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Meeting Paper

Improved, Cost Effective Interface Detector for Storage Caverns

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IMPROVED, COST EFFECTIVE INTERFACE DETECTOR FOR STORAGE CAVERNS

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Introduction

The Interface Detector was first utilized in 1970. Since that time, the electronic components of the system have remained the same. With all the advancements being made in the area of computers and electronics, Interface Detector Co. set out to develop a new Interface Detector that would utilize the latest technology and still be cost effective.

Description of System and Operation

The Interface Detector has been utilized for over twenty years to monitor the location of the brine / hydrocarbon interface. This task is achieved by using proven sonar technology. A sonar transducer is attached to a stainless steel mechanism which is lowered through the brine string to the bottom of the cavern on a specially designed cable. The mechanism is "hooked" to the bottom of the brine string and the sonar transducer is then set in place outside the brine string by applying tension to the cable. (see Figure 1) Once in place, the Interface Detector continuously indicates the distance to the brine / hydrocarbon interface with respect to the bottom of the brine string.

The transducer is attached to a support arm which is suspended on a cable and attached to the bottom of the brine string. Every few seconds, the transducer emits a sonar pulse that travels upward through the brine. At the brine / hydrocarbon interface, some of the pulse is reflected back to the transducer. The transducer senses this reflected pulse and converts it to an electrical pulse. Both the initial pulse and reflected pulse are sent through the cable to a surface panel where the amount of time between the two pulses is measured. The determined time is then converted to a distance and displayed numerically on the surface panel. The transducer can also emit a downward pulse and determine the distance to the cavern floor.
By monitoring the brine / hydrocarbon interface, a cavern operator can estimate the amount of product in a cavern and virtually eliminate all possibilities of overfilling a cavern.

Description of Old System

The Interface Detector used in the past consisted of an electronics surface panel and a downhole assembly. The downhole assembly consists of a transducer with a small amount of electronics in a sealed housing and a mechanical support arm for holding the transducer. The downhole electronics require 40 V.D.C., which is supplied by the surface electronics. Once the downhole electronics has received the necessary voltage, the transducer emits a fixed amount of energy upward. The initial burst continues upward until it contacts the brine / hydrocarbon interface, where a portion of the energy is reflected back towards the transducer. The transducer senses the reflected energy and converts it to an electric pulse. The electric pulse representing the initial burst and the electric pulse representing the reflected burst are both placed as an AC signal on the cable and sent to the surface panel. The surface panel receives the signal and determines the amount of time between the two pulses. The round trip travel time is then multiplied by the acoustic velocity and divided by two to get the distance to the interface.

The two main parameters of the initial burst are; the amplitude of the burst and the length of the burst. The electronics controlling these two parameters are located inside the downhole transducer, so once the unit is installed, the parameters cannot be altered. For example, if the interface is 1000 feet from the bottom of the brine string, a long and strong burst is required to obtain an ample reflection. The length of the initial burst, or ring down, could possibly extend ten feet of travel time before calming down to the state where it could detect a reflection. This amount of ring down is not a problem when the interface is more than ten feet away. However, as a cavern nears the filling point, the reflected energy (interface) can be "lost" in the initial burst. So, at small distances, a shorter and smaller initial burst would greatly improve the situation.

The attenuation of the AC signal in the surface cable can also cause minor problems. Obtaining a sufficient signal at the cavern wellhead is rarely a problem. Little if any downhole noise is placed on the cable and the brine string acts as additional shielding. Yet after a good signal is obtained at the wellhead, the signal must be sent to the surface panel located in the control room or other building. Sometimes after the signal reaches the surface panel, it is no longer of adequate amplitude to determine the amount of time between the two pulses. Electrical interference, poor grounding, long distances, and corrosion are also problems that have been encountered in the surface wiring between the wellhead and the surface panel.

Because the downhole transducer houses electronic components, periodically one of these components can fail. If a component fails, the unit must be pulled to the surface and repaired or replaced. In order to pull the transducer, the well must be temporarily taken out of service.

Because the downhole transducer contains printed circuit boards and electronic components, necessarily, the cost of the unit has to cover the cost of manufacturing. A one time investment is feasible, yet if a downhole transducer is lost, the cost of replacing the lost transducer would add to the system cost.

A Digital Interface Detector

In the field of instrumentation, several manufacturers have been upgrading their equipment to transfer data digitally. With the prices of computers and microprocessors continually dropping, a digital Interface Detector seemed like the next step. The digital Interface Detector would be very similar to the existing analog Interface Detector with the exception of placing a microprocessor in the downhole transducer. With a digital system, the downhole transducer parameters could be changed from the surface. However, because the system would still house electronics in the downhole transducer, downhole electronic failures and pulling costs would still be possible drawbacks. With a digital system, only a number is sent up the cable to the surface and not the analog signal. Without the analog signal, troubleshooting would be difficult, if not impossible.

Mined Cavern Transition

In working with mined caverns, Interface Detector Co. has successfully separated the electronics from the piezoelectric ceramic transducer regularly up to 500 feet. Sometimes the two items have been separated even greater distances. Although, we had separated the two items occasionally in the field, we had never tested different configurations in our test facility. In our test facility, each component of the system was analyzed to determine the optimal system that would operate with possible separations of thousands of feet.

Test Setup and Procedure

Using various lengths of cable, three systems with different frequencies were analyzed. A complete test setup would consist of; a ten foot test tank, a transducer, a specific length of cable, and the surface electronics, or transceiver. The transceiver supplies a voltage to the cable which in turn excites the piezoelectric ceramic.

The frequency and size of the piezoelectric ceramic determine the beam width or angle. In the past a frequency of 210 kilohertz has always been used. Three frequencies were tested and compared through various lengths of cable. The frequencies tested were; 120 kHz, 210 kHz, and 350 kHz. With the diameter of all elements being the same, a 120 kHz transducer will have a wider beam than a 210 kHz transducer. A same size 350 kHz transducer will have the most narrow beam.

Cable lengths of 1500 feet, 4500 feet, and 7600 feet were all tested.

The testing was conducted as follows. The electric pulse that is placed on the cable to excite the crystal is measured at the transceiver. At the other end of the cable, where the piezoelectric ceramic is attached, the pulse would be measured again. The two measured values would be recorded and the attenuation could be calculated. Once the crystal was excited and a reflection was obtained, it too, would be measured at the crystal. The reflection would also be measured after traveling through the cable to the transceiver. In doing this, we would obtain two sets of numbers to analyze the attenuation for this particular combination. After obtaining all the data for this combination, we would then switch to a longer piece of cable and test and record the results.

The New Interface Detector System

Once it was established that the piezoelectric ceramic could be separated from the electronics, the system could then designed. The finished system is comprised of; a smaller and less expensive downhole transducer, a transceiver to be located near the wellhead, and a display / controller.

The sealing and electrical connections of the downhole transducer is designed very closely to the existing unit, which has proven to be extremely reliable. The major change in the downhole transducer is the complete elimination of all downhole electronics. The transducer housing has been designed to protect the electrical conductor without having to use protective tubing or securing mechanisms. By eliminating the electronics in the downhole unit and protecting the exposed conductor, virtually all possibilities of a downhole failure are eliminated. The downhole transducer has been greatly improved and the price has been cut by 75 percent.

The transceiver, or surface electronics, is the brain of the system. The system was originally designed to have one set of electronics per downhole transducer, but having one set electronics operate multiple transducers is a possibility. The parameters involved with having one set of electronics operating multiple transducers depends on; the locations of the caverns, the depth of the caverns, and the surface wiring.

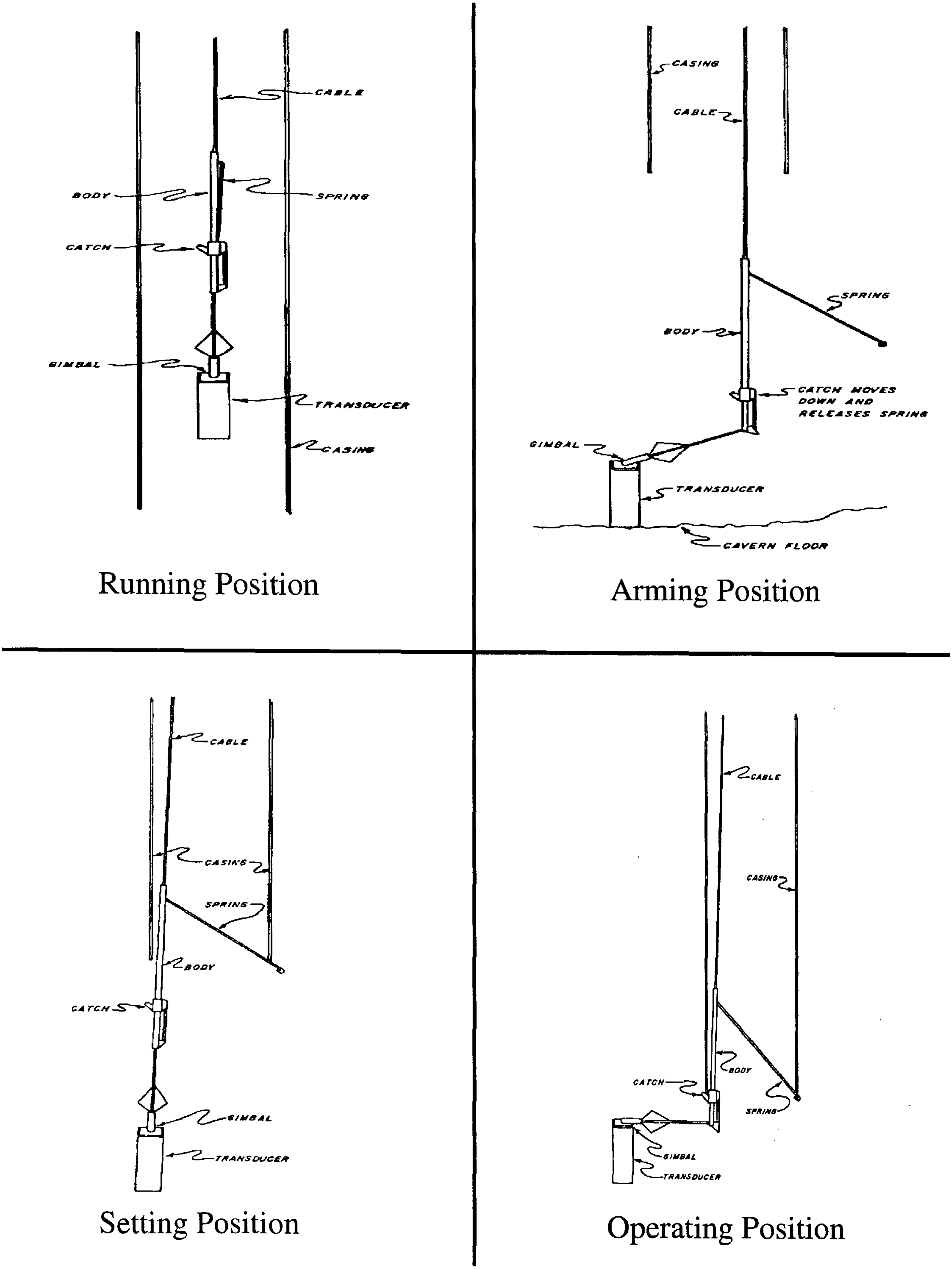
The display / controller is the device for displaying the information and also for inputting information. A small enclosure with an LCD screen can be used or any IBM compatible computer with a terminal emulation program. The display / controller can be located up to a mile from the transceiver. For displaying the distance to the interface, a 4 - 20 milliamp output is also available from the transceiver.

Price Benefits

A complete overview of price comparison between the existing equipment and the new can be seen in figure 2. From Figure 2, a significant drop in price can be easily seen. In the case of equipping one cavern, the cost of the equipment has dropped 56 %. Because the new equipment houses no electronics downhole, fewer downhole problems are expected. Added reliability translates into fewer downhole tool replacements.

Summary

The new Interface Detector system is both more reliable and less expensive. It has been approved by the Texas Railroad Commission as an overfill protection device and helps cavern operators operate their caverns to the maximum capacity in a safe manner. The first two units will be installed in the first week of April 1996.



Running Position

Arming Position

Setting Position

Operating Position

Figure 1

	Existing	New
1 Cavern	$ 14,750.00	$ 6,500.00
2 Caverns	$ 20,750.00	$ 10,500.00
3 Caverns	$ 26,750.00	$ 14,500.00
4 Caverns	$ 32,750.00	$ 18,500.00
5 Caverns	$ 38,750.00	$ 25,000.00
6 Caverns	$ 44,750.00	$ 29,000.00
7 Caverns	$ 50,750.00	$ 33,000.00
8 Caverns	$ 56,750.00	$ 37,000.00
9 Caverns	$ 62,750.00	$ 43,500.00
10 Caverns	$ 68,750.00	$ 47,500.00

Figure 2

Prices for equipping various numbers of caverns with Interface Detectors less cable and installation