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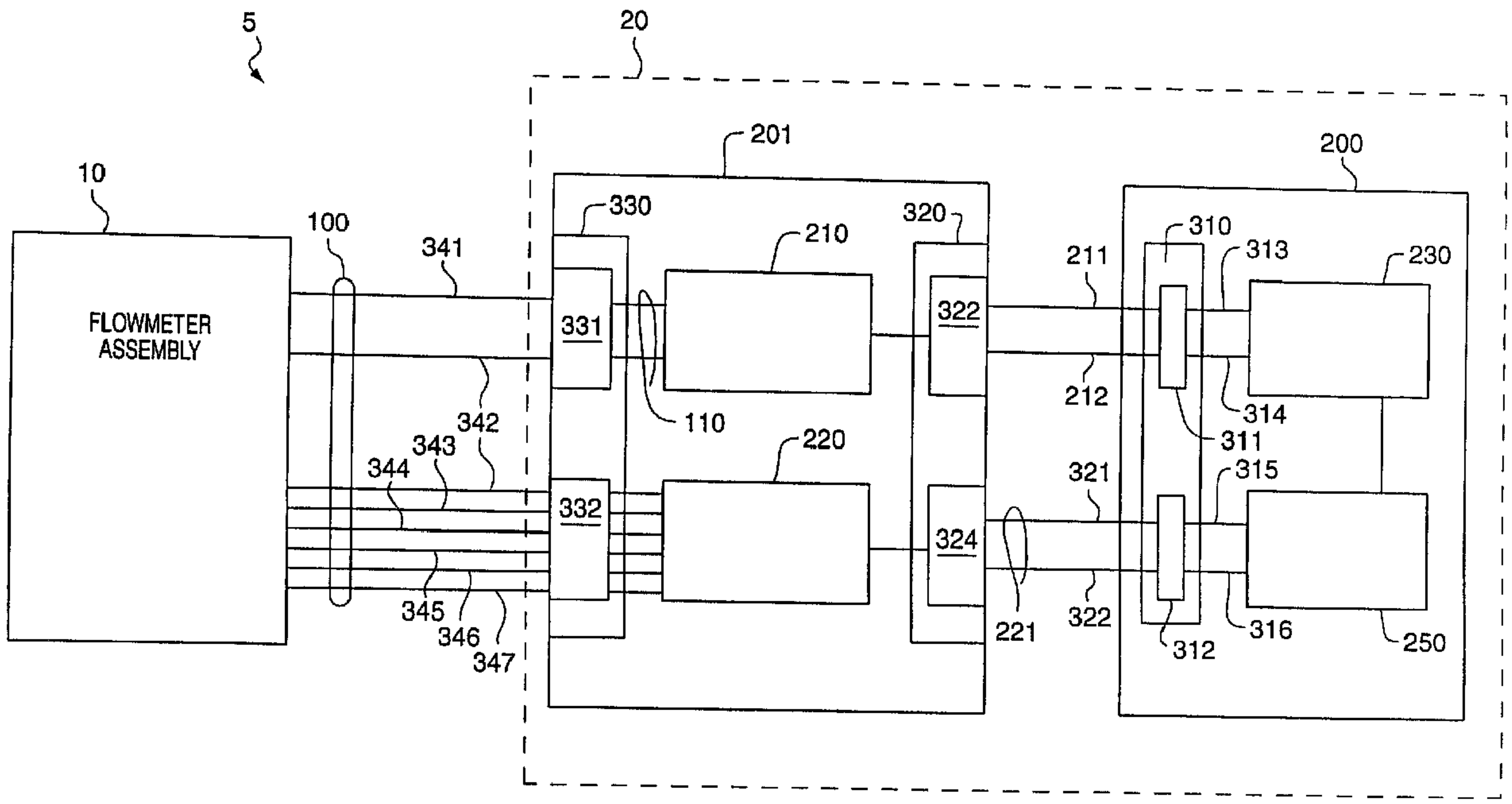
(54) Titre : CONDITIONNEUR DE SIGNAL INTRINSEQUEMENT SUR POUR DEBITMETRE A EFFET CORIOLIS
(54) Title: INTRINSICALLY SAFE SIGNAL CONDITIONER FOR A CORIOLIS FLOWMETER



(57) Abrégé/Abstract:
Meter electronics (20) for a Coriolis flowmeter (5) capable of being intrinsically safe. A signal conditioner (201) receives power from a power supply (230) in a host system (200) remote from the signal conditioner (201). Drive circuitry (210) in the signal conditioner (201) generates a drive signal and applies the drive signal to a driver (104). Pick-off signal conditioning circuitry (220) in the signal conditioner receives input signals from a first pick-off sensor (105) and a second pick-off sensor (105'), generates information indicating properties of a material flowing through the conduit from the input signals, and transmits output signals. Host-side protection circuitry (320) in the signal conditioner (201) prevents power in excess of an intrinsically safe threshold from being applied to leads connecting the signal conditioner to the host system (200) and flowmeter assembly protection circuitry (330) in said signal conditioner prevents power in excess of the intrinsically safe threshold from being applied to leads (100) connecting the signal conditioner (201) to the driver (104), the first pick-off sensor (105), and the second pick-off sensor (105').

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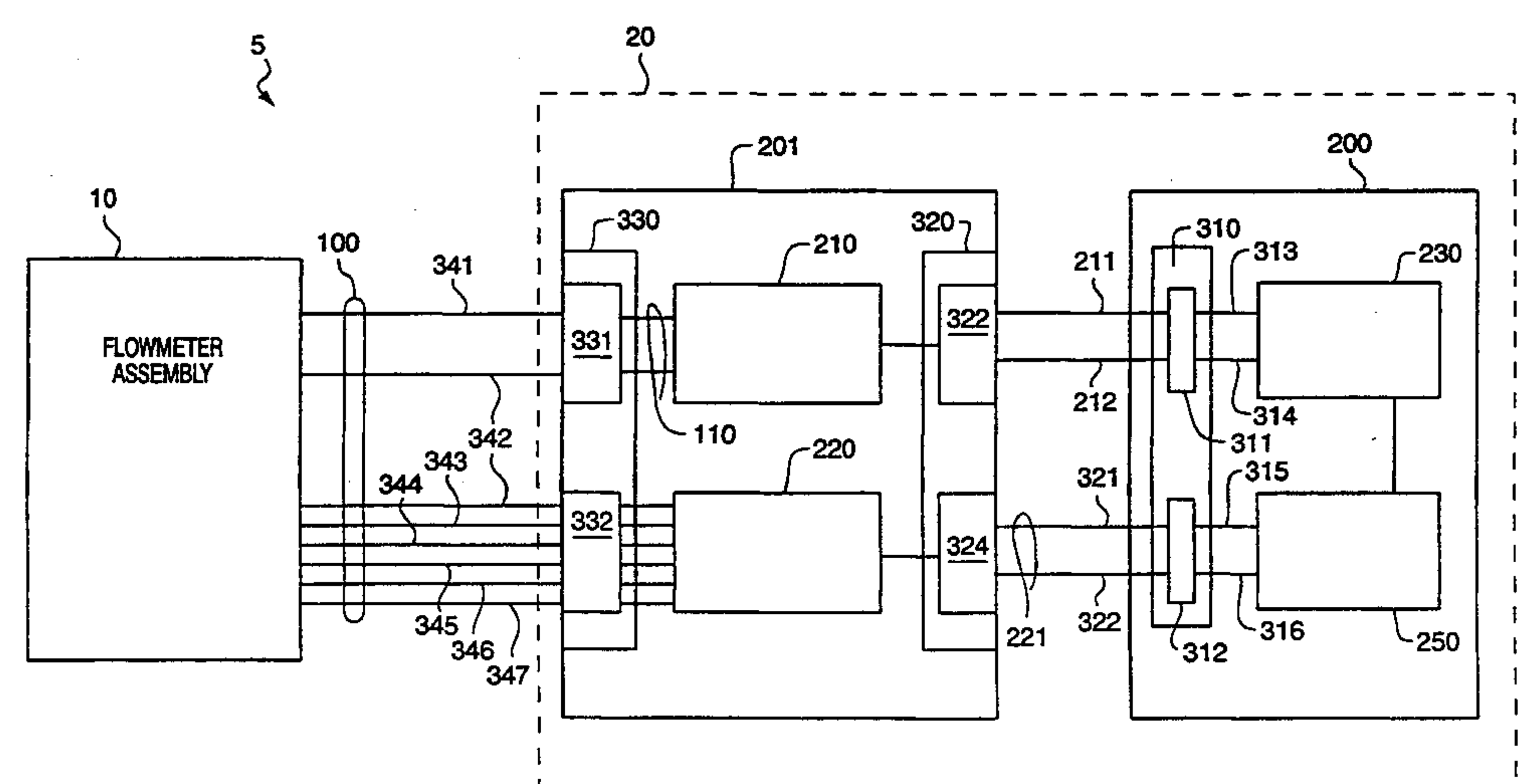

(57) Abstract: Meter electronics (20) for a Coriolis flowmeter (5) capable of being intrinsically safe. A signal conditioner (201) receives power from a power supply (230) in a host system (200) remote from the signal conditioner (201). Drive circuitry (210) in the signal conditioner (201) generates a drive signal and applies the drive signal to a driver (104). Pick-off signal conditioning circuitry (220) in the signal conditioner receives input signals from a first pick-off sensor (105) and a second pick-off sensor (105'), generates information indicating properties of a material flowing through the conduit from the input signals, and transmits output signals. Host-side protection circuitry (320) in the signal conditioner (201) prevents power in excess of an intrinsically safe threshold from being applied to leads connecting the signal conditioner to the host system (200) and flowmeter assembly protection circuitry (330) in said signal conditioner prevents power in excess of the intrinsically safe threshold from being applied to leads (100) connecting the signal conditioner (201) to the driver (104), the first pick-off sensor (105), and the second pick-off sensor (105').

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INTRINSICALLY SAFE SIGNAL CONDITIONER FOR A CORIOLIS FLOWMETER

Field of the Invention

This invention relates to meter electronics for a Coriolis flowmeter. More particularly, this invention relates to meter electronics that has a signal conditioner that is remote from a host system and is capable of being intrinsically safe. Still more particularly, this invention relates to meter electronics that have a signal conditioner that allows conventional 2 or 4 wire cable to be used to supply power to a Coriolis flowmeter.

Problem

It is known to use Coriolis effect mass flowmeters to measure mass flow and other information with respect to materials flowing through a pipeline as disclosed in U.S. Patent No. 4,491,025 issued to J.E. Smith, et al. of January 1, 1985 and Re. 31,450 to J.E. Smith of February 11, 1982. These flowmeters have one or more flow tubes of a curved or a straight configuration. Each flow tube configuration in a Coriolis mass flowmeter has a set of natural vibration modes, which may be of a simple bending, torsional, radial, or coupled type. Each flow tube is driven to oscillate at resonance in one of these natural modes. The natural vibration modes of the vibrating, material filled systems are defined in part by the combined mass of the flow tubes and the material within the flow tubes. Material flows into the flowmeter from a connected pipeline on the inlet side of the flowmeter. The material is then directed through the flow tube or flow tubes and exits the flowmeter to a pipeline connected on the outlet side.

A driver applies a vibrational force to the flow tube. The force causes the flow tube to oscillate. When there is no material flowing through the flowmeter, all points along a flow tube oscillate with a substantially identical phase. As a material begins to flow through the flow tube, Coriolis accelerations cause each point along the flow tube to have a different phase with respect to other points along the flow tube. The phase on the inlet side of the flow tube lags the driver, while the phase on the outlet side leads the driver. Sensors at two different points on the flow tube produce sinusoidal signals representative of the motion of the flow tube at the two points. A phase difference of the two signals received from the sensors is calculated in units of time. The phase difference between the two sensor signals is proportional to the mass flow rate of the material flowing through the flow tube or flow tubes.

It is a problem that a 9-wire cable must be used to connect meter electronics to an adjacent flowmeter assembly. For purposes of the present discussion, meter electronics include all of the circuitry needed to produce drive signals and to process signals from the sensors and a Coriolis flowmeter assembly includes at least one flow tube, an affixed driver, and sensors needed to measure the oscillation of the flow tube. The 9-wire cable for connecting the meter electronics to the flowmeter assembly includes two wires that connect the meter electronics to the driver, two wires that connect the meter electronics to a first pick-off, two wires that connect the meter electronics to a second pick-off, and three wires for connecting the meter electronics to a temperature sensor.

The 9-wire cable is a custom cable and is expensive to produce and is therefore expensive for a user of a Coriolis flowmeter to purchase. The expense of 9-wire cable is a particular problem when the user of a Coriolis flowmeter wishes to move the meter electronics to a control area remote from the flowmeter assembly. The 9-wire cable must be installed the entire length between the meter electronics and the Coriolis flowmeter assembly. The cost of such 9-wire cable increases greatly as the distance between the meter electronics and the flowmeter assembly increases. It would be a particular advantage if conventional 2-wire or 4-wire cable that is relatively inexpensive and readily available could be used to connect the flowmeter assembly to the meter electronics, especially for remotely situated meter electronics.

A further problem in designing meter electronics is that the meter electronics may be used in an explosive environment containing a volatile material. For purposes of the present discussion, an explosive environment is a system that includes a volatile material which can be ignited if a spark, excessive heat, or excessive energy is introduced into the environment. One manner in which a meter electronics may be safely operated in an explosion environment is to enclose the meter electronics in an explosion proof housing. An explosion proof housing is a housing that is designed to ensure that a spark or excessive heat from inside the housing does not ignite the volatile material in the environment outside the housing.

In order to make a device explosion proof, it is known to use methods including encapsulation, pressurization, and flameproof containment. Each of the above methods encloses a device to prevent the volatile material from contacting the device where heated surfaces of the device or sparks from circuitry in the device may cause an ignition of the material. If a material ignites inside an enclosure, any gaps or openings in the enclosure must provide a flame path of a sufficient length to cool the material as the material escapes from the enclosure. The cooling of the hot material prevents the hot material from igniting the volatile material outside the enclosure.

A second solution is to make the meter electronics intrinsically safe. An intrinsically safe device is a device having only circuitry that operates under a certain low energy level. By operating under a certain energy level, the generation of a spark or sufficient heat can be prevented, and an explosion, even if the device fails in some manner can be avoided. The power level needed to make a device intrinsically safe are determined by regulatory agencies such as UL in the United States, CENELEC in Europe, CSA in Canada, and TIIS in Japan.

Solution

The above and other problems are solved and an advance in the art is made by meter electronics having a signal conditioner operated in accordance with this invention. A first advantage of this invention is that the 9-wire cable to a Coriolis flowmeter assembly may be reduced in length or eliminated, including embodiments providing a power supply of the meter electronics remote from a Coriolis flowmeter assembly. A second advantage of the present meter electronics is that the entire meter electronics do not have to be enclosed in an explosion proof housing. Instead, a signal conditioner of the meter electronics is used that operates at a power level below the required energy and/or power threshold needed to be intrinsically safe. The signal conditioner may be proximate the Coriolis flowmeter assembly and does not have to be enclosed in an explosion proof housing if wires to and from the signal conditioner do not carry energy and/or power at a level greater than the threshold for being intrinsically safe.

The meter electronics of this invention eliminate the need for conventional 9-wire cable to connect a flowmeter assembly to the meter electronics in a Coriolis flowmeter. Instead, a conventional 2-wire or 4-wire cable can be used to supply

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energy and/or power to a signal conditioner from a remote host system. The signal conditioner is proximate the Coriolis flowmeter assembly and generates the drive signal, receives sensors signals from motion pickoffs and temperature sensors affixed to a flow tube of the Coriolis flowmeter, and processes the signals from the pickoffs to generate information about the properties of the material flowing through the flow tube.

The signal conditioner is connected to the driver and sensors of the Coriolis flowmeter by 9 separate wires that are distinct from the conventional 9-wire cable previously used to connect the meter electronics to a Coriolis flowmeter. After processing the pickoff signals, the signal conditioner transmits information regarding properties of the flowing material over 2 separate wires in a conventional 4-wire cable or over the 2- wires supplying power in a conventional 2-wire cable.

In order to make the signal conditioner capable of being intrinsically safe, the signal conditioner includes host-side protection circuitry and flowmeter assembly protection circuitry. The host side protection circuitry prevents energy and/or power in excess of an intrinsically safe threshold from being applied by the signal conditioner to the wires connecting the signal conditioner to the remote host system. The intrinsically safe threshold is the level of energy and/or power dictated by various agencies to ensure that a spark or heat from the circuitry does not ignite volatile material in the environment. For purposes of brevity throughout the rest of this discussion, power is understood to mean energy and/or power.

The host-side protection circuitry may include power supply protection circuitry and/or signaling protection circuitry. The power supply protection circuitry prevents power from flowing from the signal conditioner over a first wire and a second wire supplying power from the remote host system to the signal conditioner. The signaling protection circuitry prevents power in excess of the intrinsically safe threshold from being applied by the pick-off signal conditioning circuitry in the signal conditioner to the wires connecting the pick-off signal condition circuitry to the remote host system.

The flowmeter assembly protection circuitry prevents power in excess of a intrinsically safe threshold from being applied to wires connected to the flowmeter assembly. The flowmeter assembly protection circuitry includes a drive signal protection circuitry and sensor signals protection circuitry. The drive protection circuitry prevents power in excess of the intrinsically threshold power from being applied to wires connected to the driver by the drive circuitry in the signal conditioner. The sensor signal protection circuitry prevents power from being applied to a wire connected to the first pick-off and a wire connected to the second pick-off by the pick-off signal conditioning circuitry in the signal conditioner.

The remote host system includes the power supply and a secondary signal processing system. The power supply supplies power to the entire system. The secondary processing system receives output signals from the signal conditioner and determines properties of the material flowing through the flow tube. In order to be intrinsically safe, the host system includes a barrier that prevents power greater than the intrinsically safe threshold from being applied to wires connected to the signal conditioner by the host system.

The barrier of the remote host system includes power supply protection circuitry and secondary processing protection circuitry. The power supply protection circuitry prevents power in excess of the intrinsically safe threshold from being applied to the first wire and the second wire supplying power to the signal conditioner. The secondary signal protection circuitry prevents power from being applied by the secondary processing system to the wires connecting the secondary processing system to the pick-off signal condition circuitry in the signal conditioner.

An aspect of this invention is the provision of meter electronics for a Coriolis flowmeter capable of being intrinsically safe. The meter electronics includes the following components. A signal conditioner that receives power from a power supply in a remote host system via a first wire and a second wire. Drive circuitry in the signal conditioner generates a drive signal from the power received from the remote power supply and applies the drive signal to a driver affixed to at least one conduit of the Coriolis flowmeter. Pick-off signal conditioning circuitry in the signal conditioner receives input signals from a first pick-off sensor and a second pick-off sensor affixed to said at least one conduit of the Coriolis flowmeter, generates information indicating properties of a material flowing through the conduit from the input signals, and transmits output signals containing the information to the remote host system. Host-side protection circuitry in the signal conditioner prevents power in excess of an intrinsically safe threshold from being applied by circuitry in the signal conditioner to wires connecting the signal conditioner to the host system. Flowmeter assembly protection circuitry in the signal conditioner prevents power in excess of the intrinsically safe threshold from being applied by circuitry in the signal conditioner to wires connecting the signal conditioner to the driver, the first pick-off sensor, and the second pick-off sensor.

Preferably meter electronics for a Coriolis flowmeter assembly capable of being intrinsically safe, said meter electronics comprising:

drive circuitry;

a power supply capable of providing power to said meter electronics and said signal conditioner;

characterized in that said meter electronic further comprises;

a signal conditioner within which said drive circuitry is configured;

a host system remote from said signal conditioner within which said power supply is configured;

wherein said signal conditioner receives power from said power supply of said remote host system via a first wire and a second wire;

wherein said drive circuitry within said signal conditioner generates a drive signal in response to said power received from said power supply and applies said drive signal to a driver affixed to at least one conduit of said Coriolis flowmeter;

pick-off signal conditioning circuitry within said signal conditioner that receives input signals from a first pick-off sensor and from a second pick-off sensor affixed to said at least one conduit and in response thereto, generates information indicating properties of a material flowing through said at least one conduit, said signal conditioner transmits output signals containing said material information to said remote host system;

host-side protection circuitry in said signal conditioner that prevents power in excess of an intrinsically safe threshold from being applied by circuitry in said signal conditioner to said wires connecting said signal conditioner to said remote host system; and

flowmeter assembly protection circuitry in said signal conditioner that prevents power in excess of said intrinsically safe threshold from being applied by circuitry in said signal conditioner to wires connecting said signal conditioner to said driver and to said first pick-off sensor and to said second pick-off sensor of said Coriolis flowmeter.

Preferably said host-side protection circuitry comprises:

power supply protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied to said first wire and said second wire by said circuitry in said signal conditioner.

Preferably said host-side protection circuitry comprises:

signaling protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied to wires connecting said pick-off signal conditioning circuitry to said remote host system.

Preferably said flowmeter assembly protection circuitry further comprises:

drive protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied by said drive circuitry to wires connected to said driver.

Preferably said flowmeter assembly protection circuitry further comprises:

sensor protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied by said pick-off signal conditioning circuitry to wires connecting said first pick-off sensor and said second pick-off sensor to said pick-off signal conditioning circuitry.

Preferably said remote host system includes said power supply and a secondary signal processing system, said meter electronics further comprising:

a barrier in said remote host system that prevents power in excess of said intrinsically safe threshold from being applied by said host system to said wires between said signal conditioner and said remote host system.

Preferably said barrier comprises:

power protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied to a first one of said wires and to a second one of said wires by said power supply.

Preferably meter electronics further comprises:

a secondary processing protection circuitry in said remote host system that prevents power in excess of said intrinsically safe threshold from being applied by said secondary processing system to wires connecting said pick-off signal conditioning circuitry to said secondary processing system.

Preferably said output signals are applied to a first wire and a second wire extending to said remote host system by said pick-off signal conditioning circuitry.

Preferably said output signals are applied to a third wire and a fourth wire connected to said remote host system.

Preferably said drive circuitry controls the amount of current of said drive signal that is applied to said driver.

Preferably said drive circuitry controls the amount of voltage of said drive signal that is applied to said driver.

Preferably a method capable of being intrinsically safe for processing signals for a Coriolis flowmeter assembly comprises the steps of:

generating information indicating properties of a material flowing through said Coriolis flowmeter from input signals;

characterized in that said method further includes the steps of;

receiving power in a signal conditioner from a power supply in a remote host system remote from said signal conditioner via a first wire and a second wire;

preventing power in excess of an intrinsically safe threshold from being applied to said first wire and said second wire by circuitry of said signal conditioner;

generating a drive signal from said received power using drive circuitry in said signal conditioner;

applying said drive signal to a driver affixed to at least one conduit of said Coriolis flowmeter;

preventing power in excess of said intrinsically safe threshold from being applied by said drive circuitry to wires connected to said driver;

receiving input signals by pick-off signal conditioning circuitry from a first pick-off sensor and a second pick-off sensor affixed to at least one conduit of said Coriolis flowmeter;

preventing power in excess of said intrinsically safe threshold from being applied by said pick-off signal conditioning circuitry to wires connecting said first pick-off sensor and said second pick-off sensor to said pick-off signal conditioning circuitry;

transmitting output signals containing said information to said remote host system; and preventing power in excess of said intrinsically safe threshold from being applied to wires connecting said pick-off signal conditioning circuitry to said remote host system.

Preferably said remote host system includes said power supply and a secondary signal processing system, said method further comprising the step of:

preventing power in excess of said intrinsically safe threshold from being applied by said remote host system to wires between said signal conditioner and said secondary signal processing system.

Preferably said step of preventing power from said remote host system comprises the step of:

preventing power in excess of said intrinsically safe threshold from being applied to said first wire and said second wire by said power supply.

Preferably said step of preventing power from said host system comprises the step of:

preventing power in excess of said intrinsically safe threshold from being applied by said secondary processing system to leads connecting said pick-off signal conditioning circuitry to said secondary processing system.

Preferably said step of transmitting said output signals comprises the step of:

applying said output signal to said first wire and to said second wire by said pick-off signal conditioning circuitry.

Preferably said step of transmitting said output signals further comprises the step of:

applying said output signals to a third wire and a fourth wire that are connected to said host system.

Preferably said method further comprises the step of:

controlling the amount of current of said drive signal that is applied to said driver.

Preferably said method further comprises the step of:

controlling the amount of voltage of said drive signal that is applied to said driver.

Preferably said flowmeter signal processing system, comprising:

meter electronics;

characterized in that said meter electronics further comprise:

a signal conditioner;

a host system remotely coupled to said signal conditioner;

wherein said signal conditioner and said host system operate within an intrinsically safe threshold.

Preferably said signal conditioner comprises flowmeter assembly protection circuitry coupled to a flowmeter assembly and host-side protection circuitry coupled to said host system.

Preferably said flowmeter assembly protection circuitry comprises drive protection circuitry.

Preferably said flowmeter assembly protection circuitry comprises sensor protection circuitry.

Preferably said host system comprises a barrier.

Preferably said barrier comprises power supply protection circuitry coupled to said signal conditioner.

Preferably said barrier comprises processing protection circuitry coupled to said signal conditioner.

Preferably said method of processing flowmeter signals, comprising the step of:

providing meter electronics;

characterized in that said method further comprises the steps of:

providing a signal processing system of said meter electronics having a signal conditioner and a host system coupled to a flowmeter assembly;

operating said signal conditioner within an intrinsically safe threshold;

operating said host system remotely from said signal conditioner and within an intrinsically safe threshold;

receiving signals from said flowmeter assembly at said signal conditioner; and

processing said signals.

Preferably said step of operating said signal conditioner comprises the steps of:

generating a drive signal; and

applying said drive signal to a driver coupled to said flowmeter assembly.

Preferably said step of operating said signal conditioner comprises receiving signals from at least one sensor coupled to said flowmeter assembly.

Preferably said step of operating said signal conditioner comprises receiving power from said host system.

Preferably said step of operating said signal conditioner comprises providing signals to said host system.

Preferably said method further comprising the step of preventing power in excess of said intrinsically safe threshold during operation of said signal conditioner or during a short condition.

Preferably said step of preventing comprises providing protection circuitry of said signal conditioner.

Preferably said step of operating said host system comprises supplying power to said signal conditioner.

Preferably said step of operating said host system comprises receiving signals from said signal conditioner.

Preferably said method further comprising the step of preventing power in excess of said intrinsically safe threshold during operation of said host system or during a short condition.

Preferably said step of preventing comprises providing protection circuitry of said host system.

Brief Description of the Drawings

The above and other advantages of this inventions are set forth in the Detailed Description and the following drawings:

FIG. 1 illustrating a Coriolis flowmeter assembly and associated meter electronics in accordance with this invention;

FIG. 2 illustrating a block diagram of the meter electronics in accordance with this invention; and

FIG. 3 illustrating further details of the meter electronics of a preferred embodiment in accordance with this invention.

Detailed Description

Preferred embodiments of the present invention are described more fully hereinafter with reference to the accompanying drawings where like numbers refer to like elements throughout.

Figure 1 shows an exemplary Coriolis flowmeter 5 comprising a Coriolis flowmeter assembly 10 and meter electronics 20. Meter electronics 20 is connected to flowmeter assembly 10 via path 100 to provide for example, but not limited to, density, mass flow rate, volume flow rate and totalized mass flow information over path 26. A Coriolis flowmeter structure is described. The present invention could be practiced in conjunction with any apparatus having a vibrating conduit to measure properties of material flowing through the conduit. A second example of such an apparatus is a vibrating tube densitometer which does not have the additional measurement capability provided by a Coriolis mass flowmeters.

Meter assembly 10 includes a pair of flanges 101 and 101', manifold 102 and conduits 103A and 103B. Connected to conduits 103A and 103B are driver 104, pick-off sensors 105 and 105', and temperature sensor 107. Brace bars 106 and 106' serve to define the axis W and W' about which each conduit oscillates.

When Coriolis flowmeter 5 is inserted into a pipeline system (not shown) which carries the process material that is being measured, material enters flowmeter assembly 10 through flange 101, passes through manifold 102 where the material is directed to enter conduits 103A and 103B, flows through conduits 103A and 103B and back into manifold 102 from where it exits meter assembly 10 through flange 101'.

Conduits 103A and 103B are selected and appropriately mounted to the manifold 102 so as to have substantially the same mass distribution, moments of inertia and elastic modules about bending axes W-W and W'-W', respectively. The conduits 103A-103B extend outwardly from the manifold in an essentially parallel fashion.

Conduits 103A-103B are driven by driver 104 in phase opposition about their respective bending axes W and W' and at what is termed the first out of phase bending mode of the flowmeter. Driver 104 may comprise any one of many well known arrangements, such as a magnet mounted to conduit 103A and an opposing coil mounted to conduit 103B and through which an alternating current is passed for vibrating both conduits. A suitable drive signal is applied by meter electronics 20 to driver 104 via path 110.

Pick-off sensors 105 and 105' are affixed to at least one of conduits 103A and 103B on opposing ends of the conduits to measure oscillation of the conduits. As the conduits 103A-103B vibrate, pick-off sensors 105-105' generate a first pick-off signal and a second pick-off signal. The first and second pick-off signals are applied to paths 111 and 111'. The driver velocity signal is applied to path 110.

Temperature sensor 107 is affixed to at least one conduit 103A and/or 103B. Temperature sensor 107 measures the temperature of the conduit in order

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to modify equations for the temperature of the system. Path 112 carries temperature signals from temperature sensor 107 to meter electronics 20.

Meter electronics 20 receives the first and second pick-off signals appearing on paths 111' and 111", respectively. Meter electronics 20 processes these first and second signals to compute the mass flow rate, the density, or other property of the material passing through flowmeter assembly 10. This computed information is applied by meter electronics 20 over path 26 to a utilization means (not shown).

Coriolis flowmeter 5 is similar in structure to a vibrating tube densitometer. Vibrating tube densitometers also utilize a vibrating tube through which fluid flows or, in the case of a sample-type densitometer, within which fluid is held. Vibrating tube densitometers also employ a drive system for exciting the conduit to vibrate. Vibrating tube densitometers typically utilize only single feedback signal since a density measurement requires only the measurement of frequency and a phase measurement is not necessary. The description of the present invention applies equally to vibrating tube densitometers.

Description of FIG. 2

FIG. 2 illustrates a preferred embodiment of meter electronics 20 of the present invention in block diagram form. In this embodiment, the meter electronics 20 are physically divided into a remote host system 200 and a signal conditioner 201 proximate flowmeter assembly 10. In conventional meter electronics, these components are housed in one unit and are usually proximate flowmeter assembly 10. This makes it necessary, in such conventional systems, to run a 9-wire cable from the meter electronics 20 to the flow meter assembly 10. However, the separation of components of meter electronics 20 in accordance with the present invention into a remote host system 200 and a signal conditioner 201 eliminates the need for 9-wire cable to apply signals from meter electronics 20 to wires connected to driver 104, to pick-off sensors 105-105', and to temperature sensor 107. (All shown in FIG. 1). Instead, signal conditioner 201 may be connected directly to 9 wires in paths 110,111-111', and 112 by juxtapositioning signal conditioner 201 to flowmeter assembly 10.

Signal conditioner 201 includes drive circuitry 210 and pick-off conditioning circuitry 220. Signal conditioner 201 is capable of being intrinsically safe. As such, all circuitry in signal conditioner 201 performs at a power level that is below an intrinsically safe threshold. For purposes of this discussion, power means energy/and or power. The intrinsically safe threshold is the maximum power at which a device may operate in order to assure that a spark, excessive energy, or excessive heat from the circuit will not ignite volatile material in an environment. Drive circuitry 210 and pick-off conditioning circuitry 220 may be separate analog circuits or may be separate functions provided by a digital signal processor or other digital components.

Drive circuitry 210 generates a drive signal that is applied to driver 104 via path 110 of path 100 (See FIG. 1). Path 110 has a first and a second wire. Drive circuitry 210 is connected to pick-off signal conditioning circuitry via path 215. Path 215 allows drive circuitry 210 to monitor the incoming pick-off signals to adjust the drive signal. Power to operate drive circuitry 210 and pick-off signal conditioning circuitry 220 is supplied from remote host system 200 via a first wire 211 and a second wire 212. First wire 211 and second wire 212 may be a part of a conventional 2-wire or 4-wire cable.

Pick-off signal conditioning circuitry 220 receives input signals from first pick-off 105, second pick-off 105', and temperature sensor 107 via paths 111, 111' and 112 (See FIG. 1). Pick-off signal conditioning circuitry 220 determines the frequency of the pick-off signals and may also determine properties of a material flowing through conduits 103A-103B (See FIG. 1) . After the frequency of the input signals from pick-off sensors 105-105' and properties of the material are determined, output signals carrying this information are generated and transmitted to a secondary processing unit 250 in remote host system 200 via path 221. In a preferred embodiment, path 221 includes 2 wires 321 and 322 (See FIG. 3).

Remote host system 200 includes a power supply 230 and secondary processing unit 250. Power supply 230 receives electricity from a source and converts the received electricity to the proper power needed by the system. Secondary processing system 250 receives the output signals from pick-off signal conditioning circuitry 220 and perform processes needed to provide properties of the material flowing through conduits 103A-103B needed by a user. Such properties may include but are not limited to density, mass flow rate, and volumetric flow rate.

Description of FIG. 3

FIG. 3 illustrates a block diagram of an embodiment in accordance with the present invention that is intrinsically safe. This embodiment allows signal conditioner 201 to be intrinsically safe. Therefore, signal conditioner 201 does not have to be housed in an explosion proof housing. Instead, only the components of host system 200 have to be housed in explosion proof housing in an explosive environment.

In order for the signal conditioner 201 to be intrinsically safe, drive circuitry 210 and pick-off signal conditioning circuitry 220 must operate at a power below an intrinsically safe threshold which is the maximum power that the various agencies allow devices to operate to ensure that a spark or heat from the circuitry does not ignite volatile material in the environment. In this embodiment, drive control circuitry 210 receives power from power supply 230 via paths 211 and 212 and applies the drive signal to driver 104 via leads 341-342 of path 110 in path 100 (Also See FIG. 1).

Pick-off signal conditioning circuitry 220 receives signals from the pick-off sensors 105-105' (Shown in FIG. 1), and temperature sensor 107 via leads 343-347 that extend through the flowmeter assembly barrier circuitry 330 as described below. The output signals are then applied to leads 321-322 of path 221. Leads 321 and 322 are needed to support the conventional 4-20 ma or RS405 protocol. However, those skilled in the are will recognize that it is possible to apply the output signals to leads 211-212 over which power is received from host system 200.

Signal conditioner 201 also includes host -side protection circuitry 320 which prevents power in excess of an intrinsically safe threshold from being applied by signal conditioner 201 to leads connecting signal conditioner 201 to remote host system 200. Flowmeter assembly protection circuitry 330 that prevents power in excess of the intrinsically safe threshold from being applied by signal conditioner 201 to wires 341-349 connecting signal conditioner 201 flowmeter assembly 10. The intrinsically safe threshold is the maximum amount of power that the various agencies permit a device to operate and to be rated as intrinsically safe. The power can be measured either by the amount of current or voltage across the leads.

The host-side protection circuitry 320 includes power protection circuitry 322 and signaling protection circuitry 324. Power protection circuitry 322 receives power via first wire 211 and second wire 212 and ensures that power is not applied by signal conditioner 201 over wires 211-212 during operation or when a short occurs. Signaling protection circuitry 324 ensures that power in excess of the intrinsically safe threshold is not applied by the signal conditioner 201 to wires 321-322.

Flowmeter assembly protection circuitry 330 includes drive protection circuitry 331 and sensor protection circuitry 332. Drive protection circuitry 331 prevents power in excess of the intrinsically threshold from being applied by drive circuitry 210 to wires 341 and 342 connected to driver 104 (Shown in FIG. 1). Sensor protection circuitry 332 prevents power in excess of the intrinsically safe threshold from being applied by pick-off signal conditioning circuitry 220 to wires 343-347 during operation or when a short occurs.

In order to make the system intrinsically safe, remote host system 200 cannot apply power over the intrinsically safe threshold to wires connected to signal conditioner 201. Barrier 310 in host system 200 prevents power in excess of an intrinsically safe threshold from being applied to wires 211-212 and 321-322 connecting host system 200 to signal conditioner 201. Barrier 310 includes power supply protection circuitry 311 and secondary processing protection circuitry 312.

Power supply protection circuitry 311 receives power from power supply 230 via paths 313-314 and includes circuitry that prevents power being applied to wires 211-212 from passing an intrinsically safe threshold either during normal operation or when a short occurs. The amount of power may be measured in the amount of current or the amount of voltage over the wires 211-212.

Secondary processing protection circuitry 312 receives signals from signal conditioning circuitry 220 via wires 321-322 in path 221 and transmits the output signals to secondary processing unit 250 via wires 315-316. Secondary processing barrier circuitry 312 prevents power in excess of the intrinsically safe threshold from being applied to wires 321-322 of path 221 during normal operation or when a short occurs.

This above describes meter electronics for a Coriolis flowmeter having a signal conditioner that is capable of being intrinsically safe and eliminates the need for conventional of 9-wire cable.

CLAIMS:

1. Meter electronics for a Coriolis flowmeter assembly capable of being intrinsically safe, said meter electronics comprising:

drive circuitry;

a signal conditioner within which said drive circuitry is configured;

a power supply capable of providing power to said meter electronics and said signal conditioner;

a host system remote from said signal conditioner within which said power supply is configured;

wherein said signal conditioner receives power from said power supply of said remote host system via a first wire and a second wire;

wherein said drive circuitry within said signal conditioner generates a drive signal in response to said power received from said power supply and applies said drive signal to a driver affixed to at least one conduit of said Coriolis flowmeter assembly;

pick-off signal conditioning circuitry within said signal conditioner that receives input signals from a first pick-off sensor and from a second pick-off sensor affixed to said at least one conduit and in response thereto, generates information indicating properties of a material flowing through said at least one conduit, said signal conditioner transmits output signals containing said material information to said remote host system;

host-side protection circuitry in said signal conditioner that prevents power in excess of an intrinsically safe threshold from being applied by circuitry in said signal conditioner to said first and second wires connecting said signal conditioner to said remote host system; and

flowmeter assembly protection circuitry in said signal conditioner that prevents power in excess of said intrinsically safe threshold from being applied by circuitry in said signal conditioner to wires connecting said signal conditioner to said driver and to said first pick-off sensor and to said second pick-off sensor.

2. The meter electronics of claim 1 wherein said host-side protection circuitry comprises:

power supply protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied to said first wire and said second wire by said circuitry in said signal conditioner.

3. The meter electronics of claim 1 further comprising wires connecting said pick-off signal conditioning circuitry to said remote host system, wherein said host-side protection circuitry comprises:

signaling protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied to the wires connecting said pick-off signal conditioning circuitry to said remote host system.

4. The meter electronics of claim 1 further comprising wires connecting said drive circuitry to said driver, wherein said flowmeter assembly protection circuitry further comprises:

drive protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied by said drive circuitry to the wires connecting said drive circuitry to said driver.

5. The meter electronics of claim 1 wherein said flowmeter assembly protection circuitry further comprises:

sensor protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied by said pick-off signal conditioning circuitry to wires connecting said first pick-off sensor and said second pick-off sensor to said pick-off signal conditioning circuitry.

6. The meter electronics of claim 1 wherein said remote host system includes said power supply and a secondary signal processing system, said meter electronics further comprising:

a barrier in said remote host system that prevents power in excess of said intrinsically safe threshold from being applied by said host system to said first and second wires between said signal conditioner and said remote host system.

7. The meter electronics of claim 6 wherein said barrier comprises:

power protection circuitry that prevents power in excess of said intrinsically safe threshold from being applied to the first and second wires by said power supply.

8. The meter electronics of claim 7 further comprising:

wires connecting said pick-off signal conditioning circuitry to said secondary processing system; and

a secondary processing protection circuitry in said remote host system that prevents power in excess of said intrinsically safe threshold from being applied by said secondary signal processing system to the wires connecting said pick-off signal conditioning circuitry to said secondary processing system.

9. The meter electronics of claim 1 wherein said output signals are applied to a first pair of wires extending to said remote host system by said pick-off signal conditioning circuitry.

10. The meter electronics of claim 9 where said output signals are applied to a second pair of wires connected to said remote host system.

11. The meter electronics of claim 1 wherein said drive circuitry controls the amount of current of said drive signal that is applied to said driver.

12. The meter electronics of claim 1 wherein said drive circuitry controls the amount of voltage of said drive signal that is applied to said driver.

13. A method capable of being intrinsically safe for processing signals for a Coriolis flowmeter assembly comprising the steps of:

generating information indicating properties of a material flowing through said Coriolis flowmeter from input signals;

receiving power in a signal conditioner from a power supply in a remote host system remote from said signal conditioner via a first wire and a second wire;

preventing power in excess of an intrinsically safe threshold from being applied to said first wire and said second wire by circuitry of said signal conditioner;

generating a drive signal from said received power using drive circuitry in said signal conditioner;

applying said drive signal to a driver affixed to at least one conduit of said Coriolis flowmeter assembly;

preventing power in excess of said intrinsically safe threshold from being applied by said drive circuitry to wires connecting said drive circuitry to said driver;

receiving input signals by pick-off signal conditioning circuitry from a first pick-off sensor and a second pick-off sensor affixed to at least one conduit of said Coriolis flowmeter assembly;

preventing power in excess of said intrinsically safe threshold from being applied by said pick-off signal conditioning circuitry to wires connecting said first pick-off sensor and said second pick-off sensor to said pick-off signal conditioning circuitry;

transmitting output signals containing said information to said remote host system; and

preventing power in excess of said intrinsically safe threshold from being applied to wires connecting said pick-off signal conditioning circuitry to said remote host system.

14. The method of claim 13 wherein said remote host system includes said power supply and a secondary signal processing system, said method further comprising the step of:

preventing power in excess of said intrinsically safe threshold from being applied by said remote host system to wires connecting said signal conditioner and said secondary signal processing system.

15. The method of claim 14 wherein said step of preventing power in excess of said intrinsically safe threshold from being applied by said remote host system comprises the step of:

preventing power in excess of said intrinsically safe threshold from being applied to said first wire and said second wire by said power supply.

16. The method of claim 14 wherein said step of preventing power in excess of said intrinsically safe threshold from being applied by said host system comprises the step of:

preventing power in excess of said intrinsically safe threshold from being applied by said secondary signal processing system to leads connecting said pick-off signal conditioning circuitry to said secondary processing system.

17. The method of claim 13 wherein said step of transmitting said output signals comprises the step of:

applying said output signal to said first wire and to said second wire by said pick-off signal conditioning circuitry.

18. The method of claim 17 wherein said step of transmitting said output signals further comprises the step of:

applying said output signals to a third wire and a fourth wire that are connected to said host system.

19. The method of claim 13 further comprising the step of:

controlling the amount of current of said drive signal that is applied to said driver.

20. The method of claim 13 further comprising the step of:

controlling the amount of voltage of said drive signal that is applied to said driver.

21. A flowmeter signal processing system, comprising:

a signal conditioner;

a host system remotely coupled to said signal conditioner;

wherein said signal conditioner and said host system operate within an intrinsically safe threshold, and wherein said signal conditioner comprises flowmeter assembly protection circuitry coupled to a flowmeter assembly and host-side protection circuitry coupled to said host system.

22. The flowmeter signal processing system of claim 21, wherein said signal conditioner comprises flowmeter assembly protection circuitry coupled to a flowmeter assembly and host-side protection circuitry coupled to said host system.

23. The flowmeter signal processing system of claim 22 wherein said flowmeter assembly protection circuitry comprises drive protection circuitry.

24. The flowmeter signal processing system of claim 22 or 23 wherein said flowmeter assembly protection circuitry comprises sensor protection circuitry.

25. The flowmeter signal processing system of claim 21 wherein said host system comprises a barrier.

26. The flowmeter signal processing system of claim 25, wherein said barrier comprises power supply protection circuitry coupled to said signal conditioner.

27. The flowmeter signal processing system of claim 25 or 26 wherein said barrier comprises processing protection circuitry coupled to said signal conditioner.

28. A method of processing flowmeter signals, comprising the step of:
providing meter electronics;
characterized in that said method further comprises the steps of:
providing a signal processing system of said meter electronics having a signal conditioner and a host system coupled to a flowmeter assembly;
operating said signal conditioner within an intrinsically safe threshold;

operating said host system remotely from said signal conditioner and within an intrinsically safe threshold;

receiving signals from said flowmeter assembly at said signal conditioner; and

processing said signals.

29. The method of claim 28, wherein said step of operating said signal conditioner comprises the steps of:

generating a drive signal; and

applying said drive signal to a driver coupled to said flowmeter assembly.

30. The method of claim 28, wherein said step of operating said signal conditioner comprises receiving signals from at least one sensor coupled to said flowmeter assembly.

31. The method of claim 28, wherein said step of operating said signal conditioner comprises receiving power from said host system.

32. The method of claim 28, wherein said step of operating said signal conditioner comprises providing signals to said host system.

33. The method of claims 29, 30, 31, or 32, further comprising the step of preventing power in excess of said intrinsically safe threshold during operation of said signal conditioner or during a short condition.

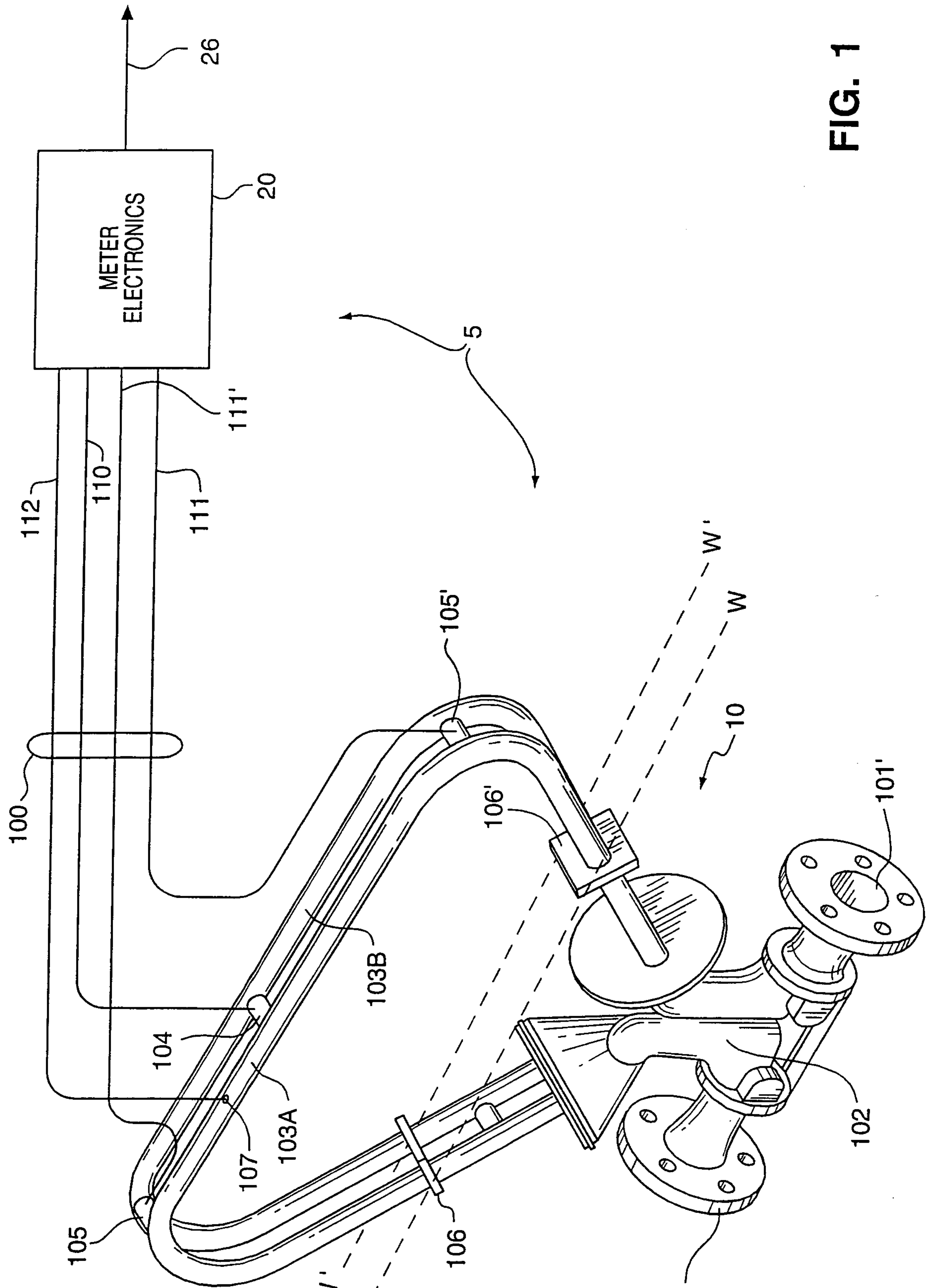
34. The method of claim 33, wherein said step of preventing comprises providing protection circuitry of said signal conditioner.

35. The method of claim 28, wherein said step of operating said host system comprises supplying power to said signal conditioner.

36. The method of claim 28, wherein said step of operating said host system comprises receiving signals from said signal conditioner.

37. The method of claims 35 or 36, further comprising the step of preventing power in excess of said intrinsically safe threshold during operation of said host system or during a short condition.

38. The method of claim 37, wherein said step of preventing comprises providing protection circuitry of said host system.


METER ELECTRONICS
26
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112
111
100
105'
W'
W
10
106'
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103B
104
103A
107
102
105
106
101

FIG. 1

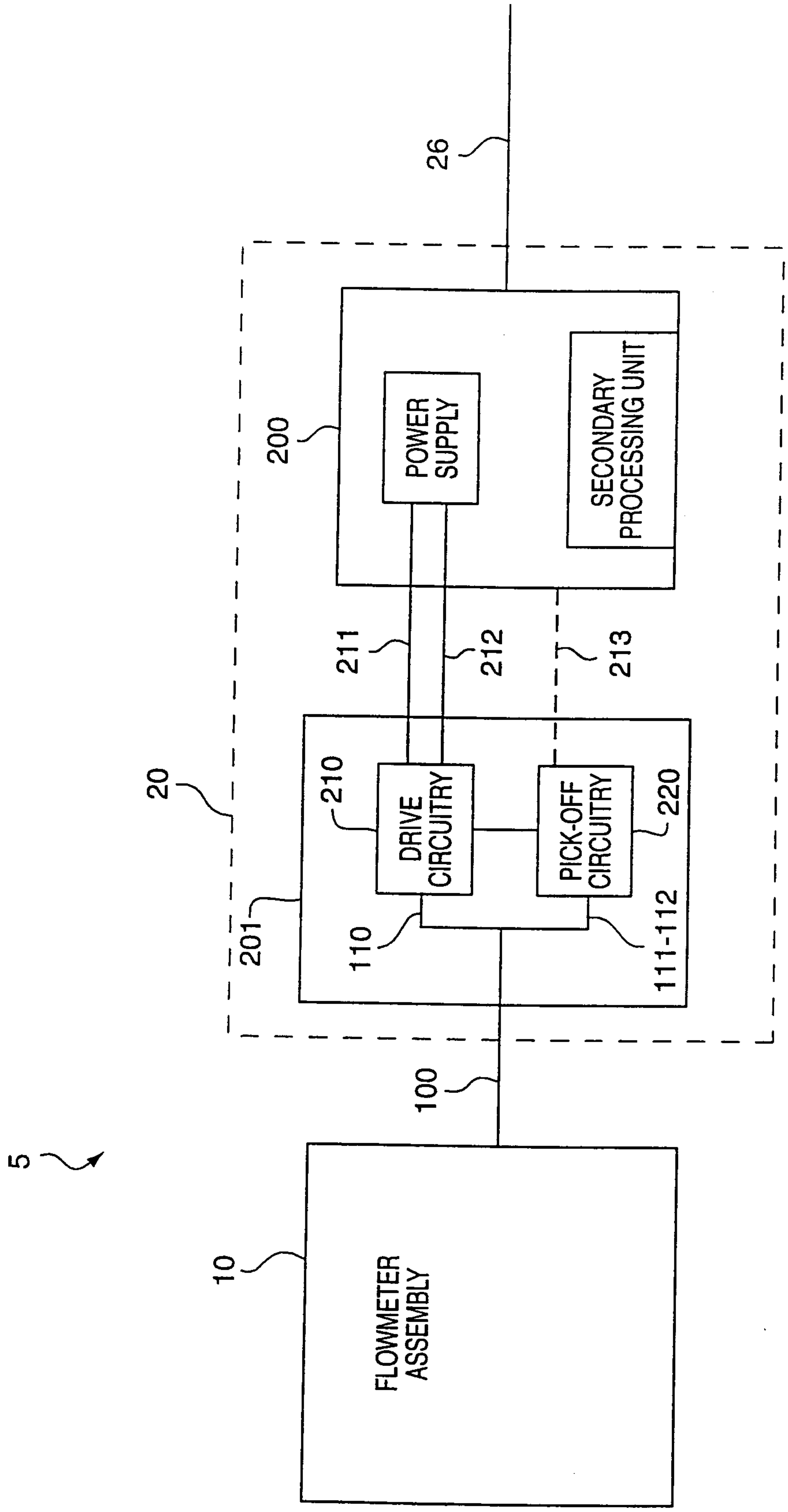
26
200
POWER SUPPLY
SECONDARY PROCESSING UNIT
211
212
213
20
210
DRIVE CIRCUITRY
PICK-OFF CIRCUITRY
220
201
110
111-112
100
5
10
FLOWMETER ASSEMBLY

FIG. 2

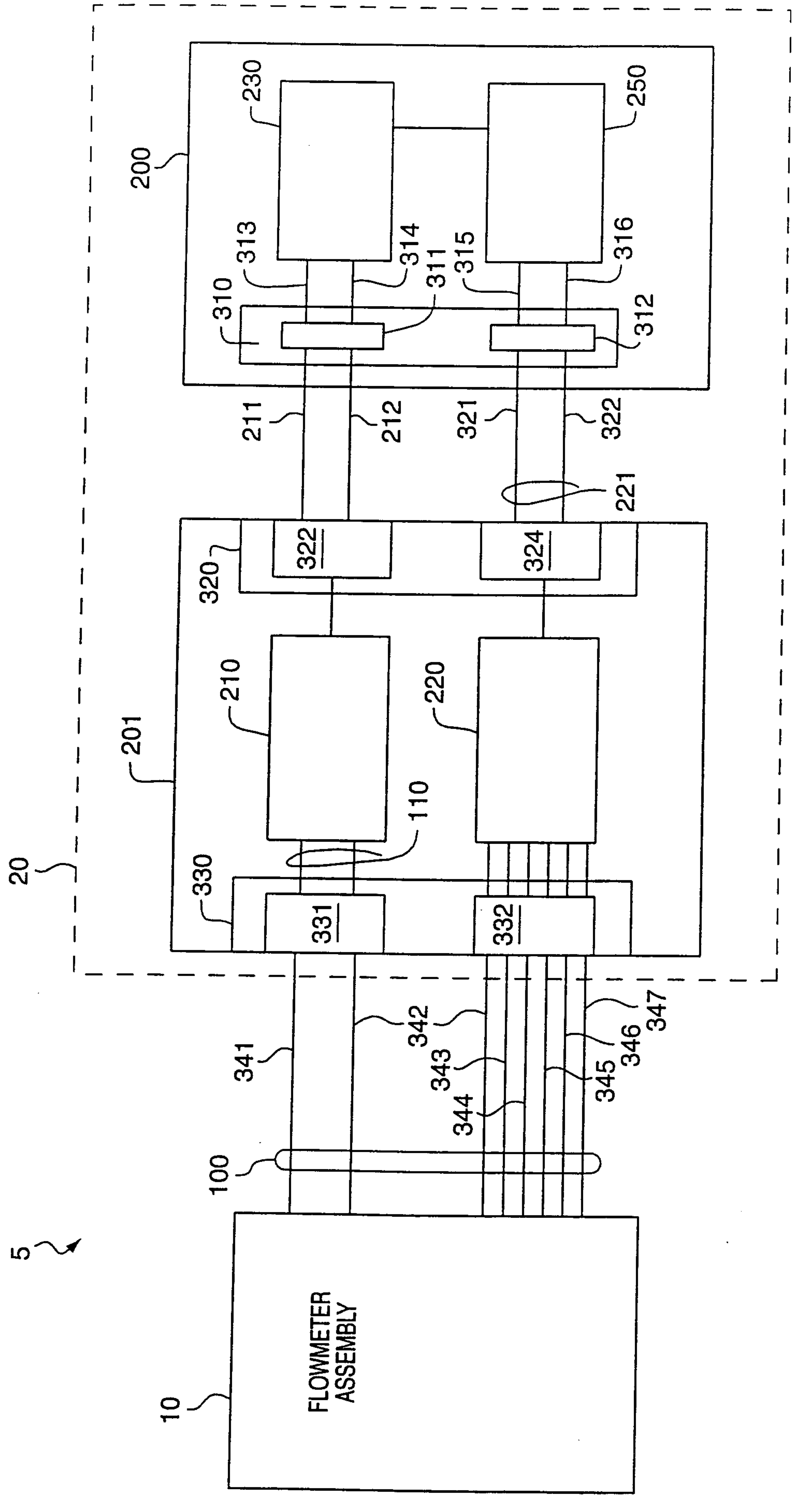
FLOWMETER ASSEMBLY
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FIG. 3


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FLOWMETER
ASSEMBLY
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