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(54) FIELD-MOUNTED CONTROL UNIT

IN EINER ARBEITSUMGEBUNG MONTIERTE STEUEREINHEIT

UNITE DE COMMANDE INSTALLEE SUR SITE

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- **MACHINE DESIGN vol. 59, no. 10, 10 September 1987, CLEVELAND US pages 125 - 129 I. AHMED, S. LINDQUIST 'DIGITAL SIGNAL PROCESSORS SIMPLIFYING HIGH-PERFORMANCE CONTROL'**

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Description

1. Field of the Invention

[0001] The present invention relates to a control unit communicating over a two-wire circuit and providing an output representative of a process variable produced by a process.

2. Background of the Invention

[0002] Transmitters measure process variables representative of a process controlled by remote devices and communicate transmitter outputs representing the process variables to controllers over two wire circuits. The transmitters are typically mounted in a field area where current and voltage levels are limited to provide intrinsic safety. The transmitter output is scaled by user definable parameters such as span, zero and damping. Span and zero adjustments allow the user to reference the measurement range extremes of the transmitter to specific transmitter output levels, thereby setting the range of desired outputs. Damping affects the response time of the transmitter to changes in the process variable. The scaled transmitter output is sent over the two wire circuit to the controller.

[0003] Controllers, typically located in a control room, combine the transmitter output with signals representing other process variables to generate command output signals. Command output signals are typically sent over a separate pair of wires to remote devices, such as a valve, which control the process according to the command output. In certain applications, controllers select the most appropriate set of instructions for process control from multiple sets of instructions, depending on the process to be controlled and the accuracy required.

[0004] In other applications, controllers sense several transmitter outputs representing process variables to determine the command output for the remote device. Typically, a separate transmitter senses each process variable. The transmitters send a signal representative of the sensed process variable to the controller over a two wire circuit, the controller determines the command output and controls the remote device, such as a valve position, pump speed, thermostat setting, etc.

[0005] One limitation of the prior art arrangement is that the transmitter, remote device and controller, components in the feedback loop, must all operate continuously for control of the process. Another limitation is the amount of interconnecting cabling connecting the feedback loop components. The controller is typically far from the process in a control room, while the remote device and the transmitter are usually in the field and physically proximate to each other and the process. Installation and maintenance complexity is another limitation, since each cable may require installation of an intrinsic safety barrier device at the interface between the control room and the field devices. In cases where multiple process variables are used by the controller, cabling is required between each transmitter and the controller. Feedback loop reliability is a fourth limitation, since failure of one of several interconnections adversely affects process control.

[0006] JP-A-63/1988-41904 discloses a two-wire field device incorporating a sensor for detecting a specific physical quantity which is used to control a regulator.

SUMMARY OF THE INVENTION

[0007] To reduce these limitations, a process variable transmitter (or control unit) provides a control output directly, thereby bypassing the controller itself. Outputs representative of other process variables are communicated to the transmitter (or control unit) rather than the controller. The transmitter communicates with the controller over a common two-wire link which forms a single loop with the controller, control unit and external control device all connected in series. Process control reliability and response time is enhanced and control is realized with fewer communication exchanges while installation complexity, maintenance complexity and cost decreases.

[0008] According to the present invention, there is provided a two wire control unit for mounting in the field comprising:

> a housing;
> a sensing device in the housing having means for sensing a process variable and generating a process variable signal representative of the process variable;
> input means in the housing for coupling to a DC current two wire process control loop for receiving power from the two wire process control loop, the input means comprising means for receiving at least one process signal via the two-wire process control loop, and for storing such process signal; and
> control means in the housing coupled to the sensing device and the input means for providing a command output for an external control device which controls a process characterized in that the control means is also for storing the command output, where the command output is a function of the stored process signal, the process variable signal and a previously stored value of the command output;
> and in that the control unit is adapted to generate a digital output signal in a carrier modulated format which is superimposed on the command output.

[0009] The process signals received from the two wire circuit can determine operation of the control means in producing a command output. Alternatively, the process signals comprise a process variable reported to the control unit over the two wire circuit or a set of instructions sent over the two wire circuit for determining the command output. When the process signals comprise a setpoint representative of a desired state of the process, the controlling section can generate the command output as a function of the difference between the setpoint and the process variable. As appropriate for the process to be controlled, the controlling section uses an equation including a linear combination of the process variable and the time integral of the process variable to determine the command output. As the application requires, the equation for determining the command output includes the time-rate-of-change of the process variable.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 shows a diagram of a part of a process control system having a control unit, a supervisory master unit and a master controller; and

FIG. 2 shows a block diagram of a preferred embodiment of a control unit coupled to a remote device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] FIG. 1 shows an industrial process control application as in a petrochemical tank farm 1; where a fluid 2 flows in a pipe network 4. A master controller 6 commands a supervisory master unit 10 via a cabling 12. Supervisory master unit 10 communicates over a two wire circuit 18 with a feedback loop 14, which controls flow in pipe segment 20. Feedback loop 14 comprises a control unit 22 and a two terminal remote device 26, which controls fluid flow, Q, from a tank 30 into pipe network 4. The capacity of tank farm 1 can be expanded by additional feedback loops, located at pipe segments 20A, 20B, 20C and 20D and controlled by master supervisor 10. An even larger expansion requires even more additional feedback loops and additional supervisory master units. Regardless of capacity, tank farm 1 is divided into a field area 34 requiring intrinsically safe equipment and a control room area, indicated by block 36. An intrinsically safe barrier device 16, which limits voltage and current to specified levels, is mounted on cable 12 at the interface between control room 36 and field 34. Each additional cable between control room 36 and field 34 requires installation of such a barrier device.

[0012] The flow, Q, in pipe segment 20 is given as:

$$Q = k \{ \rho * DP \}^{0.5} \qquad \text{Eq. 1}$$

where Q is the mass flow rate, ρ is the density of fluid 2, DP is the differential pressure across an orifice in pipe segment 20 and k is a constant of proportionality. This calculation of flow requires one process variable representative of differential pressure.

[0013] However, when ρ varies as is typical in petrochemicals, a more accurate assessment of the flow, Q, is given as:

$$Q = k' \{ AP * DP / AT \}^{0.5} \qquad \text{Eq. 2}$$

where AP is the absolute pressure in pipe segment 20, k' is another constant of proportionality and AT is the absolute temperature of fluid 2. Two additional process variables, absolute temperature and absolute pressure are required.

[0014] FIG. 2 shows a "smart" control unit 22, communicating with supervisory master unit 10 over two wire circuit 18 and comprising input means 50 and controlling means 52. "Smart" means that a computing capability is in the control unit, such as is performed by a microprocessor. Control units are connected in two wire circuits in a variety of ways. Each two wire circuit is coupled to a power source powering instruments on the circuit. In a first configuration, the supervisory master unit includes the power source which powers a control unit. Additional control units may be powered by the supervisory master unit and are connected in parallel across the power source. In a second configuration, the supervisory master unit includes the power source which powers at least one control unit and at least one remote device, connected in series across the power source. In a third configuration, a control unit used in the first configuration powers one or more remote devices, control units or both. The number of instruments receiving power is typically limited by available current, but alternative power sources are sometimes available for remote devices. The remote device may be connected to the control unit by a pair of wires, or alternatively, by a second two wire circuit.

[0015] The input means 50 has receiving means 54 coupled to two wire circuit 18 for receiving process signals and storing means 56 coupled to receiving means 54 for storing process signals 55. Controlling means 52 receives process signals 55 from receiving means 54 and storing means 56 of input means 50, as desired. A storage means 53 receives command output 58 and outputs a previous command output 60. Command output 58 is provided by block 52a as a function of process signals 55 and previous command output 60 and coupled to cable 57, which may be part of a second two wire circuit depending on the configuration. The command output 58 can be provided in some applications as a function of process signals 55 alone. A control unit such as this is used in a feedforward control application, where no feedback is used to generate the command output. In either application, remote device 26 is a transducer such as one which uses a current magnitude to regulate a pressure and is known in the process control industry as a current to pressure (I/P) converter. In a cascaded control application, however, the command output of one control unit is used as a process signal representative of a setpoint for another control unit. Accordingly, in a cascaded control application, remote device 26 is another control unit 22.

[0016] Remote device 26 applies an energy source 59 of pneumatic air to the process as a function of the command output 58. Process signals used in generating command output 58 comprise setpoints representative of a desired process state, process variables produced by the process, commands directing the operation of controlling means 52, instruction sets in part or in whole for operation of controlling means 52, coefficients of terms for controlling means 52 and requests for status information about control unit 22 from supervisory master unit 10. Different types of process signals are sent to control unit 22 depending on control unit 22 and the process control application.

[0017] A first type of process signal is the process variable. Process variables are categorized as primary process variables when they are directly representative of the variable to be controlled by the feedback loop. The primary process variable for control unit 22 is flow. Secondary process variables affect the primary process variable and are typically used to more accurately assess the primary process variable. Such compensation techniques are disclosed in U.S. Patent No. 4,598,381 titled <u>Pressure Compensated Differential Pressure Sensor and Method,</u> owned by the same assignee as this application. Alternatively, two process variables representative of the same measurand are sent to control unit 22 from different instruments on the same feedback loop, providing redundancy of a critical measurement.

[0018] A second type of process signal is the setpoint, indicative of a desired process state. In this application an example of a setpoint is a desired flow of 10 m^3/minute in pipe segment 20. Typically, process signals 55 representative of a setpoint and representative of process variables are sent to control unit 22. The primary process variable is typically compensated by other process variables sent over circuit 18. Controlling means 52 evaluate the difference between the setpoint and the compensated process variable and adjust command output 58.

[0019] Another type of process signal 55 is representative of commands which select between instructions sets stored in control unit 22 for providing command output 58. For example, a shut-down command causes command output 58 to be governed by an instruction set for safely shutting down feedback loop 14. Shutdown commands allow manual intervention of feedback loop 14. Another type of command instructs control unit 22 to adaptively set its own instruction set for operation of controlling means 52. In adaptive control, the instruction set may vary as a function of time. In such mode, control unit 22 calculates its own terms and coefficients, as desired, for operation of controlling means 52. Alternatively, another command may cause control unit 22 to operate in an exceptional mode, where it communicates with supervisory master unit 10 only if process variables exceed specified limits. Exceptional mode operation reduces communications between instruments in tank farm 1 and releases supervisory master unit 10 from continually communicating with feedback loop 14. The resulting decrease in communication overhead frees supervisory master unit 10 to monitor larger numbers of feedback loops and to perform more duties than before.

[0020] Process signals representative of instructions sets, in part or whole, are sent to control unit 22 to direct operation of controlling means 52. Partial instruction sets are sent to control unit 22 when a subset of an instruction set is needed to adjust command output 58.

[0021] A typical instruction set adjusts command output 58. A general equation for control is given:

$$\Delta q_K = \sum_{i=0}^{K} a_i r_i + \sum_{i=0}^{K} b_i y_i \qquad Eq. 3$$

where q_K is the command output at the Kth time, r_i and y_i are the setpoint and process variable values at the Kth time respectively, i varies from 0 to K, and a_i and b_i are application specific constants which may be time varying. Many applications require control which is proportional to a substantially linear combination of the process variable, the time integral of the process variable and the time-rate-of-change of the process variable, sometimes called proportional-integral-derivative (PID) action. The following equations define constants a_i and b_i from Eq. 3 appropriately for PID control action. The constant a_i for the present time and two previous evaluations are defined in Eq. 3.1a-c:

$$a_K = K_P + K_I , \qquad Eq. 3.1a$$

where K_P and K_I are defined as proportional or integral gain constants.

$$a_{K-1} = - K_P , \qquad Eq. 3.1b$$

$$a_{K-x} = 0 \text{ , where } x \geq 2 \qquad Eq. 3.1c$$

The constant b_i for the present time and two previous evaluations is defined in Eq. 3.2a-c:

$$b_K = \{ R / (1 - Q) - K_P - K_I \} \qquad Eq. 3.2a$$

where $R = (K_D T_D N) / (T_D + N h)$,

$Q = T_D / (T_D + N h)$, and K_D is a derivative gain constant, T_D is a derivative time constant, N is a rate limiting constant and h is a measure of the amount of time required to adjust command output 58. Furthermore,

$$b_{K-1} = \{ -2R / (1 - Q) + K_P \qquad \text{Eq. 3.2b}$$

$$b_{K-2} = R / (1 - Q) \qquad \text{Eq. 3.2c}$$

and all $b_{K-x} = 0$, where $x \geq 3$.

Substituting Eq. 3.1a-c and Eq. 3.2a-c into general control Eq. 3 yields a three term PID control Eq. 3.3, which becomes a PI equation when the third term is set to 0:

$$\Delta q_K = \Delta P_K + \Delta I_K + \Delta D_K \qquad \text{Eq. 3.3}$$

where $\Delta P_K = K_P \{ E_K - E_{K-1} \}$, $\Delta I_K = K_I E_K$ and $\Delta D_K = \{ R / (1 - Q) \} \{ y_K - 2y_{K-1} + y_{K-2} \}$ and

$E_K = r_K - y_K$ is the difference between the process variable and the setpoint at time K and represents the error.

[0022] The process control application dictates appropriateness of a PI or PID control equation. When proportional gain of a control application is relatively low, varies over a wide span and the controlled variable is slow to change, as is typical in flow and liquid pressure applications, integral control action is necessary, while derivative control action is not. Such control best uses a PI control action. PID control action, on the other hand, is best suited for applications such as temperature control, where proportional gain is low, is confined to a narrow band of values and the controlled variable is slow to change.

[0023] Another type of process signal is representative of coefficients for terms of an instruction set already stored in control unit 22. For example, if modifications in pipe network 4 were required, supervisory master unit 10 sends a new value of K_P, in Eq. 3.1a, to control unit 22.

[0024] A final type of process signal is representative of a request for information from control unit 22. This request originates from other control units and from supervisory master unit 10, as desired. Status information such as process control statistics, current modes of operation, process variable values and unit serial numbers may be monitored.

[0025] Various types of remote device 26 can be used with control unit 22. As discussed, remote device 26 is an I/P converter receiving command output 58 applying pneumatic air 59 for positioning valve 62 as a function of command output 58. Other process control applications may control absolute pressure, temperature, conductivity, pH, oxygen concentration, chlorine concentration, density, force, turbidity, motion and others. In these applications, remote device 26 may comprise a motor, a valve for a gauge pressure application, a switch and contact as desired in a temperature controlling application, a relay in a pH or level application or other implementation device.

[0026] The control unit 22 includes in the housing a sensing device 100 having a sensed output 112 from either a sensing means 102 or a scaling means 104. In this application, flow is given by Eq. 1, requiring only a process variable representative of differential pressure. In sensing device 100, sensing means 102 senses pressure on either side of an orifice 106 protruding into fluid 2. As required, scaling means 104 scales sensed process variables according to user definable constants such as span, zero and damping. Span and zero adjustments allow known pressures to be referenced to the range extremes of sensing means 102 while damping affects the time response of the unit to a process variable input change. Methods for scaling the process variable through the use of span and zero adjustments are disclosed in U.S. Application 112,410, titled "Transmitter with Magnetic Zero/Span Actuator" and owned by the same assignee as this application, incorporated herein by reference.

[0027] The sensed output 112 of sensing means 102 and scaling means 104, as desired, is used in controlling means 52 or coupled directly to cabling 57, as desired. When sensed output 112 is coupled to cabling 57, the signal on cabling 57 is representative of the sensed process variable, as from a transmitter. Transmitters sense process variables and output a signal representative of the sensed process variable. Transmitters are known and disclosed in U.S. Patent No. 4,833,922 by Frick et al. titled "Modular Transmitter", owned by the same assignee.

[0028] Control unit 22 as shown in FIG. 2 is connected in two wire circuit 18 per the second configuration as discussed above, but may be connected in other configurations. One terminal of remote device 26 is connected via cable 57 to control unit 22 while the other is connected to master supervisor 10 by two wire circuit 18.

[0029] The ability of control unit 22 to function as a transmitter or a controller allows use of several types of process signals. Different options are available for process signals representative of process variables.

[0030] Process signals 55 representative of a process variable and those representative of a setpoint are sent over two wire circuit 18 and used by controlling means 52 for providing command output 58. Process variables sent to control unit 22 are typically representative of secondary process variables as when Eq. 2 is used to calculate flow and typically compensate the primary process variable sensed by sensing device 100. Alternatively, process signals 55 representative of a redundantly sensed primary process variable are sent via two wire circuit 18 for increased reliability in critical applications. A third command provides for simultaneous execution of the controlling mode and transmitter mode. In such dual mode operation, command output 58 is coupled to cable 57 in an analog fashion and the magnitude of cable 57 current varies as command output 58. Remote device 26 adjusts valve 62 as a function of cable 57 current magnitude. Several communication standards vary current magnitude as a function of the information sent, such as 4-20mA and 10-50mA current loop communications standards. Alternatively, the voltage on cable 57 is representative in a voltage magnitude communication standard such as 1-5V. Concurrently, control unit 22 digitally couples sensed process variable 112 to cable 57 in a carrier modulated fashion. For example, signals representative of a command output are encoded by the 4-20mA standard and signals representative of a process variable are digitally encoded by a carrier modulated format. Typical carrier modulation communication standards which may be used are frequency shift key (FSK), amplitude modulation (AM), phase modulation (PM), frequency modulation (FM), Quadrature Amplitude Modulation (QAM) and Quadrature Phase Shift Key (QPSK).

[0031] Master supervisor 10 monitors process variables while control unit 22 controls the remote device 26 simultaneously, due to the series connection of master supervisor 10, control unit 22 and remote device 26 and because remote device 26 cannot change current on circuit 18 due to its passive nature. Such operation provides cost and efficiency advantages, because the number of two wire circuits needed for process control is reduced from two circuits to one circuit for each feedback loop. If such a mode is not used, a first two wire circuit communicates a process variable between a transmitter and master supervisor 10 and a second two wire circuit communicates a command output between master supervisor 10 and remote device 26. With such mode, a single two wire circuit connecting master supervisor 10, control unit 22 and remote device 26 in series controls the process. Wiring costs in field areas are expensive, with each feedback loop wiring representing approximately the same investment as a transmitter and a remote device. Secondly, process signals 55 representative of commands sent over two wire circuit 18 select between the two operational modes. This command directs control unit 22 to couple sensed process variable 112 or command output 58 onto cabling 57. Upon such command, the same control unit 22 functions as a transmitter or a controller, respectively. During operation as a controller, a command directing operation on exceptional basis is sent over circuit 18. Exceptional basis operation instructs control unit 22 to communicate with master supervisor 10 only when process variables received or sensed by the unit are not within specific limits. Such commands obviate master supervisory 10 monitoring or intervention in control unit 22 operation, resulting in fewer communications to maintain process control. Another advantage is increased reliability of process control, since cable 12 may be broken without compromising the process in this mode.

[0032] Thirdly, process signals 55 representative of varied instruction sets are sent to control unit 22 as appropriate for the process control application discussed above. Diverse functionality in varied applications is achieved. For example, control unit 22 senses differential pressure in a process controlling flow when a first instruction set governs controlling means 52 and senses differential pressure in a process controlling level when a second instruction set governs controlling means 52. Alternatively, control unit 22 provides command output 58 to different types of remote devices 26, changing such command output 58 as a function of process signals 55.

Claims

1. A two wire control unit for mounting in the field comprising:

   a housing;
   a sensing device (100) in the housing having means for sensing a process variable and generating a process variable signal (112) representative of the process variable;
   input means (54) in the housing for coupling to a DC current two wire process control loop (18) for receiving power from the two wire process control loop (18), the input means (54) comprising means (56) for receiving at least one process signal via the two-wire process control loop, and for storing such process signal; and
   control means (52) in the housing coupled to the sensing device (100) and the input means (54) for providing a command output (58) for an external control device (26) which controls a process characterized in that the control means is also for storing the command output, where the command output is a function of the stored process signal, the process variable signal and a previously stored value of the command output;
   and in that the control unit (22) is adapted to generate a digital output signal in a carrier modulated format which is superimposed on the command output.

2. A system comprising a two wire control unit as recited in claim 1, an external control device (26) and a master unit (10) which are electrically connected in series.

3. A two wire control unit as recited in claim 1 which adaptively sets an instruction set for operation of the control means.

4. A two wire control unit as recited in claim 1 where

the process signal comprises instructions for operation of the control means.

5. A two wire control unit as recited in claim 1 where the process signal comprises a setpoint and where the control means is adapted to adjust the command output as a function of a difference between the setpoint and the process variable signal.

6. A two wire control unit as recited in claim 1 where the control means is adapted to adjust the command output, q_k, according to an equation

$$\Delta q_k = \Sigma \sum_{i=0}^{k} a_i r_i + \Sigma \sum_{i=0}^{k} b_i y_i$$

where q_k is the command output at a kth time, r_i and y_i are a setpoint value and a process variable signal value at an ith time respectively, i varies from 0 to k and a_i and b_i are application specific constants which may be time varying.

7. A two wire control unit as recited in claim 1 where the command output is adapted to be coupled in an analog manner to the external control device (26) over the two-wire process control loop.

8. A two wire control unit as recited in claim 7 where the format for coupling the command output to the two-wire process control loop comprises a 4-20mA current loop communications standard.

9. A two wire control unit as recited in claim 1 where the means for sensing comprises a sensor selected from the group of sensors for sensing pressure, temperature, flow, mass, conductivity, moisture, pH, oxygen concentration, chlorine concentration, density, force and turbidity.

Patentansprüche

1. Zweidraht-Steuereinheit zum Anbringen am Einsatzort, die aufweist:

   ein Gehäuse;
   eine Erfassungsvorrichtung (100) in dem Gehäuse, die eine Einrichtung zum Erfassen einer Prozeßvariablen und zum Erzeugen eines Prozeßvariablensignales (112) hat, das für die Prozeßvariable repräsentativ ist;
   eine Eingangseinrichtung (54) in dem Gehäuse zum Koppeln mit einer Gleichstrom-Zweidraht-Prozeßsteuerschleife (18) zum Empfangen von Energie von der Zweidraht-Prozeßsteuerschleife (18), wobei die Eingangseinrichtung (54) aufweist eine Einrichtung (56) zum Empfangen von zumindest einem Prozeßsignal über die Zweidraht-Prozeßsteuerschleife und zum Speichern dieses Prozeßsignals; und
   eine Steuereinrichtung (52) in dem Gehäuse, die mit der Erfassungsvorrichtung (100) und der Eingangseinrichtung (54) gekoppelt ist, zum Erzeugen eines Befehlsausgangs (58) für eine externe Steuervorrichtung (26), die einen Prozeß steuert, dadurch gekennzeichnet, daß die Steuereinrichtung auch zum Speichern des Befehlsausgangs ist, wobei der Befehlsausgang eine Funktion des gespeicherten Prozeßsignals, des Prozeßvariablensignals und eines zuvor gespeicherten Werts des Befehlsausgangs ist; und
   daß die Steuereinheit (22) dafür ausgelegt ist, ein digitales Ausgangssignal in einem trägermodulierten Format zu erzeugen, das dem Befehlsausgang überlagert ist.

2. System, das eine Zweidraht-Steuereinheit, wie in dem Anspruch 1 zitiert, eine externe Steuervorrichtung (26) und eine Haupteinheit (10) aufweist, die elektrisch in Serie verbunden sind.

3. Zweidraht-Steuereinheit, wie in Anspruch 1 zitiert, die einen Befehlssatz für den Betrieb der Steuereinrichtung adaptiv setzt.

4. Zweidraht-Steuereinheit, wie in Anspruch 1 zitiert, wobei das Prozeßsignal Befehle für den Betrieb der Steuereinrichtung aufweist.

5. Zweidraht-Steuereinheit, wie in Anspruch 1 zitiert, wobei das Prozeßsignal einen Sollwert aufweist und wobei die Steuereinrichtung dafür ausgelegt ist, den Befehlsausgang als eine Funktion der Differenz zwischen dem Sollwert und dem Prozeßvariablensignal einzustellen.

6. Zweidraht-Steuereinheit, wie in Anspruch 1 zitiert, wobei die Steuereinrichtung dafür ausgelegt ist, den Befehlsausgang q_k gemäß einer Gleichung

$$\Delta q_k = \Sigma \sum_{i=0}^{k} a_i r_i + \Sigma \sum_{i=0}^{k} b_i y_i$$

einzustellen, wobei q_k der Befehlsausgang zu einem k-ten Zeitpunkt ist, r_i und y_i ein Sollwert bzw. ein Prozeßvariablensignalwert zum i-ten Zeitpunkt ist, wobei 1 zwischen 0 und k variiert und a_i und b_i applikationsspezifische Konstanten sind, die sich mit der Zeit ändem können.

7. Zweidraht-Steuereinheit, wie in Anspruch 1 zitiert, wobei der Befehlsausgang ausgelegt ist, in einer analogen Art und Weise mit der externen Steuereinrichtung (26) über die Zweidraht-Prozeßsteuerschleife gekoppelt zu sein.

8. Zweidraht-Steuereinheit, wie in Anspruch 7 zitiert, wobei das Format für das Koppeln des Befehlsausgangs mit der Zweidraht-Prozeßsteuerschleife einen 4-20mA-StromschleifeKommmunikationsstandart aufweist.

9. Zweidraht-Steuereinheit, wie in Anspruch 1 zitiert, wobei die Einrichtung zum Erfassen einen Sensor aufweist, der aus der Gruppe von Sensoren für die Erfassung des Drucks, der Temperatur, des Flusses, der Masse, der Leitfähigkeit, der Feuchtigkeit, des pH-Werts, der Sauerstoffkonzentration, der Chlorkonzentration, der Dichte, der Kraft und der Trübheit ausgewählt ist.

Revendications

1. Unité de régulation à deux fils destinée à être montée sur site, comprenant :

   un boîtier ;
   un dispositif de détection (100) placé dans le boîtier et ayant des moyens pour détecter une variable de procédé et générer un signal de variable de procédé (112) représentant la variable de procédé ;
   des moyens d'entrée (54) placés dans le boîtier et destinés à être accouplés à un circuit (18) de régulation de procédé à deux fils, à courant continu, pour recevoir de l'énergie du circuit de régulation de procédé à deux fils (18), les moyens d'entrée (54) comprenant des moyens (56) pour recevoir au moins un signal de procédé par l'intermédiaire du circuit de régulation de procédé à deux fils, et pour stocker ce signal de procédé ; et
   des moyens de régulation (52) placés dans le boîtier et accouplés au dispositif de détection (100) et aux moyens d'entrée (54) pour fournir un signal de sortie de commande (58) à un dispositif de régulation externe (26) qui régule un procédé, l'unité de régulation étant caractérisée en ce que les moyens de régulation servent également à stocker le signal de sortie de commande, où le signal de sortie de commande est une fonction du signal de procédé stocké, du signal de variable de procédé et d'une valeur préalablement stockée du signal de sortie de commande ;
   et en ce que l'unité de régulation (22) est conçue pour générer un signal de sortie numérique, dans un format à modulation de porteuse, qui est superposé au signal de sortie de commande.

2. Système comprenant une unité de régulation à deux fils selon la revendication 1, un dispositif de régulation externe (26) et une unité maîtresse (10), qui sont connectés par raccordement électrique en série.

3. Unité de régulation à deux fils selon la revendication 1, qui établit de manière adaptative un ensemble d'instructions pour le fonctionnement des moyens de régulation.

4. Unité de régulation à deux fils selon la revendication 1, dans laquelle le signal de procédé comprend des instructions pour le fonctionnement des moyens de régulation.

5. Unité de régulation à deux fils selon la revendication 1, dans laquelle le signal de procédé comprend un point de réglage et dans laquelle les moyens de régulation sont conçus pour ajuster le signal de sortie de commande en fonction d'une différence entre le point de réglage et le signal de variable de procédé.

6. Unité de régulation à deux fils selon la revendication 1, dans laquelle les moyens de régulation sont conçus pour ajuster le signal de commande, qk, selon une équation

$$\Delta q_k = \Sigma \sum_{i=0}^{k} a_i r_i + \Sigma \sum_{i=0}^{k} b_i y_i$$

où q_k est le signal de sortie de commande à un instant kth, r_i et y_i sont respectivement une valeur de point de réglage et une valeur de signal de variable de procédé à un instant ith, 1 varie de 0 à k, et a_i et b_i sont des constantes spécifiques d'application qui peuvent varier en fonction du temps.

7. Unité de régulation à deux fils selon la revendication 1, dans laquelle le signal de sortie de commande est conçu pour être transféré de manière analogique à un dispositif de régulation externe (26) par l'intermédiaire du circuit de régulation de procédé à deux fils.

8. Unité de régulation à deux fils selon la revendication 7, dans laquelle le format de transfert du signal de sortie de commande au circuit de régulation de procédé à deux fils comprend une norme de communication de circuit de courant de 4-20 mA.

9. Unité de régulation à deux fils selon la revendication

1, dans laquelle les moyens de détection comprennent un capteur choisi parmi le groupe constitué des capteurs servant à détecter la pression, la température, le débit, la masse, la conductivité, l'humidité, le pH, la concentration en oxygène, la concentration en chlore, la masse volumique, la force et la turbidité.

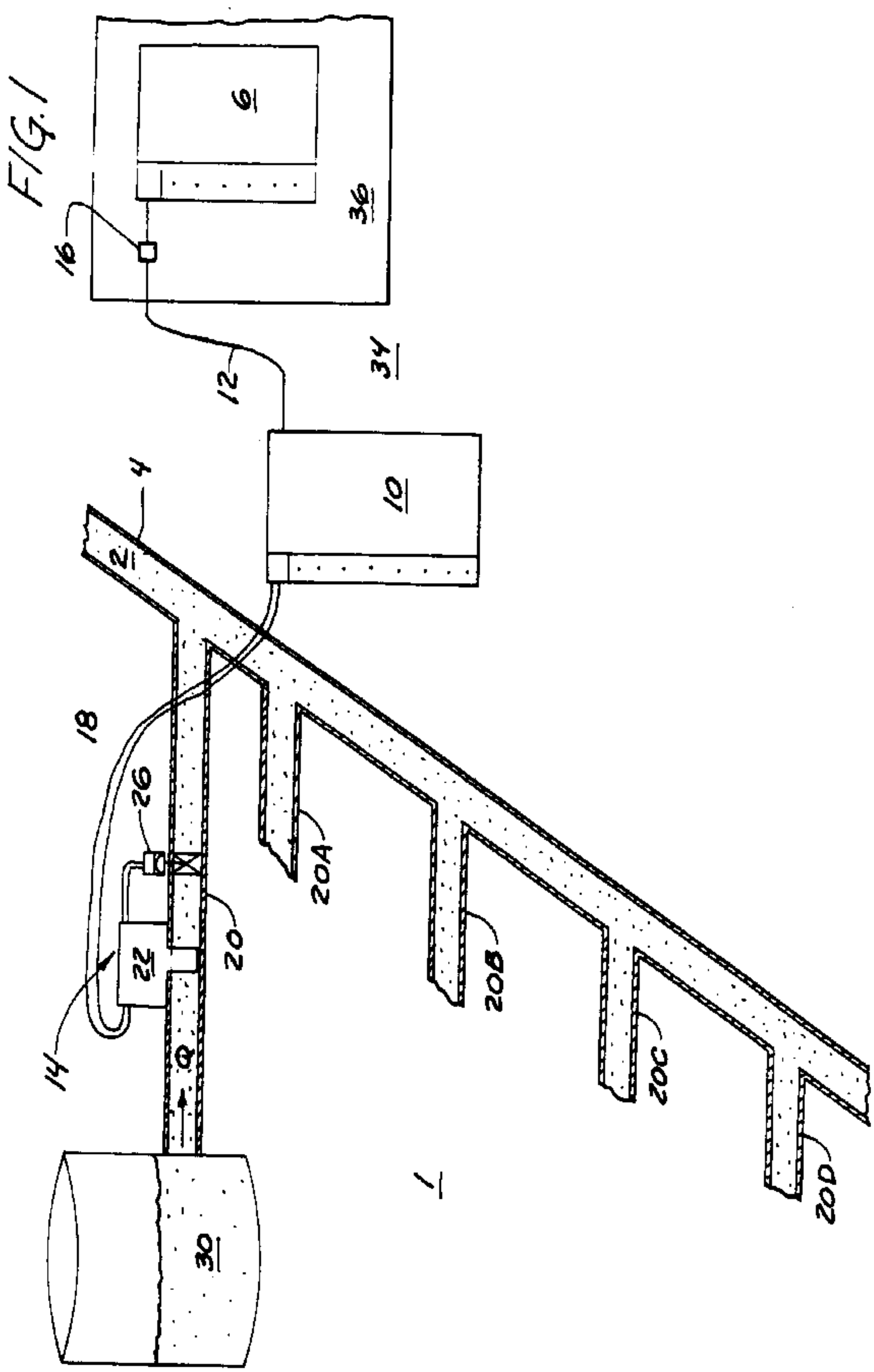
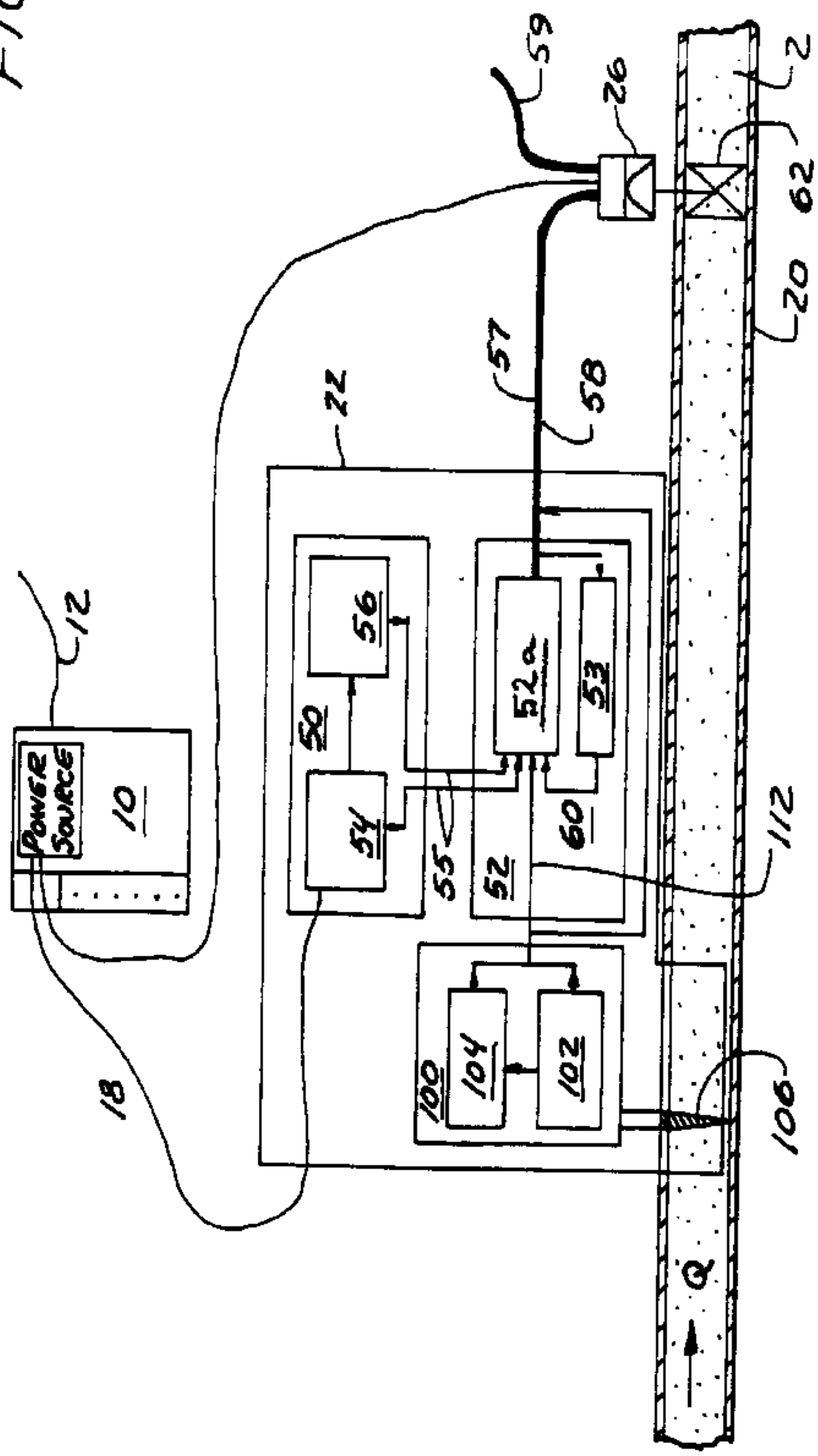


FIG. 1

FIG. 2


POWER SOURCE
10
12
18
22
50
54
56
55
52
52a
53
60
57
58
59
26
2
62
20
112
100
104
102
106
Q