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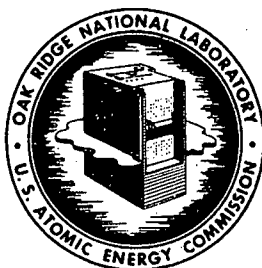
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SURVEY OF PRESSURE AND DIFFERENTIAL PRESSURE INSTRUMENT
TYPES FOR POSSIBLE APPLICATION TO HRE-3 SLURRY SYSTEM

This survey is confined to the sensing devices in subject instruments as distinguished from transmitted or output signals.

The objective of this survey is to define the types of instruments which are acceptable for the HRE-3 slurry system in order to intelligently plan an instrument development program. A development program is needed because commercially available instruments require connecting pipes which are subject to slurry plugging, or incorporate fluid fills not compatible with the reactor fluids or construction materials, or lack a secondary seal behind thin members.

The desired characteristics of these pressure and differential pressure instruments are defined as follows:

- A. Require no piping which will be subject to slurry plugging.
- B. Require a minimum of auxiliary appurtenances such as purge systems or freeze plugs.
- C. Be expected to demonstrate maximum reliability.

The following sensing mechanisms are considered in this survey:

- 1. Purged pipe connections
- 2. Vapor space connections
- 3. Mechanically coupled flush diaphragm instruments
- 4. Sealed fluid coupled flush diaphragm instruments
- 5. Unsealed fluid coupled flush diaphragm instruments

1. Purged Pipe Connections - See Fig. 1

These could be used with modified commercially available instruments of low displacement volumes but would not satisfy condition B. This would require the least instrument development effort but would require a purge system. This type of installation has been used satisfactory in test loops with intermittent purge sometimes sufficing. Slurry traps which are occasionally drained or flushed have also been satisfactory in test loops but would considerably complicate a reactor system.

2. Vapor Space Connections -

These are applicable only where a vapor space exists and where this vapor space can be maintained at all times. (See Fig. 2) The most obvious example of this is a system pressure instrument connected to the top of the pressurizer. It is foreseeable that slurry could reach such an instrument connection upon violent boiling in the bottom of this vessel, due to a rapid pressure decrease. The possibility exists that such action could plug the instrument connection. Therefore, this method does not fully satisfy condition A. This method would require little instrument development except as related to 3 below.

3. Mechanically Coupled Flush Diaphragm Instruments -

These are instruments in which the transmitting mechanism is in close proximity and mechanically connected to a low displacement diaphragm which is essentially flush with the inside surface of the vessel. Pressure instruments of this type would satisfy all the above listed desired characteristics. This method is applicable to differential pressure instruments only where the reference side of the diaphragm can be handled by 1 or 2 above. (See Fig. 3 and Fig. 6) A considerable instrument development effort would be required to develop reactor grade instruments of this type.

4. Sealed Fluid Coupled Flush Diaphragm Instruments -

These differ from the mechanically coupled in that the instrument itself can be located remote from the vessel, and that both sides of the instrument diaphragm can be fluid coupled to the vessel. (See Fig. 4) The diaphragm or diaphragms in contact with the process are flush with the inside of the vessel. A pressure transmitting fluid is sealed in a cavity on the outer side of the process diaphragm and transmits system pressure via a capillary tube to a cavity on one side of the instrument diaphragm. This fluid must exhibit a nearly constant volume characteristic over long periods of radiation and during temperature and pressure variations. Possibly mercury, cesium, gallium or rubidium could be used as this fluid. This type of instrument would satisfy all the above listed characteristics dependent upon a successful development program. Possible disadvantage of this system is that rupture of the diaphragm would release fluid coupling material into the reactor system. The effects of the release of foreign material into the reactor system would depend on the nuclear and chemical nature of the material used. Careful design of the instrument could minimize the amount of material released. Comments and suggestions on the feasibility of these fill fluids are solicited. Instruments of this type using silicone oil, mercury and NaK fills are commercially available.

5. Unsealed Fluid Coupled Flush Diaphragm Instruments -

These differ from the sealed variety in that water or D_2O could possibly be used as the fluid by employing a purge system to flush any vapor. However, a complicated control system would be required to control the fluid volume. Water would be pumped into the fluid cavity at the low point and bleed off at the high point and the rate of flow in and out be controlled by a Servo system to hold the diaphragm at a nearly constant position. (See Fig. 5) This type of instrument would not satisfy condition B above.

Conclusion:

Presently available instruments require purge systems and/or drainable slurry traps when applied to slurry systems. Such systems could become very complex in a reactor installation. Sealed flush diaphragm type instruments appear most desirable from the instrumentation viewpoint, but offer the possibility of contamination of the reactor system in the event of a diaphragm rupture. An unpurged system using conventional pressure elements with vapor space taps and mechanically coupled flush diaphragm differential pressure elements with vapor space reference could be developed if it can be assured that the vapor space taps will not be susceptible to slurry plugging as shown in Fig. 6.

It is recommended that slurry instrument development efforts proceed toward development of both sealed fluid coupled flush diaphragm systems and mechanically coupled flush diaphragm systems. Suggestions are solicited pertinent to this survey, and in particular, any limitations with regard to liquid metals for use as fluid coupling in sealed systems.

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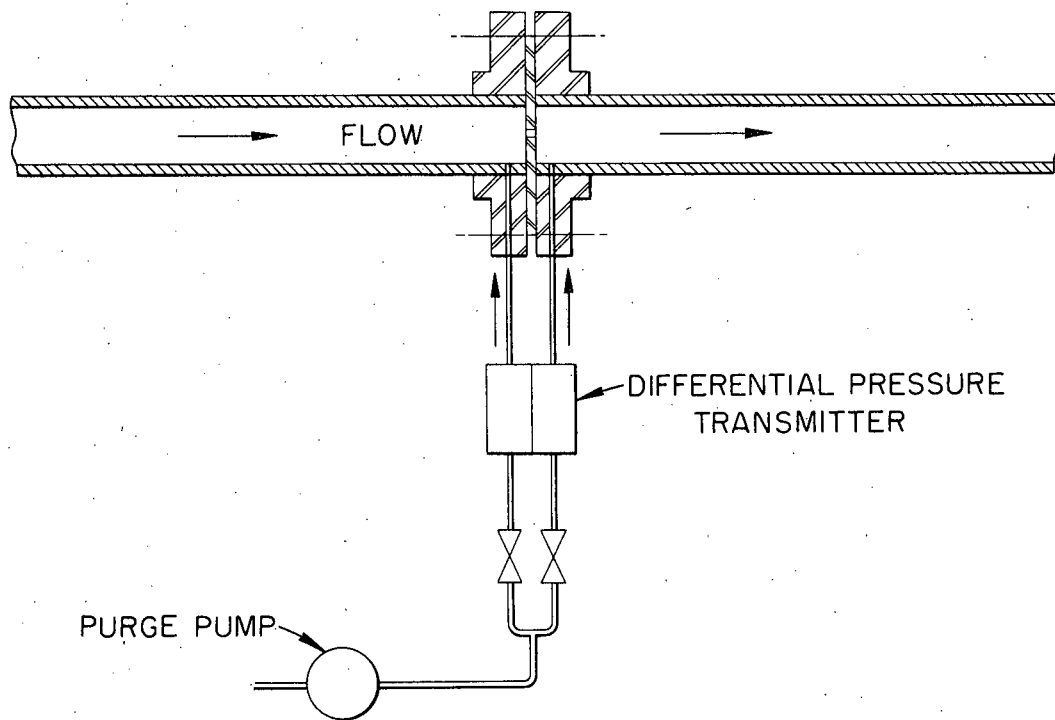


Fig. 1. Liquid Purged Differential Pressure Measurement.

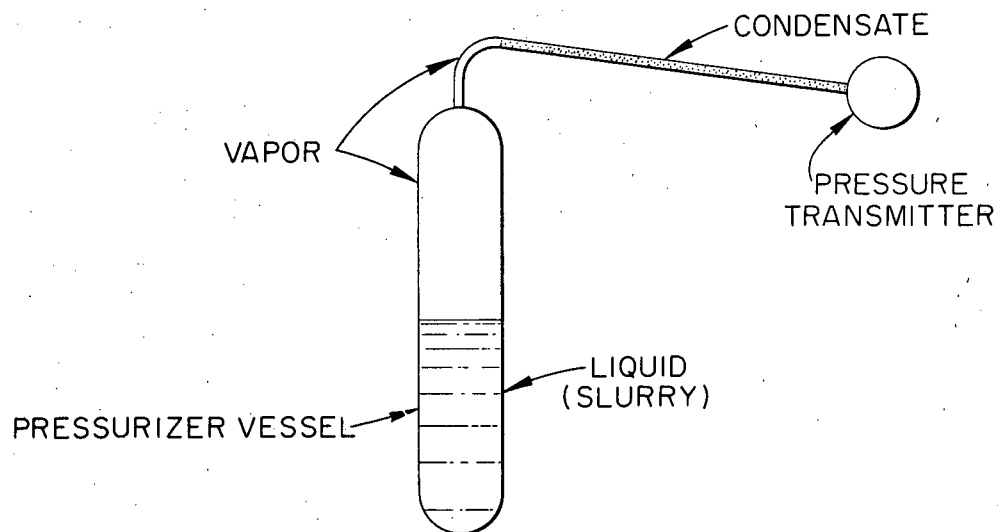
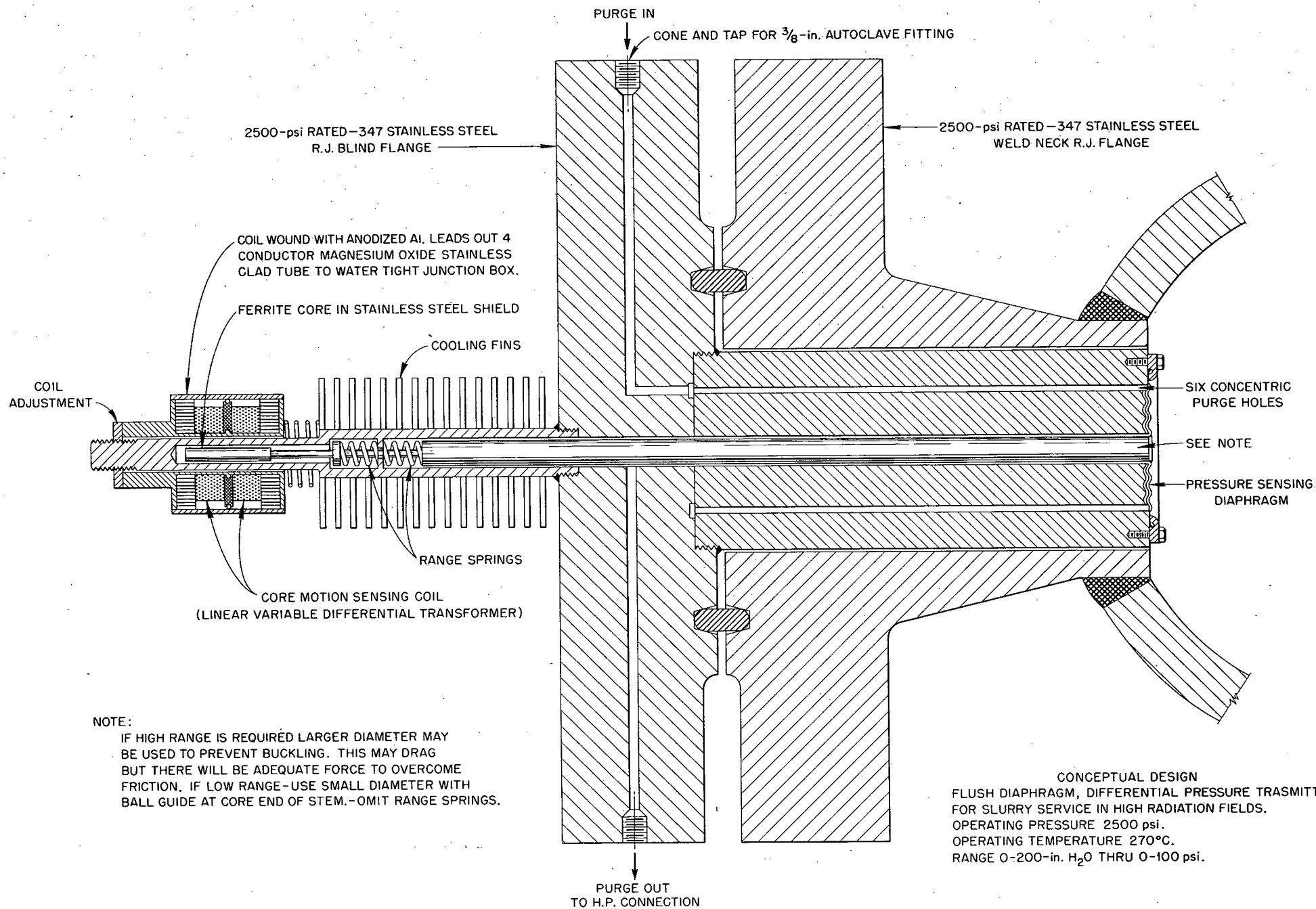


Fig. 2. Vapor Space Connection, Condensate Filled Line Pressure Measurement.



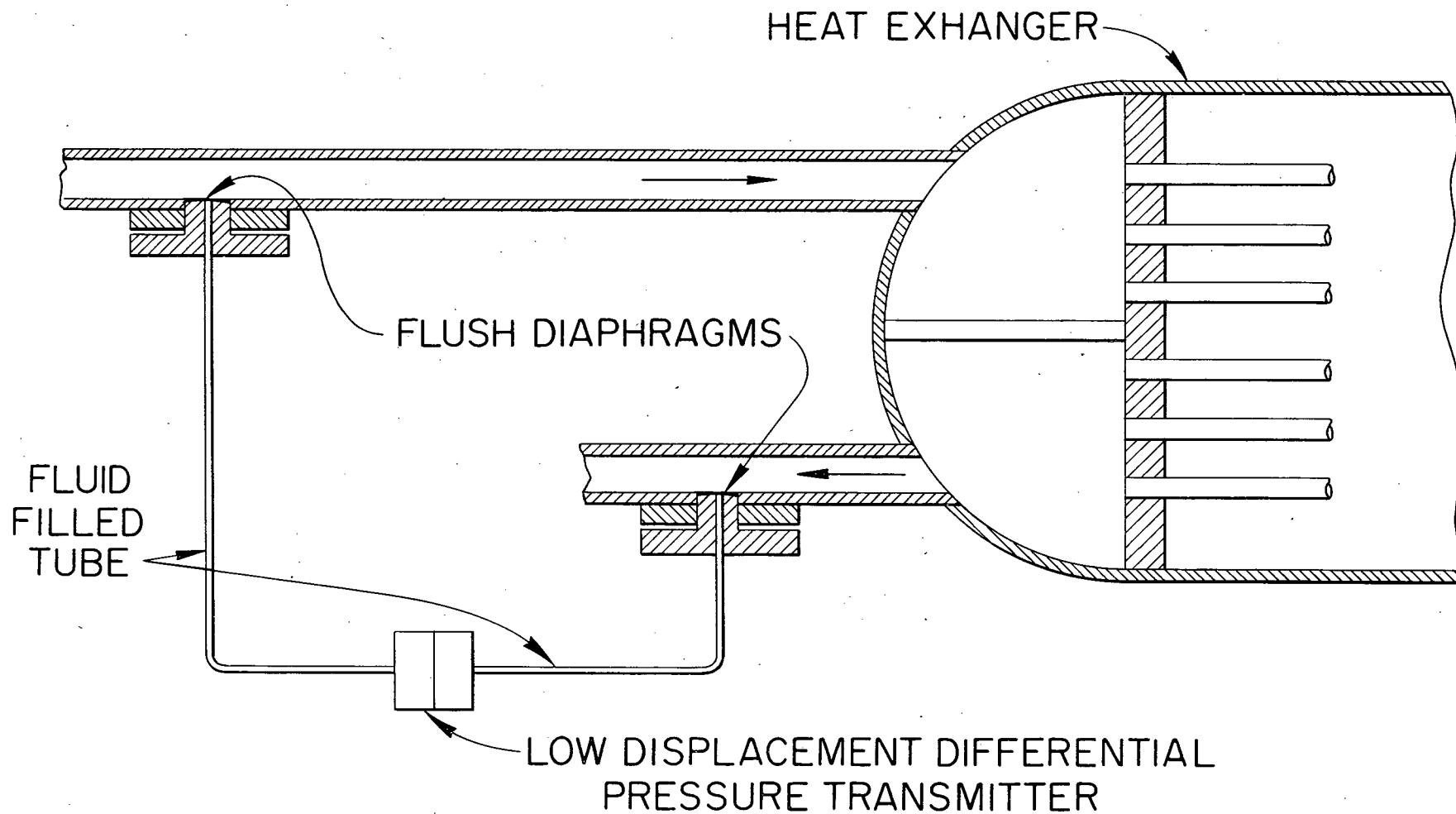


Fig. 4. Scaled Fluid Filled System, Differential Pressure Measurement.

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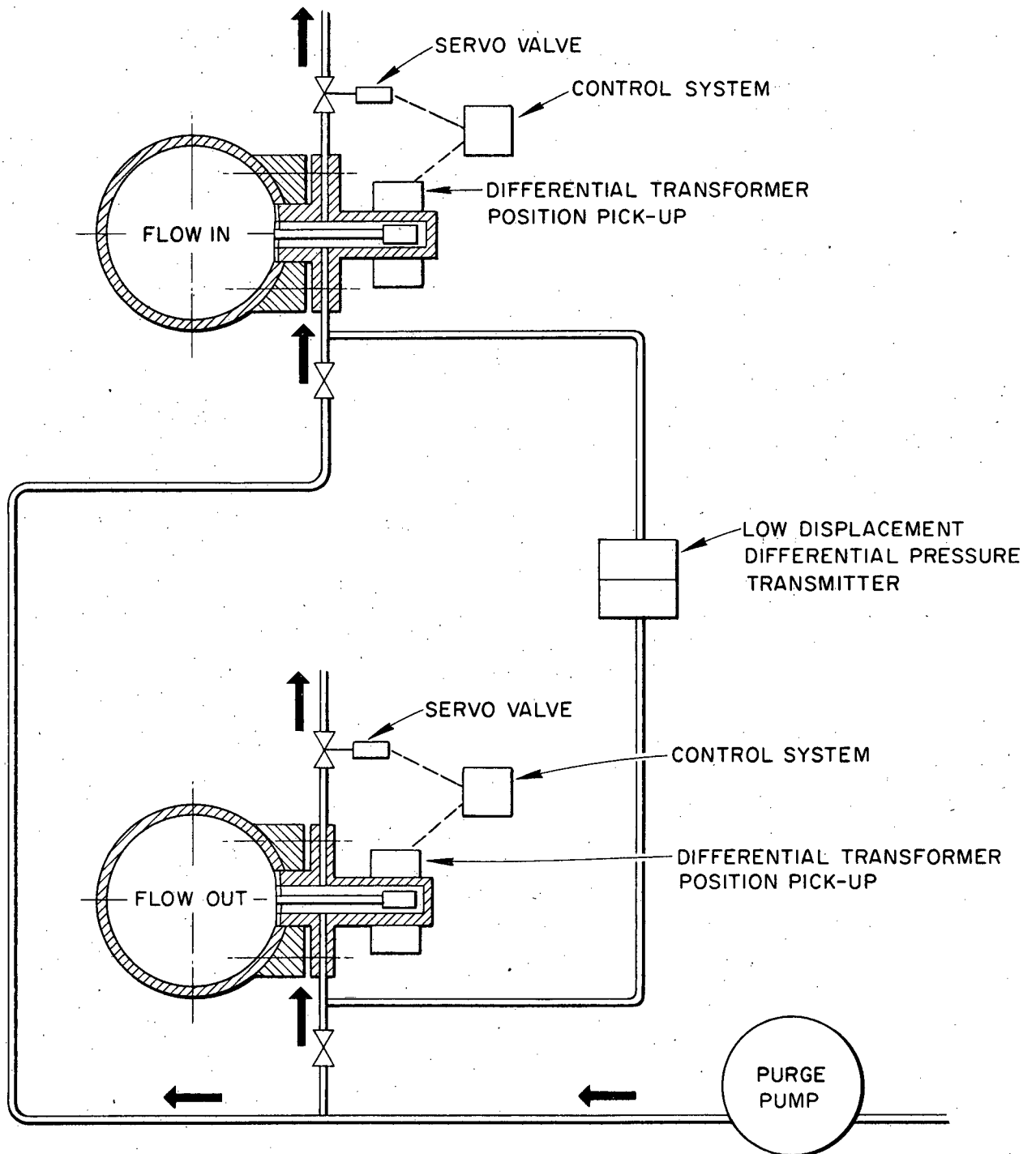


Fig. 5. Unscaled, Fluid Coupled Flush Diaphragm Differential Pressure Measurement

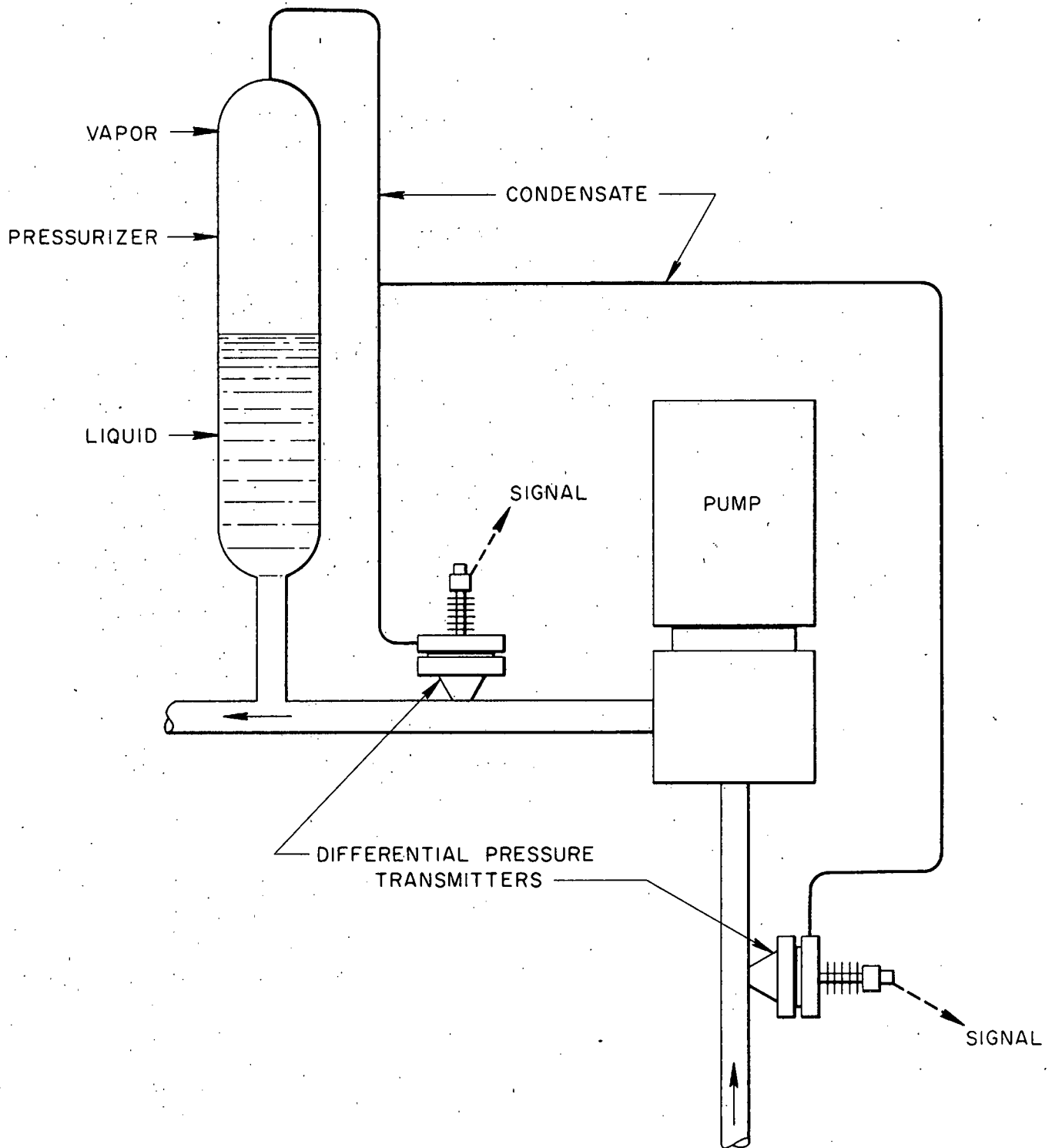


Fig. 6. Mechanically Coupled Flush Diaphragm with Vapor Space Reference Differential Pressure Measurement.