through a linear rectifier 12, through an automatic zeroing circuit 13 which is inhibited during measurements, the inhibit auto zero signal being transmitted along line 14 from the start switch 15, which is also connected on line 16 to trigger opening of the solenoid valve 7 and along line 17 to the ROM 18 to activate read out of a stored perfect duct signal which is converted back into an analogue signal in the digital to analogue converter 19 and input to a comparator 20 where it is compared with the measurement signal which is input to the comparator on line 21. From the output of the comparator there is a feedback loop 22 to the automatic gain control, the main output being input to a level detector 23 which determines whether the difference value signal from the comparator exceeds a predetermined value or 'significant value', that is a value which is greater than the error or normal variation caused by environmental changes for example. If it does exceed the significant value, the signal is transmitted on line 24 to hole/blockage indicator 25 which initiates a hole or block signal for the display 26 depending upon whether the difference value was positive

pering is continued until the cores have reduced in size sufficiently such that the mode fields each side of the splice are reasonably well matched. In practice light could be launched into the central fibre and the device would be pulled until the output signal reaches a maximum.

An alternative fabrication technique involves using a glass former 20 without the central hole. In this method the prepared fibres 10 are inserted into the glass former 20, as shown in Figure 4 (only two fibres are shown for clarity). The former 20 is collapsed as described above and it is then pulled to form a taper with a waist diameter equal to the diameter of a single fibre 10. The structure is cleaved at the waist and the resulting composite fibre end is fusion spliced to a single fibre. This fusion splice is then further tapered to equalise the mode fields on either side of the splice. The tapering is continued until maximum power transmission is obtained.

Referring now to Figure 5, consider light propagating along the single input fibre 1, towards the taper region marked 22. As light travels down the taper 22, its mode field expands and eventually becomes bounded by the cladding/external medium interface. In this central taper region 24 the fibre cores play little part in the field guidance and the output fibres O_1 to O_8 act as a single output fibre assembly. Therefore, the mode profiles of the single fibre 1 and output fibre assembly are reasonably well matched. This ensures that the optical field will traverse this critical region 24 with little loss. In the upward taper region, 26, the growing cores gradually capture equal amounts of the optical field such that when the fibres have reached their normal size, each fibre carries the same optical power.

1xN couplers having other N values may be formed by these methods. The output fibres need not be arranged in a symmetrical circular array. For example, four fibres can be arranged at the vertices of a rectangle and still obtain equal coupling as each fibre is positioned at the same relative distance and angular disposition from the other three, i.e. in that they are each positioned identically relative to the other output fibres.

The insertion of the fibres 10 into the former 20 may be aided by the use of a lubricating fluid that is readily evaporated before or during the application of heat to form the taper, for example methanol, ethanol, acetone or other similar fluid.

Claims

1. A method of forming a 1xN optical star coupler having an input single mode fibre (1) and N identical output single mode fibres ($O_1...O_N$) where N is two or more, the method comprising the steps of:
 - (a) forming N+1 fibre portions (10) each comprising a single mode optical fibre (12) fusion spliced to a coreless fibre (14);
 - (b) placing the N+1 fibre portions into a former (2) such that the N output single mode fibres ($O_1...O_N$) extend from one end of the former, and one single mode input fibre (1) extends from the other end of the former, the N output fibres being positioned centro-symmetrically with respect to the input fibre, and the distribution of the output fibres with respect to a given output fibre being identical to that with respect to any other output fibre, the former being such as to maintain the fibres in their positions and comprising material having a refractive index that is the same as, or is slightly less than, that of the cladding of the fibre portions;
 - (c) positioning all the fusion splices in substantially the same plane within the former (A); and
 - (d) forming a taper (22,26) from the former and fibre arrangement such that the fundamental mode fields on each side of the fusion splices are substantially matched at some region of the taper.
2. A method of forming a 1xN optical star coupler where N is two or more, the method comprising the steps of:
 - (a) inserting N identical single mode output fibres ($O_1...O_N$) into a former (2) so as to extend from the same side of the former, the distribution of the output fibres around a given one of the output fibres being identical to that around any other output fibre, the former being such as to maintain the fibres in their positions and comprising material having a refractive index that is the same as, or is slightly less than, that of the cladding of the fibre portions;
 - (b) forming a taper from the former and fibre arrangement with a waist diameter substantially equal to the diameter of a single fibre;
 - (c) cleaving the taper at the waist (24);
 - (d) fusion splicing the cleaved taper to a single mode input fibre so that the N output fibres are positioned centro-symmetrically with respect to the input fibre; and
 - (e) further tapering the taper to equalise the fundamental mode fields on either side of the splice.
3. A method of forming a coupler as claimed in claim 1 or claim 2, in which a lubricant is applied to the fibres prior to their insertion into the former.
4. A method of forming a coupler as claimed in claim



pering is continued until the cores have reduced in size sufficiently such that the mode fields each side of the splice are reasonably well matched. In practice light could be launched into the central fibre and the device would be pulled until the output signal reaches a maximum.

An alternative fabrication technique involves using a glass former 20 without the central hole. In this method the prepared fibres 10 are inserted into the glass former 20, as shown in Figure 4 (only two fibres are shown for clarity). The former 20 is collapsed as described above and it is then pulled to form a taper with a waist diameter equal to the diameter of a single fibre 10. The structure is cleaved at the waist and the resulting composite fibre end is fusion spliced to a single fibre. This fusion splice is then further tapered to equalise the mode fields on either side of the splice. The tapering is continued until maximum power transmission is obtained.

Referring now to Figure 5, consider light propagating along the single input fibre 1, towards the taper region marked 22. As light travels down the taper 22, its mode field expands and eventually becomes bounded by the cladding/external medium interface. In this central taper region 24 the fibre cores play little part in the field guidance and the output fibres O_1 to O_8 act as a single output fibre assembly. Therefore, the mode profiles of the single fibre 1 and output fibre assembly are reasonably well matched. This ensures that the optical field will traverse this critical region 24 with little loss. In the upward taper region, 26, the growing cores gradually capture equal amounts of the optical field such that when the fibres have reached their normal size, each fibre carries the same optical power.

1xN couplers having other N values may be formed by these methods. The output fibres need not be arranged in a symmetrical circular array. For example, four fibres can be arranged at the vertices of a rectangle and still obtain equal coupling as each fibre is positioned at the same relative distance and angular disposition from the other three, i.e. in that they are each positioned identically relative to the other output fibres.

The insertion of the fibres 10 into the former 20 may be aided by the use of a lubricating fluid that is readily evaporated before or during the application of heat to form the taper, for example methanol, ethanol, acetone or other similar fluid.

Claims

1. A method of forming a 1xN optical star coupler having an input single mode fibre (1) and N identical output single mode fibres ($O_1...O_N$) where N is two or more, the method comprising the steps of:

- (a) forming N+1 fibre portions (10) each comprising a single mode optical fibre (12) fusion spliced to a coreless fibre (14);
- (b) placing the N+1 fibre portions into a former (2) such that the N output single mode fibres ($O_1...O_N$) extend from one end of the former, and one single mode input fibre (1) extends from the other end of the former, the N output fibres being positioned centro-symmetrically with respect to the input fibre, and the distribution of the output fibres with respect to a given output fibre being identical to that with respect to any other output fibre, the former being such as to maintain the fibres in their positions and comprising material having a refractive index that is the same as, or is slightly less than, that of the cladding of the fibre portions;
- (c) positioning all the fusion splices in substantially the same plane within the former (A); and
- (d) forming a taper (22,26) from the former and fibre arrangement such that the fundamental mode fields on each side of the fusion splices are substantially matched at some region of the taper.

2. A method of forming a 1xN optical star coupler where N is two or more, the method comprising the steps of:

- (a) inserting N identical single mode output fibres ($O_1...O_N$) into a former (2) so as to extend from the same side of the former, the distribution of the output fibres around a given one of the output fibres being identical to that around any other output fibre, the former being such as to maintain the fibres in their positions and comprising material having a refractive index that is the same as, or is slightly less than, that of the cladding of the fibre portions;
- (b) forming a taper from the former and fibre arrangement with a waist diameter substantially equal to the diameter of a single fibre;
- (c) cleaving the taper at the waist (24);
- (d) fusion splicing the cleaved taper to a single mode input fibre so that the N output fibres are positioned centro-symmetrically with respect to the input fibre; and
- (e) further tapering the taper to equalise the fundamental mode fields on either side of the splice.

3. A method of forming a coupler as claimed in claim 1 or claim 2, in which a lubricant is applied to the fibres prior to their insertion into the former.

4. A method of forming a coupler as claimed in claim



- duct,
 comparing said monitored pressure decay with
 a set of values indicative of a reference pressure decay to detect a significant difference
 between the monitored and reference pressure
 decays, and
 determining the time interval between introduction
 of the pulse and any significant detected
 difference to give an indication of the location
 of a fault in the duct.
3. A method according to claim 1 in which the
 pressure at the particular location (4) is established
 after a predetermined interval to give an
 indication of the average speed of travel of the
 wavefront along the duct.
4. A method according to claim 1 or claim 2 for
 detecting leaks and blockages in an elongated
 duct (6) prior to blowing an optical fibre member
 thereinto, wherein the pulse of compressed
 gas is injected into an accessible end of said
 duct; the resulting gas pressure decay is monitored
 as a function of time at a predetermined
 location in the duct proximate said accessible
 end; and said comparison step involves comparing
 said gas pressure decay to a nominally perfect
 reference pressure decay curve to detect (a), if
 present, a duct blockage if the monitored
 decaying pressure substantially exceeds said
 reference pressure decay curve, and (b), if
 present, a duct leakage if the monitored
 decaying pressure is substantially lower than
 said reference pressure decay curve.
5. A method as in claim 4 further comprising the
 step of:
 determining the approximate location of a detected
 leak or blockage with respect to said accessible
 end of the duct as a function of the elapsed
 time interval from pulse injection until a
 substantial deviation from said reference
 pressure decay curve is first detected during
 said comparing step.
6. Apparatus for testing a duct (6), the apparatus
 comprising:
 means (1, 2, 3) to introduce a pulse of compressed
 gas into the duct (6) to establish a pressure
 wavefront advancing through the duct,
 a sensor (4) for establishing a set of values
 indicative of pressure variation at a particular
 location as the wavefront travels along the duct
 (6), characterised by storage means to store a
 set of values indicative of a reference pressure
 variation,
 means (5, 20) to compare said pressure variation
 with said set of values from said storage
 means and to determine whether there is a
 significant difference between the monitored
 and reference pressure variations, and
 means (2, 8) to establish the time interval
 between the introduction of the pulse and the
 onset of any significant difference between the
 monitored and reference pressure variations.
7. Apparatus according to claim 6 further comprising
 means for varying the set of values
 indicative of the reference pressure variation.
8. Apparatus according to claim 6 further comprising
 means for storing the set of values
 indicative of pressure variation and comparing
 such values with a plurality of different sets of
 values indicative of reference pressure variation.
9. Apparatus according to any of claims 6 to 8 in
 which the temperature of the sensor is controlled.
10. Apparatus according to any of claims 6 to 9 in
 which the pressure variation that is monitored
 is pressure decay as the pulse wavefront travels
 away from the sensor which is located proximate
 the end of the duct into which the pulse is
 introduced.
11. Apparatus according to any one of claims 6 to
 10 in which the means (5, 20) for comparing
 comprises a monitor (2, 8) for displaying a
 trace of the sensed pressure variation.
12. Apparatus according to any one of claims 6 to
 11, further characterised in that the sensor (4),
 when in use monitors pressure at a predetermined
 location a predetermined time interval after
 introduction of the pulse into the duct to
 establish a value for the relative speed of travel
 of the wavefront along the duct and hence a
 value for the relative blowability of the duct.
13. Apparatus to detect leaks and blockages in an
 elongated duct (6) prior to blowing an optical
 fibre member thereinto, said apparatus comprising:
 means (1, 2, 3) to inject a pulse of compressed
 gas into an accessible end of said duct;
 means (4) to monitor the resulting gas pressure
 decay as a function of time at a predetermined
 location in the duct proximate said accessible
 end; and
 means to (5, 20) compare said gas pressure
 decay to a nominally perfect reference pressure
 decay curve to detect a duct blockage if



the monitored decaying pressure substantially exceeds said reference pressure decay curve and to detect a duct leakage if the monitored decaying pressure is substantially lower than said reference pressure decay curve.

14. Apparatus as in claim 13 further comprising:
means (2, 8) for determining the approximate location of a detected leak or blockage with respect to said accessible end of the duct as a function of the elapsed time interval from pulse injection until a substantial deviation from said reference pressure decay curve is first detected during said comparing step.

Patentansprüche

1. Verfahren zum Testen einer Röhrenleitung (6), die ein erstes und ein zweites Ende hat, wobei das Verfahren die Schritte aufweist:
Einführen eines Impulses von komprimiertem Gas in die Röhrenleitung (6) um eine Druckwellenfront aufzubauen, die durch die Röhrenleitung fortschreitet, dadurch gekennzeichnet, daß der Impuls an oder benachbart zu dem ersten Ende eingeführt wird,
Bestimmen nach zumindest einem Zeitintervall, das der Einführung folgt, und während dem Wandern der Wellenfront längs der Röhrenleitung, eines Wertes, der einen Druckabfall bei einem bestimmten Ort (4) anzeigt, um eine Anzeige einer Charakteristik der Röhrenleitung (6) zu geben, die die Rate des Druckabfalles bei einem gegebenen Ort der Röhrenleitung zwischen dem ersten und zweiten Ende beeinflußt, wenn die Wellenfront dadurch fortschreitet, und Vergleichen des Wertes mit gespeicherten Referenzwerten.
2. Verfahren gemäß Anspruch 1, das die Schritte aufweist:
Überwachen des Druckabfalles an dem bestimmten Ort, wenn die Wellenfront durch die Röhrenleitung fortschreitet,
Vergleichen des überwachten Druckabfalles mit einer Menge von Werten, die einen Referenzdruckabfall anzeigen, um eine signifikante Differenz zwischen den überwachten und den Referenzdruckabfällen zu erfassen, und
Bestimmen des Zeitintervalles zwischen der Einführung des Impulses und irgendeiner signifikanten erfaßten Differenz, um eine Anzeige des Ortes eines Fehlers in der Röhrenleitung zu geben.
3. Verfahren gemäß Anspruch 1, bei dem der Druck an dem bestimmten Ort (4) nach einem vorbestimmten Intervall aufgebaut wird, um

eine Anzeige der durchschnittlichen Wander- geschwindigkeit der Wellenfront längs der Röhrenleitung zu geben.

4. Verfahren gemäß Anspruch 1 oder 2 zum Erfassen von Lecks und Blockierungen in einer langen Röhrenleitung (6) vor dem Blasen eines optischen Fasergliedes dort hinein, wobei der Impuls von komprimiertem Gas in ein zugängliches Ende der Röhrenleitung injiziert wird; der resultierende Gasdruckabfall wird als eine Funktion der Zeit an einem vorbestimmten Ort in der Röhrenleitung nahe dem zugänglichen Ende überwacht; und der Vergleichsschritt umfaßt Vergleichen des Gasdruckabfalles mit einer nominalen perfekten Referenzdruckabfallkurve, um (a), wenn vorliegend, eine Röhrenleitungsblockierung zu erfassen, wenn der überwachte abfallende Druck im wesentlichen die Referenzdruckabfallkurve überschreitet, und um (b), wenn vorliegend, ein Röhrenleitungsleck zu erfassen, wenn der überwachte abfallende Druck im wesentlichen niedriger als die Referenzdruckabfallkurve ist.
5. Verfahren gemäß Anspruch 4, das weiterhin den Schritt aufweist:
Bestimmen des ungefähren Ortes eines erfaßten Lecks oder einer Blockierung mit Bezug auf das zugängliche Ende der Röhrenleitung als eine Funktion des verstrichenen Zeitintervalles von der Impulsinjektion, bis daß eine wesentliche Abweichung von der Referenzdruckabfallkurve zuerst während dem Vergleichsschritt erfaßt wird.
6. Gerät zum Testen einer Röhrenleitung (6), wobei das Gerät aufweist:
Einrichtungen (1, 2, 3), um einen Impuls von komprimiertem Gas in die Röhrenleitung (6) einzuführen, um eine Druckwellenfront aufzubauen, die durch die Röhrenleitung fortschreitet,
einen Sensor (4) zum Aufbauen einer Menge von Werten, die eine Druckvariation an einem bestimmten Ort anzeigt, wenn die Wellenfront längs der Röhrenleitung (6) wandert, gekennzeichnet durch eine Speichereinrichtung, um eine Menge von Werten zu speichern, die eine Referenzdruckvariation anzeigen,
Einrichtungen (5, 20), um die Druckvariation mit der Menge von Werten aus der Speichereinrichtung zu vergleichen, und um zu bestimmen, ob es eine signifikante Differenz zwischen den überwachten und den Referenzdruckvariationen gibt, und
Einrichtungen (2, 8), um das Zeitintervall zwischen der Einführung des Impulses und dem



Einsetzen irgendeiner signifikanten Differenz zwischen dem Überwachten und den Referenzdruckvariationen aufzubauen.

7. Gerät gemäß Anspruch 6, das weiterhin eine Einrichtung zum Variieren der Menge von Werten aufweist, die die Referenzdruckvariation anzeigen. 5
8. Gerät gemäß Anspruch 6, das weiter eine Einrichtung zum Speichern der Menge von Werten aufweist, die eine Druckvariation anzeigen, und Vergleichen solcher Werte mit einer Vielzahl von verschiedenen Mengen von Werten, die eine Referenzdruckvariation anzeigen. 10 15
9. Gerät gemäß einem der Ansprüche 6 bis 8, bei dem die Temperatur des Sensors gesteuert wird. 20
10. Gerät gemäß einem der Ansprüche 6 bis 9, bei dem die Druckvariation, die überwacht wird, der Druckabfall ist, wenn die Impulswellenfront weg von dem Sensor wandert, der nahe dem Ende der Röhrenleitung angeordnet ist, in das der Impuls eingeführt wird. 25
11. Gerät gemäß einem der Ansprüche 6 bis 10, bei dem die Einrichtungen (5, 20) zum Vergleichen, einen Monitor (2, 8) zum Anzeigen einer Kurve der erfüllten Druckvariation aufweisen. 30
12. Gerät gemäß einem der Ansprüche 6 bis 11, weiter dadurch gekennzeichnet, daß der Sensor (4), wenn er verwendet wird, einen Druck an einem vorbestimmten Ort während einem vorbestimmten Zeitintervall nach dem Einführen des Impulses in die Röhrenleitung überwacht, um einen Wert für die relative Wandergeschwindigkeit der Wellenfront längs der Röhrenleitung aufzubauen und damit einen Wert für die relative Blasbarkeit der Röhrenleitung. 35 40
13. Gerät, um Lecks und Blockierungen in einer langen Röhrenleitung (6) vor dem Blasen eines optischen Fasergliedes dorthinein zu erfassen, wobei das Gerät aufweist:
Einrichtungen (1, 2, 3) um einen Impuls von komprimiertem Gas in ein zugängliches Ende der Röhrenleitung zu injizieren;
eine Einrichtung (4), um den resultierenden Gasdruckabfall als eine Funktion der Zeit an einem vorbestimmten Ort in der Röhrenleitung nahe dem zugänglichen Ende zu überwachen; und
Einrichtungen (5, 20), um den Gasdruckabfall mit einer nominal perfekten 45 50 55

,Referenzdruckabfallkurve zu vergleichen, um eine Röhrenleitungsblockierung zu erfassen, wenn der Überwachte abfallende Druck im wesentlichen die Referenzdruckabfallkurve überschreitet, und um ein Röhrenleitungsleck zu erfassen, wenn der Überwachte abfallende Druck im wesentlichen niedriger als die Referenzdruckabfallkurve ist.

14. Gerät gemäß Anspruch 13, das weiterhin aufweist:

Einrichtungen (2, 8) zum Bestimmen des ungefähren Ortes eines erfaßten Lecks oder einer Blockierung, mit Bezug auf das zugängliche Ende der Röhrenleitung als eine Funktion des verstrichenen Zeitintervalles von der Impulsinjektion, bis eine wesentliche Abweichung von der Referenzdruckabfallkurve während des Vergleichsschritts zuerst erfaßt wird.

Revendications

1. Un procédé d'essais d'un conduit (6) comportant une première et une deuxième extrémités, le procédé comprenant les étapes consistant à:
introduire une impulsion de gaz comprimé dans le conduit (6) afin d'établir un front d'onde de pression avançant à travers le conduit, caractérisé en ce que l'impulsion est introduite à ladite première extrémité ou près de celle-ci, déterminer après au moins un intervalle de temps qui suit ladite introduction, et pendant le déplacement du front d'onde le long du conduit, une valeur indicative de l'amortissement de pression à un emplacement particulier (4), afin de donner une indication d'une caractéristique du conduit (6) qui influence la vitesse de l'amortissement de pression à un emplacement donné du conduit, intermédiaire entre lesdites première et deuxième extrémités, au fur et à mesure que le front d'onde avance à travers celui-ci, et comparer ladite valeur à des valeurs de référence mémorisées,
2. Un procédé selon la revendication 1 comprenant les étapes consistant à:
surveiller l'amortissement de pression à l'emplacement particulier au fur et à mesure que le front d'onde avance à travers le conduit, comparer ledit amortissement de pression surveillé à un ensemble de valeurs indicatives d'un amortissement de pression de référence afin de détecter une différence significative entre l'amortissement de pression surveillé et l'amortissement de pression de référence, et déterminer l'intervalle de temps entre l'introduction de l'impulsion et l'une quelconque

des différences significatives détectées pour obtenir une indication de l'emplacement d'un défaut dans le conduit.

3. Un procédé selon la revendication 1 dans lequel la pression à l'emplacement particulier (4) est établie après un intervalle prédéterminé afin de donner une indication de la vitesse moyenne de déplacement du front d'onde le long du conduit. 5
4. Un procédé selon la revendication 1 ou la revendication 2, servant à détecter des fuites et des blocages dans un conduit allongé (6) avant d'y souffler un élément de fibre optique, dans lequel l'impulsion de gaz comprimé est injectée dans une extrémité accessible dudit conduit; l'amortissement de pression de gaz qui en résulte est surveillé en fonction du temps à un emplacement prédéterminé du conduit, proche de ladite extrémité accessible; et ladite étape de comparaison implique de comparer ledit amortissement de pression de gaz à une courbe nominale parfaite d'amortissement de pression de référence afin de détecter (a) un blocage éventuel si la pression surveillée qui s'amortit dépasse sensiblement ladite courbe d'amortissement de pression de référence et (b) une fuite éventuelle du conduit si la pression surveillée qui s'amortit est sensiblement inférieure à ladite courbe d'amortissement de pression de référence. 10 15 20 25 30
5. Un procédé selon la revendication 4 comprenant en outre l'étape consistant à: 35
déterminer l'emplacement approximatif d'une fuite ou d'un blocage détecté par rapport à ladite extrémité accessible du conduit en fonction de l'intervalle de temps qui s'est écoulé, à partir de l'injection de l'impulsion, jusqu'à ce qu'un écart sensible vis-à-vis de la courbe d'amortissement de pression de référence soit détecté pendant ladite étape de comparaison. 40
6. Appareil d'essais d'un conduit (6), l'appareil comprenant: 45
un moyen (1, 2, 3) d'introduction d'une impulsion de gaz comprimé dans le conduit (6) afin d'établir un front d'onde de pression avançant à travers le conduit, 50
un capteur (4) permettant d'établir un ensemble de valeurs indicatives d'une variation de pression à un emplacement particulier au fur et à mesure que le front d'onde se déplace le long du conduit (6) caractérisé par un moyen de mémorisation permettant de mémoriser un ensemble de valeurs indicatives d'une

variation de pression de référence,

un moyen (5, 20) de comparaison de ladite variation de pression, avec ledit ensemble de valeurs provenant dudit moyen de mémorisation, et de détermination de la présence éventuelle d'une différence significative entre la variation de pression surveillée et la variation de pression de référence, et

un moyen (2, 8) d'établissement de l'intervalle de temps entre l'introduction de l'impulsion et l'apparition d'une différence significative quelconque entre la variation de pression surveillée et la variation de pression de référence.

7. Appareil selon la revendication 6 comprenant en outre un moyen de faire varier l'ensemble de valeurs indicatives des valeurs de pression de référence.
8. Appareil selon la revendication 6 comprenant en outre un moyen de mémorisation de l'ensemble des valeurs indicatives de la variation de pression et de comparaison de ces valeurs avec une série d'ensembles différents de valeurs indicatives d'une variation de pression de référence.
9. Appareil selon l'une quelconque des revendications 6 à 8 dans lequel la température du capteur est réglée.
10. Appareil selon l'une quelconque des revendications 6 à 9 dans lequel la variation de pression qui est surveillée est un amortissement de pression au fur et à mesure que le front d'onde d'impulsion s'écarte du capteur qui est situé près de l'extrémité du conduit dans lequel l'impulsion est introduite.
11. Appareil selon l'une quelconque des revendications 6 à 10 dans lequel le moyen (5, 20) de comparaison comprend un dispositif de surveillance (2, 8) pour afficher une trace de la variation de pression captée.
12. Appareil selon l'une quelconque des revendications 6 à 11, caractérisé en outre en ce que le capteur (4), lorsqu'il est utilisé, surveille la pression à un emplacement prédéterminé, un intervalle de temps prédéterminé après l'introduction de l'impulsion dans le conduit, afin d'établir une valeur de la vitesse relative de déplacement du front d'onde venant du conduit et donc une valeur de l'aptitude au soufflage, ou soufflabilité, relative du conduit.



13. Appareil de détection de fuites et de blocages dans un conduit allongé (6) avant d'y souffler un élément de fibre optique, ledit appareil comprenant:

un moyen (1, 2, 3) d'injection d'une impulsion de gaz comprimé dans une extrémité accessible dudit conduit; 5

un moyen (4) de surveillance de l'amortissement de pression de gaz, qui en résulte, en fonction du temps à un emplacement prédéterminé du conduit, proche de ladite extrémité accessible; et 10

un moyen (5, 20) de comparaison dudit amortissement de pression de gaz avec une courbe nominale parfaite d'amortissement de pression de référence afin de détecter un blocage dans le conduit si la pression surveillée qui s'amortit dépasse sensiblement la courbe d'amortissement de pression de référence et afin de détecter une fuite de pression si la pression surveillée qui s'amortit est sensiblement inférieure à ladite courbe d'amortissement de pression de référence. 15 20

14. Appareil selon la revendication 13 comprenant en outre: 25

un moyen (2, 8) de détermination de l'emplacement approximatif d'une fuite ou d'un blocage détecté par rapport à ladite extrémité accessible du conduit en fonction de l'intervalle de temps qui s'est écoulé, à partir de l'injection de l'impulsion, jusqu'à ce qu'un écart sensible vis-à-vis de la courbe d'amortissement de pression de référence soit détecté pendant ladite étape de comparaison. 30 35

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