reduced, while also reducing the risk of accidents involved with pipeline personnel manually checking operations at monitoring stations.

A related advantage of the invention is that each of the components of the system is readily available, so a highly reliable and cost effective monitoring system is obtained.

These and further objects, features, and advantages of the present invention will become apparent from the following detailed description, wherein reference is made to the figures in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating a pipeline monitoring system according to the present invention.

FIG. **2** depicts a monitoring station positioned along the pipeline.

FIG. **3** illustrates both surface and subsea monitoring stations for a pipeline.

FIG. **4** is a block diagram of a monitoring station.

FIG. **5** is a block diagram of a pig signaling detector.

FIG. **6** is a block diagram of the check alarms section shown in FIG. **5**.

FIG. **7** is a block diagram of the pipeline pig check section shown in FIG. **6**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** illustrates a pipeline monitoring system **10** according to a preferred embodiment of the invention, As shown in FIG. **3**, the pipeline P being monitored may include a plurality of pipe sections which are land based and underwater. The wide variety of environmental conditions which the pipeline may be exposed are known to those skilled in the art.

Positioned along the pipeline are plurality of monitoring stations **20**, with one such station being shown in FIG. **1**. The number of monitoring stations will depend on the length of the pipeline being monitored, and literally hundreds or thousands of monitoring stations may be monitored according to the system of the present invention. Each monitoring stations communicates with a central monitoring facility **50**, as discussed below.

Each monitoring station **20** serves as a data collection unit. A data transmission unit **22**, which may include an antenna and related communication circuitry such as that offered by Quake Global Communications, forwards the sensed data via satellite **60** to the central facility **50**. A magnetic pig position detector **24** is positioned close enough to the pipeline so that the magnetic field developed within the pipe by the pig is detected, thereby signaling pig position. The monitoring stations **20** may be installed when the pipeline is first laid or may be a retrofit to an existing pipeline. The monitoring stations may be conveniently positioned at pipeline warning signs typically positioned at road or waterway crossings.

Referring still to FIG. **1**, monitoring station **20** is adapted to receive receives signals from test leads **70** to determine the pipe/soil potentials for cathodic protection of the pipeline by the cathodic protection rectifiers (CPRs) **36**. The CPRs may also be used to transmit power to the monitoring station **20** which may then be used for monitoring various sensors **88** (see FIG. **4**), including potential pipeline damage sensors, the CPR voltage, CPR current, CPR meter metering, leak detection, fluid flow rate through the pipeline, fluid temperature and pressure, valve position information, and pipeline temperatures.

An important pipeline operation to be monitored is a warning against foreign objects causing damage to a pipeline system. Others digging in the area of pipelines may damage the pipeline coating or cause indentations to the pipe wall. One of the sensors **88** is thus a potential pipeline damage detector or sensor, such as a geophone or a pipeline vibration sensor, which is coupled to the central monitoring station **50** to alert the pipeline operator of potential pipeline damage, which may be due to terrorist activities, by outputting a potential pipeline damage signal and the location of the event. As each analog signal from sensor **88** is received, the conditioner **92** converts the analog voltage to a digital signal. Command signals from the central monitoring facility may control a valve actuator for controlling operation of a valve at the monitoring station.

Each monitoring station **20** includes a power source **26** to power circuitry **28**. The power source **26**, which may be a battery **30** and/or solar collector **32** as shown in FIG. **2**, may also power the data transmission unit **22**. Connecting the power source **26** to the data transmission unit **22** also provides the operator at the central monitoring facility **50** with the information required to test or change the power source.

In another embodiment, the monitoring station **20** receives power from the voltage applied directly to the pipeline by the power source **34** of the cathodic protection rectifiers (CPRs) **36**. The CPRs **36** place a voltage, typically between −0.85 vdc and −1.2 vdc, at various locations along the pipeline to protect the pipeline from corrosion. Hence, the monitoring station **20** may be powered without any power source other than the voltage applied to the pipeline by the CPRs **36**. A monitoring station power source will typically operate at a voltage up to about 5 volts to about 24 volts. Quick disconnect determinations may be used for all power and communication components.

Referring to FIG. **2**, a typical monitoring station **20** may be positioned at a pipeline marker **70**, which extends upwardly from the ground and marks the location of the buried pipeline P. Battery packs **30** previously discussed may be positioned within the pipeline marker, and solar panel **32** may be secured at an upper end of the marker **70**. The antenna **22** extends upward from or may be contained within the pipeline marker, while the electronics package or circuitry **28** is housed within the pipeline marker. Although various functions may be monitored, the monitoring station **20** preferably includes at least a magnetic pig position detector **24** and test leads **70** for outputting signals indicative of the pipe/test voltage. As shown in FIG. **2**, the test leads include pipeline test lead **72** for obtaining a voltage signal of the pipeline P and ground test lead **74**, which may go to ground. A half-cell **75**, which may be buried in the ground, may be used to monitor the voltage differential between test lead **72** and ground lead **74**. The half-cell potential technique is an established and reliable method of monitoring pipeline voltage potential.

Referring now to FIG. **3**, the satellite communication system **60** is able to communicate with both land base monitoring stations **20**, **20**A, and **20**B as shown in FIG. **3**, each substantially similar to the system shown in FIG. **2**. When the pipeline is under water, the subsea sensor packages **80** provide signals of the pipeline operation, and transmit those signals by various means, including conventional wirelines **82**, to the monitoring station **20**, which in this case may be supported on a surface buoy **84**. The