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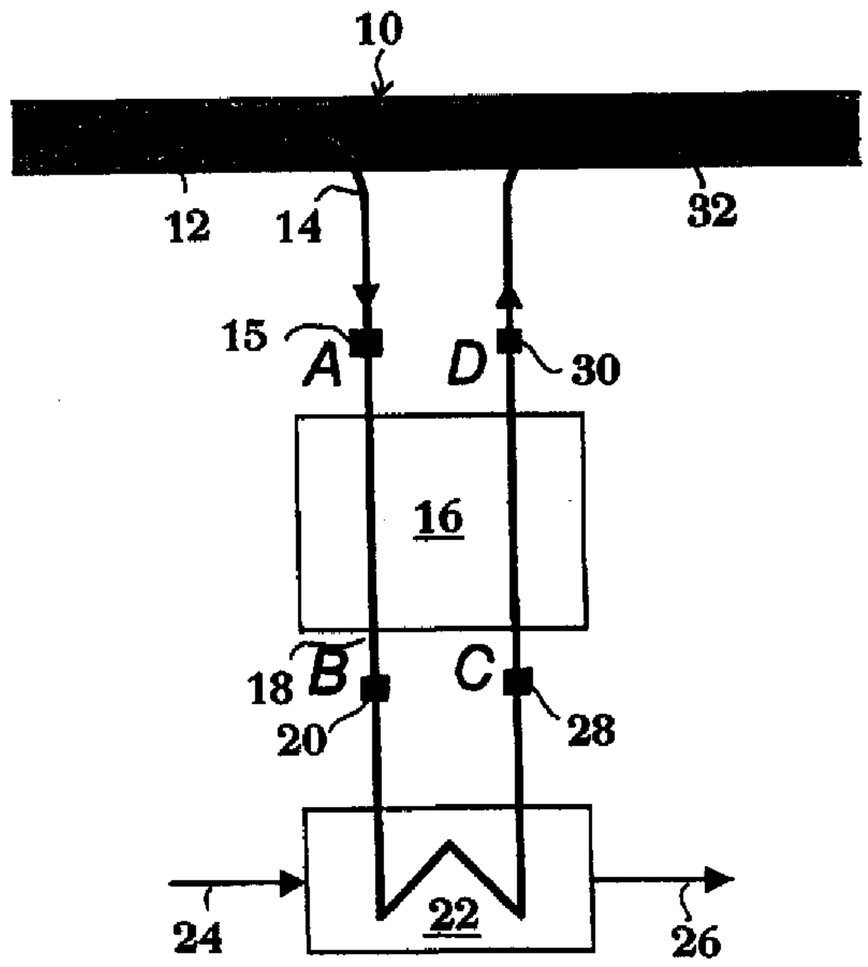
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(54) **PROCEDE ET DISPOSITIF DE MISE EN EVIDENCE D'UNE CONCENTRATION D'UN MELANGE DE GLACE FLUIDE**

(54) **METHOD AND DEVICE FOR DEMONSTRATING A CONCENTRATION OF A FLUID ICE MIXTURE**



(57) La présente invention concerne un procédé et un dispositif de mise en évidence d'une concentration d'un mélange de glace fluide (glace fluide binaire), comprenant les étapes suivantes: découplage d'un courant partiel du fluide, qui est ensuite introduit et réchauffé dans un échangeur de chaleur (16) jusqu'à fusion complète, avec mesure de la température d'admission (t_A) et de la température de sortie (t_B); poursuite du réchauffement du courant fluide par une source de chaleur extérieure et renvoi du courant partiel à travers l'échangeur de chaleur (16) avec, à nouveau, mesure de la température d'admission (t_C) et de la température de sortie (t_D); et calcul de la concentration de gaz selon l'équation $X_{glace} = (t_C - t_D - t_B + t_A) \times (cp_{fluide} / h_{glace})$, où cp_{fluide} est la capacité calorifique et h_{glace} est l'enthalpie de fusion de la glace binaire.

(57) The invention relates to a method and device for demonstrating a concentration of a fluid ice mixture (fluid binary ice), comprising the following steps: decoupling a partial current of the fluid, which is then fed into a heat exchanger (16) in which it is heated up to total fusion, while measuring the inlet temperature (t_A) and the outlet temperature (t_B); further heating the fluid current by an external source of heat and returning the partial current through the heat exchanger (16), while measuring again the inlet temperature (t_C) and the outlet temperature (t_D); and computing the gas concentration based on the equation $X_{ice} = (t_C - t_D - t_B + t_A) \times (cp_{fluid} / h_{ice})$, where cp_{fluid} is the heat capacity and h_{ice} is the fusion enthalpy of the binary ice.

ABSTRACT

Method for determining the ice concentration in a liquid ice mixture (binary ice fluid), with the steps:

- separating a partial flow of the fluid and introducing and heating the partial flow into a heat exchange (16) until complete melting takes place, accompanied by the measurement of the inlet temperature t_A and outlet temperature t_B,
- further heating of the fluid flow by an external heat source and return of the partial flow through the heat exchanger (16), accompanied by the measurement of the inlet temperature t_C and outlet temperature t_0 of the return partial flow and
- calculating the ice concentration according to the equation

$X_{ice} = (t_C - t_0 - t_B + t_A) \cdot (cp_{fluid}/h_{ice})$, in which
cp_{fluid} is the specific heat capacity of the binary ice fluid and
h_{ice} is the enthalpy of fusion of the binary ice.

METHOD AND APPARATUS FOR DETERMINING THE CONCENTRATION OF A LIQUID ICE MIXTURE

The invention relates to a method and an apparatus for determining the concentration of a liquid ice mixture.

Liquid ice mixtures comprise suspensions or mixtures of ice crystals or ice fragments in liquid (hereinafter called "binary ice fluid"). Such two-phase fluids are used for cold transport, storage and use. With respect to such fluids it is important to precisely know the ice concentration in order to maintain and/or determine all the process parameters in installations where such liquid ice mixtures are used. It is difficult to precisely determine the ice concentration in a binary ice fluid. The determination of the ice concentration by measuring the electrical conductivity, as known from DE 43 25 793 C2, is not very accurate and cannot be used for any random liquid. Viscosity measurements are difficult to perform even when possible. The pressure drop over a fixed distance is also not a suitable signal, because the viscosity of the liquid is based on the temperature, quantity and quality of additives.

The reason for the use of a binary ice fluid is the latent energy (enthalpy of fusion) of the ice contained in the fluid. This makes it possible to reduce pipeline cross-sections, reduce pumping energy and reduce the size of energy storage devices and heat exchanger surfaces.

The latent energy of binary ice cannot be determined with temperature sensors, because the temperature of the binary ice in the melting range does not or only just changes. Thus, another way for determining the ice concentration is required.

Normally the ice concentration of binary ice is determined by the "calorimetric" method. A volume of binary ice is weighed and its temperature determined. A second volume of sufficiently warm fluid (e.g. water) is weighed and its temperature determined. The two volumes are then mixed and it is then possible by means of the mixture temperature to back-calculate the ice concentration, provided that the mixture no longer contains ice.

However, this method is discontinuous, time-consuming and is only suitable

for manual utilization on a laboratory scale.

It is known from DE 43 25 794 C1 to determine the ice concentration in a fluid mixture by measuring the pressure exerted by it.

The problem of the invention is to provide a method and an apparatus for determining the concentration of a liquid mixture, which is applied to a pipeline and which can determine the concentration at least in short intervals.

According to the invention this problem is solved by a method having the features of claims 1 or 2 and by an apparatus with the features of claim 3.

The proposed method and the appropriate apparatus for the same make it possible to determine the ice concentration automatically, as well as continuously or discontinuously. It is possible to determine the ice concentration of binary ice in storage devices and pipelines.

Use is made of a method for determining the ice concentration in a binary ice fluid, in which initially part of the flow or storage volume to be measured is removed and introduced into a heat exchanger, accompanied by the simultaneous measurement of the inlet and outlet temperatures and in which by heating the fluid flow and a further return to the heat exchanger, accompanied by a further measurement of the inlet and outlet temperatures of the return flow, the ice concentration is mathematically determined.

Further features and advantages of the invention can be gathered from the following description of a preferred embodiment relative to the attached drawings, wherein show:

Fig. 1 The diagrammatic construction of an apparatus for ice concentration determination at a pipeline.

Fig. 2 The arrangement of the apparatus of fig. 1 at a storage container.

The pipeline 10 shown in fig. 1 is provided with a device 12 for removing a

partial flow feeding the same into a pipeline 14. A temperature sensor 15 at the pipeline 14 measures the binary ice temperature. The binary ice is then melted in a heat exchanger 16, where the heat transferred must be sufficient in order to completely melt the ice. At the outflow line 18 ice-free fluid is present, whose temperature is equal to or higher than the temperature at entry into the heat exchanger 16.

A further temperature sensor 20 is provided on the pipeline on leaving the heat exchanger.

The fluid then enters a second heat exchanger 22, in which it is further heated by an external heat source. As is e.g. shown in fig. 1, said heat source can be a further water circulation, in which water enters in heated form (reference numeral 24) and leaves again in cooled form (reference numeral 26).

The separated partial flow is then heated from the temperature measured by the temperature sensor 20 to a higher temperature, which is measured by a further temperature sensor 28 prior to reentering the heat exchanger 16. In the heat exchanger the fluid once again loses heat and passes out at a location 30 at a lower temperature. The separated partial flow can now be returned via a device 32 to the main flow and mix with the binary ice.

In the heat exchanger 16 the heated binary ice fluid is cooled and melts or heats the binary ice fluid flowing in the opposite direction, i.e. the enthalpy difference of the binary ice fluid flows between points A and B and C and D are the same, although of different sign.

As the binary ice mass flow in the measuring apparatus remains the same, it is possible to determine the ice concentrations of the binary ice with the aid of four measured temperatures. A volume or mass flow measurement is unnecessary.

The ice concentration is calculated according to the following equation:

$$X_{ice} = (t_C - t_D - t_B + t_A) \cdot (cp_{fluid}/h_{ice}),$$ in which

X_{ice} Ice concentration

t_C Temperature at point C

t_D Temperature at point D

t_B Temperature at point B

t_A Temperature at point A

cp_{fluid} Specific heat capacity of the binary ice fluid

h_{ice} Enthalpy of fusion of the binary ice.

In the case of large pipelines or ice storage devices it is possible to continuously remove a small binary ice mass flow for ice concentration determination, provided that the energy supply resulting from the measurement is relatively small and the energy balance is not permanently disturbed.

With small pipelines or storage devices 34 a discontinuous measurement can be used, if a continuous measurement would excessively disturb the energy balance.

The heat exchanger 22 can be heated both by heated fluid (e.g. water, optionally the cooling water of the refrigerating machine condenser) or also electrically.

CLAIMS

1. Method for determining the ice concentration in a liquid ice mixture (binary ice fluid), characterized by

- separating a partial flow of the fluid and introducing and heating the partial flow into a heat exchanger (16) until complete melting takes place, accompanied by the measurement of the inlet temperature t_A and outlet temperature t_B,
- further heating of the fluid flow by an external heat source and return of the partial flow through the heat exchanger (16), accompanied by the measurement of the inlet temperature t_C and outlet temperature t_0 of the return partial flow and
- calculating the ice concentration according to the equation
  $X_{ice} = (t_C - t_0 - t_B + t_A) \cdot (cp_{fluid}/h_{ice})$, in which
  cp_{fluid} is the specific heat capacity of the binary ice fluid and
  h_{ice} is the enthalpy of fusion of the binary ice.

2. Method according to claim 1, characterized in that the ice is melted in a second heat exchanger (22).

3. Apparatus for determining the ice concentration in a liquid ice mixture (binary ice fluid), characterized by

- a device (12) for separating a partial flow of the binary ice fluid,
- a first heat exchanger (16) through which the partial flow is passed,
- a second heat exchanger (22), in which the partial flow passed through the first heat exchanger (16) is further heated accompanied by complete melting and is then returned through the first heat exchanger (16) and
- temperature sensors (15, 20, 28, 30) located at the four inlet and outlet points of the first heat exchanger (16).

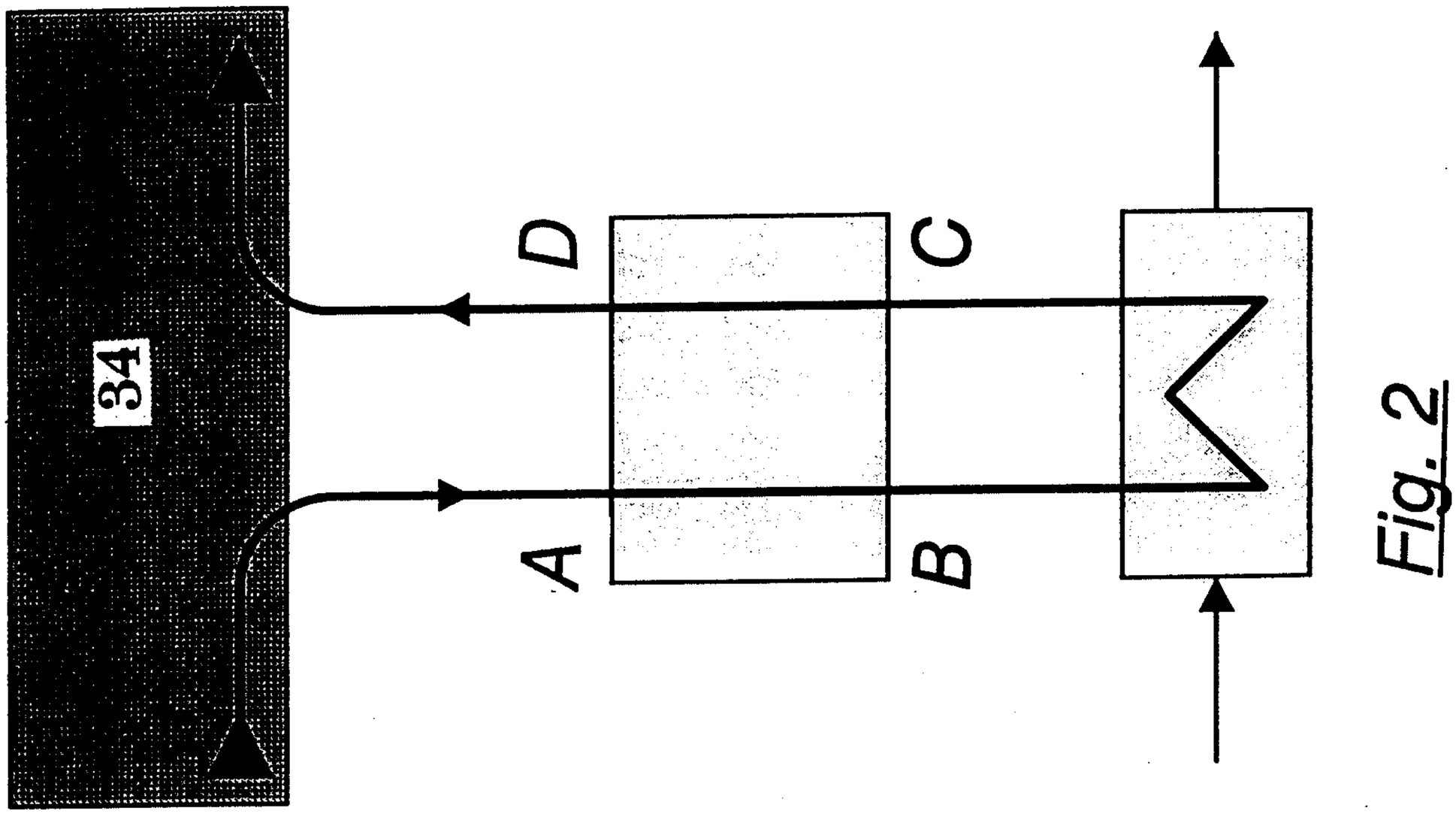


Fig. 2

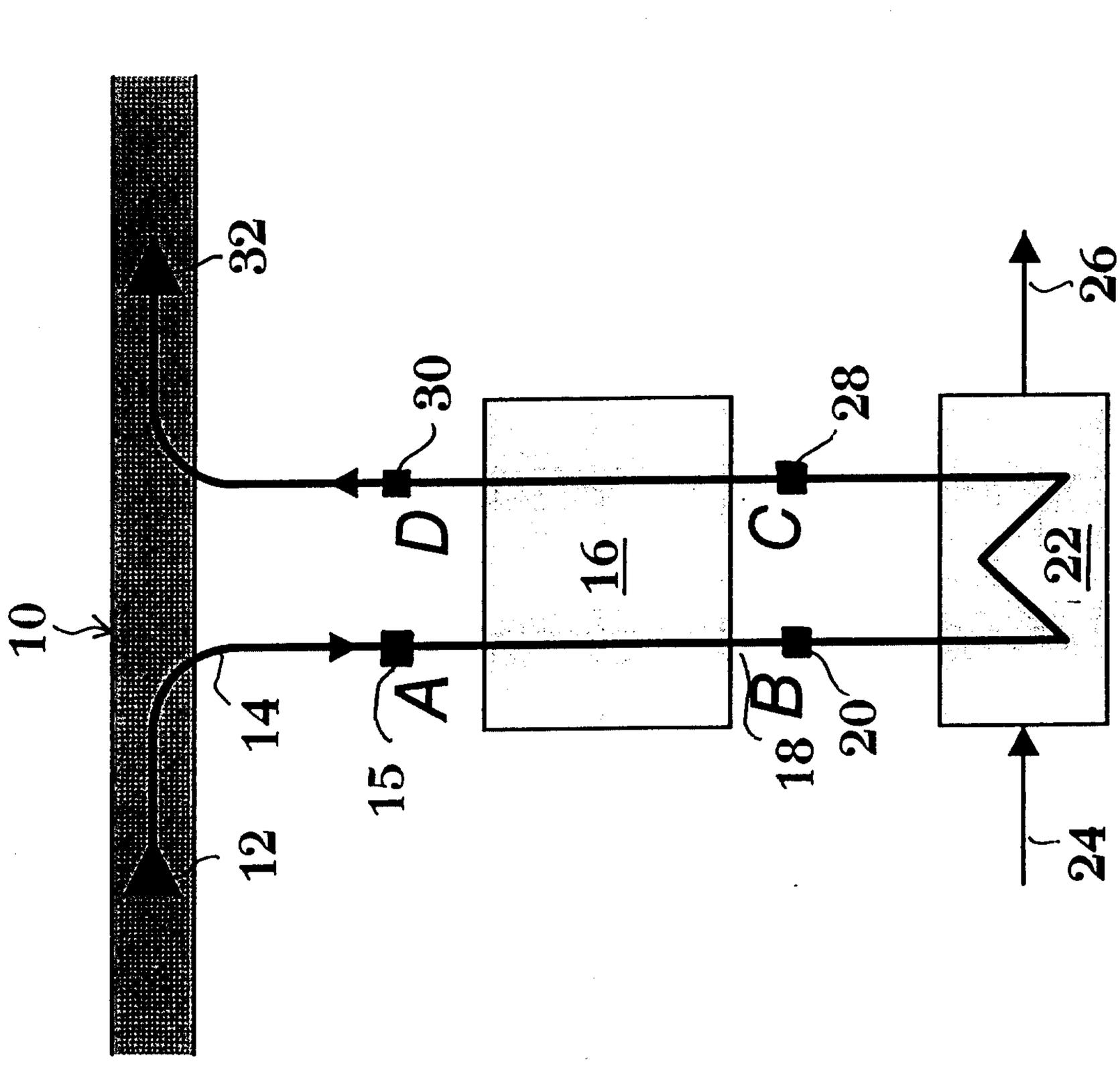


Fig. 1