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(54) Title: PROCESS AND APPARATUS FOR MIXING GASES

(57) Abstract: When mixing two gases of different temperature and/or composition in a converter for producing SO_3 from an SO_2-containing gas, a first gas flow is introduced into a mixing chamber from below, whereas a second gas flow is countercurrently introduced into the mixing chamber from above. The gas mixture obtained in the mixing chamber is discharged from the mixing chamber via an upwardly directed connecting tube and supplied to a heat exchanger integrated in the converter.

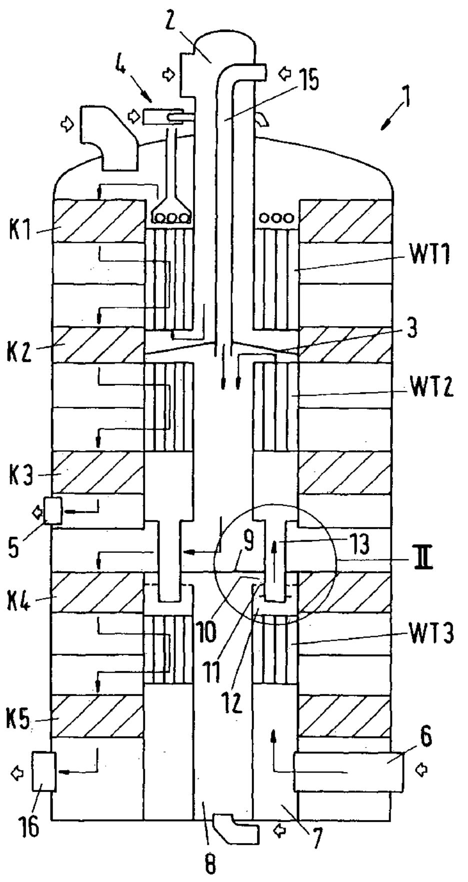

Fig.1

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Process and Apparatus for Mixing Gases

The present invention relates to a process for mixing two gases of different temperature and/or composition in a converter for producing SO_3 from an SO_2-containing gas, and to an apparatus for performing this process.

The present invention is concerned with the production of sulfuric acid. Conventionally, sulfuric acid mostly is produced by the so-called double absorption process, which is described in Ullmann's Encyclopedia of Industrial Chemistry, 5th edition, Vol. A25, pp. 635 to 700. First of all, a starting gas containing sulfur dioxide is at least partly reacted with oxygen in a plurality of successive contact stages of a converter corresponding to the formula

$$SO_2 + 1/2\ O_2 \rightarrow SO_3 + 98\ KJ$$

to obtain sulfur trioxide. The produced gas containing sulfur trioxide then is supplied to an absorber and converted there to sulfuric acid. The oxidation of the sulfur dioxide to sulfur trioxide is effected in the presence of a catalyst, which usually contains vanadium pentoxide as active component and has a working range of about 380 to 640°C. While at temperatures above 640°C an irreversible damage of the catalyst occurs, the same is inactive at temperatures below 380°C. As the process is strongly exothermal, the gas inlet temperature into the contact stage must be about 400°C. At a distinctly lower inlet temperature, the reaction is not initiated, whereas at a much higher inlet temperature the temperature rises so much during the process that the catalyst is damaged. It is, however, possible to also use other catalysts which allow a higher working temperature, as is known e.g. from EP 1 047 497 B1 or DE 100 23 178 A1. To obtain a high yield, the reaction is performed in several stages, between which the process gas each is cooled by means of integrated heat exchangers, in order to achieve a suitable gas inlet temperature for the next contact stage. Usually, such converter includes four to five contact stages, and in the above-mentioned double absorption process the process gas having passed through a number of, e.g. three, contact stages is supplied to an intermediate absorption tower, in which the SO_3 is converted to sulfuric acid, oleum or liquid SO_3, and the SO_3 concentration in the process gas thereby is decreased again. Upon heating to the required process temperature, the process gas then is supplied to the next contact stages of the converter and thereafter to the final absorption.

The process gas supplied to the converter suffers from frequent fluctuations of the quantity and SO_2 concentration. While in conventional converters the SO_2 concentration usually is restricted to about 12 vol-% due to the high temperatures achieved in the first step of catalysis, the process described in DE 102 49 782 A1 provides for using higher SO_2 concentrations by recirculating SO_3-containing gas. This recirculation limits the reaction in the first contact stage and as a result the heat generated there.

Due to the fluctuations of the inlet gas, it is required to control the temperature at the inlet of the contact mass. This is effected by supplying cold SO_2-containing gas via a bypass conduit. In the above-mentioned recirculation of SO_3-containing gas, the mixing ratio must also be adjusted. Therefore, gases of different temperature and/or composition must be mixed in the converter at different points. Even with gases of the same composition, the temperature difference leads to different viscosities, which render mixing difficult. For the efficiency of the process it is, however, required to achieve a homogeneous gas mixture. If no sufficient homogeneity of the gas is achieved at the inlet of the contact mass, there are zones in which there is no conversion of SO_2 to SO_3 when passing through the contact stage, so that the efficiency of the converter is impaired. In zones with too high SO_2 content, overheating possibly can lead to a damage of the catalyst. It was found that mixing gases of different temperature in the pipe conduits of sulfuric acid plants is no fast, spontaneous process. Due to the different viscosities, the gases flow parallel to each other without mixing (so-called streaming).

For the solution of this problem, it is state of the art to provide local pressure losses, which lead to turbulences with a high degree of fluidization. However, this solution is not sufficient in many cases, as the entire pressure loss achievable or allowed in the system is limited or must be limited for reasons of plant technology.

Therefore, it is the object of the invention to increase the homogeneity of the mixture of two gases of different temperature and/or composition in a converter and reduce or prevent what is called streaming.

This object substantially is solved by means of the invention in that a first gas flow is introduced into a mixing chamber in a first direction, in particular from below, that a second gas flow is countercurrently introduced into the mixing chamber in a direction opposite to the first direction, in particular from above, and that the gas mixture obtained in the mixing chamber is discharged from the mixing chamber via a connecting tube extending in the first direction, in particular directed from the bottom to the top, and supplied to a heat exchanger integrated in the converter. By countercurrently guiding the two gas flows one on top of the other, turbulences are generated, which ensure a thorough mixing of the two gas flows.

In accordance with a preferred aspect of the invention, the second gas flow is introduced into the converter from below through a central supply conduit and then deflected radially to the outside by substantially 180°, so that it flows downwards into the mixing chamber surrounding the supply conduit.

In accordance with a development of the invention, the second gas flow here enters the mixing chamber through a hole arrangement, so that it is divided and enters the mixing chamber as a multitude of small gas flows. Mixing with the first gas flow coming from below thereby is promoted.

In adaptation to the usual design of converters for producing sulfur trioxide, the first gas is an SO_2- and SO_3-containing process gas in accordance with the invention, which for instance is recirculated from the intermediate absorption, and the second gas is either an SO_2-containing gas of another, e. g. lower temperature or an SO_3-containing gas having another, e. g. a higher, concentration of SO_3 or has differences in both to the first gas. The second SO_2-containing gas can also contain SO_3, e. g. 1 to 10 vol-% SO_3, but preferably contains less than 1 % SO_3. The SO_3-containing gas normally contains a certain amount of SO_2, too.

In accordance with the invention, the second gas flow is smaller than the first gas flow and amounts to 20 to 70%, preferably ≥ 50% of the first gas flow.

An inventive apparatus for mixing two gases in a converter for producing SO_3 from an SO_2-containing gas, which can be used in particular for performing the process described above, includes a mixing chamber, to which a first gas flow is supplied in a first direction, in particular from below, a supply conduit for a second gas flow, wherein the mixing chamber is provided in the form of a ring around the supply conduit and is connected with the supply conduit, and a connecting tube, which extends from the mixing chamber in the first direction, in particular to the top, and connects the mixing chamber with the integrated heat exchanger.

In accordance with a preferred aspect of the invention, the connecting tube protrudes into the mixing chamber as an immersion tube. Therefore, the second gas flow must first traverse the mixing chamber by overcoming the resistance of the first (main) gas flow, before it is discharged from the mixing chamber via the connecting tube. The homogeneous mixing of the two gas flows thereby is promoted.

In accordance with a particularly preferred development of the invention, a prechamber is provided above the mixing chamber, into which opens the supply conduit for the second gas flow and which is separated from the mixing chamber by a permeable dividing device, e. g. a perforated plate. By means of a perforated plate, the second gas flow is divided into a multitude of smaller gas flows, which promotes thorough mixing with the first gas flow. In accordance with the invention, the connecting pipe extending from the mixing chamber in the first direction, in particular to the top, extends through the perforated plate and the prechamber. Here, the term perforated plate should not necessarily be understood to be a plate with openings, but can rather be a variety of arrangements, e.g. welded grids, riveted strips of metal or other materials placed one on top of the other. The openings can be round, angular or be present as slots or in different shapes. The openings likewise can have different sizes and shapes, e.g. in dependence on the distance of the opening from the immersion tube. Furthermore, it is possible that further gas conducting means or structures are present on the so-called perforated plate, e.g. sheets, welding seams.

In a further embodiment of the invention the gas flow in the mixing chamber can be guided e. g. by guiding plates or by the gas inlet of the permeable dividing device, so that e. g. a stream like a swirl in the mixing chamber results or the stream has different directions inside the mixing chamber.

In another further embodiment of the inventive idea the permeable dividing device and/or the supply conduits for the first gas can be controlled in the cross sectional area to maintain a uniform mixing if the volume flow of the gases are changed.

For generating additional turbulences in the mixing chamber, a ring disk is provided on the outside of the connecting tube. It thereby is prevented that the part of the second gas flow flowing along the connecting tube is directly diverted at the end of the immersion tube and is discharged via the connecting tube without mixing. This part of the first gas flow impinges on the ring disk, so that additional turbulences are generated and thorough mixing with the first gas flow is ensured. The ring disk is not necessarily like an annulus around the connecting tube. It is possible, that this ring disk has an irregular boundary e. g. a saw tooth or sinusoidal. This ring disk also can have some further guiding plates or the like to create e. g. a curled stream in the mixing chamber or different flow directions.

To achieve a uniform transfer from the ring-shaped mixing chamber into the integrated heat exchanger likewise provided in the form of a ring above the mixing chamber, a plurality of connecting tubes preferably uniformly distributed around the periphery of the mixing chamber are provided in accordance with the invention, through which the gas mixture is discharged.

Developments, advantages and possible applications of the invention can also be taken from the following description of embodiments and from the drawing. All features described and/or illustrated per se or in any combination form the subject-matter of the invention, independent of their inclusion in the claims or their back-reference.

In the drawing:

Fig. 1 schematically shows a sectional representation of a converter for producing SO_3 from an SO_2-containing gas with an apparatus for mixing gases in accordance with the present invention, and

Fig. 2 shows an enlarged section in accordance with detail II of Fig. 1 with the apparatus for mixing gases, in which the gas flows are illustrated.

The converter 1 for converting SO_2 to SO_3 as shown in Fig. 1 includes a total of five contact stages K1 to K5, in which a catalyst, in particular a catalyst containing vanadium pentoxide, is provided for converting SO_2 to SO_3.

Via a central supply conduit 2, SO_2-containing gas is introduced into the converter 1 from above and deflected by 180° via a deflector plate 3, so that it traverses an integrated heat exchanger WT1 arranged in the form of a ring around the central supply conduit 2 from the bottom to the top. Above the heat exchanger WT1, a gas can be supplied via a supply means 4 not described here in detail, in order to adjust the temperature and/or composition of the gas mixture supplied to the first contact stage K1. The process gas then passes through the contact stages K1 to K3, and after the conact stages K1 and K2 it is cooled by means of the integrated heat exchangers WT1 and WT2 to an inlet temperature of about 400°C suitable for the inlet region of each succeeding contact K2 and K3, respectively, and then is supplied to a non-illustrated heat recovery means and intermediate absorption via the outlet 5.

The present invention is directed to the mixing of gases in the lower part of the converter 1 with the contact stages 4 and 5, so that the upper part of the converter 1 need not be described here in greater detail. The process parameters in the contact stages K1 to K3 and in the heat exchangers WT1 and WT2 correspond to those of usual sulfuric acid plants.

After the intermediate absorption not illustrated here, SO_2- and possibly SO_3-containing process gas with a temperature of e.g. 300 to 320°C is introduced into a ring duct 7 via an inlet 6 at the lower end of the converter 1 and traverses the integrated heat exchanger WT3 from the bottom to the top.

Via a central supply conduit 8, cooler SO_2-containing gas with a temperature of e.g. 100 to 200°C is fed into the converter from below and traverses the same from the bottom to the top, until the second gas is passed via a deflector plate 9 to the outside into a prechamber 10, which is provided in the form of a ring around the central supply conduit 8. At the bottom, the prechamber 10 is closed by a perforated plate 11, which includes a multitude of openings in the form of bores, slots or the like. The perforated plate 11 separates the prechamber 10 from a mixing chamber 12, which is provided above the integrated heat exchanger WT3 and surrounds the central supply conduit 8 in the form of a ring. The first gas supplied via the ring duct 7 enters the mixing chamber 12 from below, whereas the second gas supplied via the prechamber 10 enters from above. Thus, the two gas flows countercurrently impinge on each other, which leads to a thorough mixing.

A connecting tube 13 extending through the prechamber 10 and the perforated plate 11 opens into the mixing chamber 12 from above, which connecting tube constitutes an immersion tube and, for instance with a diameter of about 800 mm, distinctly protrudes into the mixing chamber 12 by 500 mm.

As can be taken from Fig. 2, a ring disk 14 is provided below the perforated plate 11 on the outside of the connecting tube 13. Therefore, the second gas entering the mixing chamber 12 through the perforated plate 11 impinges on the ring disk 14, so that additional turbulences are generated, which promote mixing with the first gas.

The second gas, whose volumetric flow rate is distinctly smaller than that of the first gas, for instance by 50%, first must traverse the mixing chamber 12, before it can be discharged to the top with the first gas flow via the connecting tube 13. In this way, a homogeneous incorporation of the second gas flow into the first gas flow is achieved.

Via the connecting tube 13, the gas mixture is discharged from the mixing chamber 12 to the top and passed through the integrated heat exchanger WT2, in which the gas mixture is heated up by heat exchange with the process gas leaving the second contact stage K2, so that it has a temperature suitable for entering the contact stage K4. Further SO_2-containing gas can be supplied through a central conduit 14 coming from above, in order to adjust the inlet temperature for the fourth contact stage K4. The gas then traverses the contact stage K4 and is again cooled in the integrated heat exchanger WT3 to a temperature of about 400°C suitable for entering the fifth contact stage K5, before it is supplied via the outlet 15 to a non-illustrated heat recovery system and to the final absorption.

In an alternative embodiment the gas streams are introduced in an inverted manner, i.e., the first gas flow is introduced from above while the second gas flow is introduced from below.

List of Reference Numerals:

1	converter
2	central supply conduit
3	deflector plate
4	supply means
5	outlet
6	inlet
7	ring duct
8	central supply conduit
9	deflector plate
10	prechamber
11	perforated plate
12	mixing chamber
13	connecting tube
14	ring disk
15	conduit
16	outlet
K1-K5	contact stages
WT1-WT3	integrated heat exchangers

Claims:

1. A process for mixing two gases of different temperature and/or composition in a converter for producing SO_3 from an SO_2-containing gas, wherein a first gas flow is introduced into a mixing chamber in a first direction, in particular from below, wherein a second gas flow is countercurrently introduced into the mixing chamber in a direction opposite to the first direction, in particular from above, and wherein the gas mixture obtained in the mixing chamber is discharged from the mixing chamber via a connecting tube extending in the first direction, in particular directed from the bottom to the top, and is supplied to a heat exchanger integrated in the converter.

2. The process according to claim 1, **characterized in** that the second gas flow is introduced into the converter from below through a central supply conduit and then is deflected radially to the outside by substantially 180°, so that it downwardly enters the mixing chamber surrounding the supply conduit.

3. The process according to claim 1, **characterized in** that the second gas flow enters the mixing chamber through a hole arrangement.

4. The process according to claim 1, **characterized in** that the first gas is an SO_2- and SO_3-containing process gas and that the second gas is either an SO_2-containing gas of another, e. g. lower temperature or an SO_3-containing gas having another, e. g. a higher concentration of SO_3 or has differences in both to the first gas..

5. The process according to any of the preceding claims, **characterized in** that the second gas flow is smaller than the first gas flow.

6. An apparatus for mixing two gases in a converter for producing SO_3 from an SO_2-containing gas, in particular for performing a process according to any of the preceding claims, comprising a mixing chamber (12) to which a first gas flow is supplied in a first direction, in particular from below, a supply conduit (8) for a second gas flow, wherein the mixing chamber (12) is provided in the form of a ring around the supply conduit (8) and is connected with the supply conduit (8), and a connecting tube (13), which extends from the mixing chamber (12) in the first direction, in particular from the bottom to the top, and connects the mixing chamber (12) with an integrated heat exchanger (WT2).

7. The apparatus according to claim 6, **characterized in** that the connecting tube (13) protrudes into the mixing chamber (12) as an immersion tube.

8. The apparatus according to claim 6 or 7, **characterized in** that before the mixing chamber (12) a prechamber (10) is provided, into which opens the supply conduit (8) for the second gas flow and which is separated from the mixing chamber (12) via a perforated plate (11).

9. The apparatus according to claim 8, **characterized in** that the connecting tube (13) extends through the perforated plate (11).

10. The apparatus according to claim 8, **characterized in** that the connecting tube (13) extends through the prechamber (10).

11. The apparatus according to any of claims 6 to 10, **characterized in** that on the outside of the connecting tube (13) a ring disk (14) is provided.

12. The apparatus according to any of claims 6 to 11, **characterized in** that a plurality of connecting tubes (13) are provided, which preferably are uniformly distributed around the periphery of the mixing chamber (12).

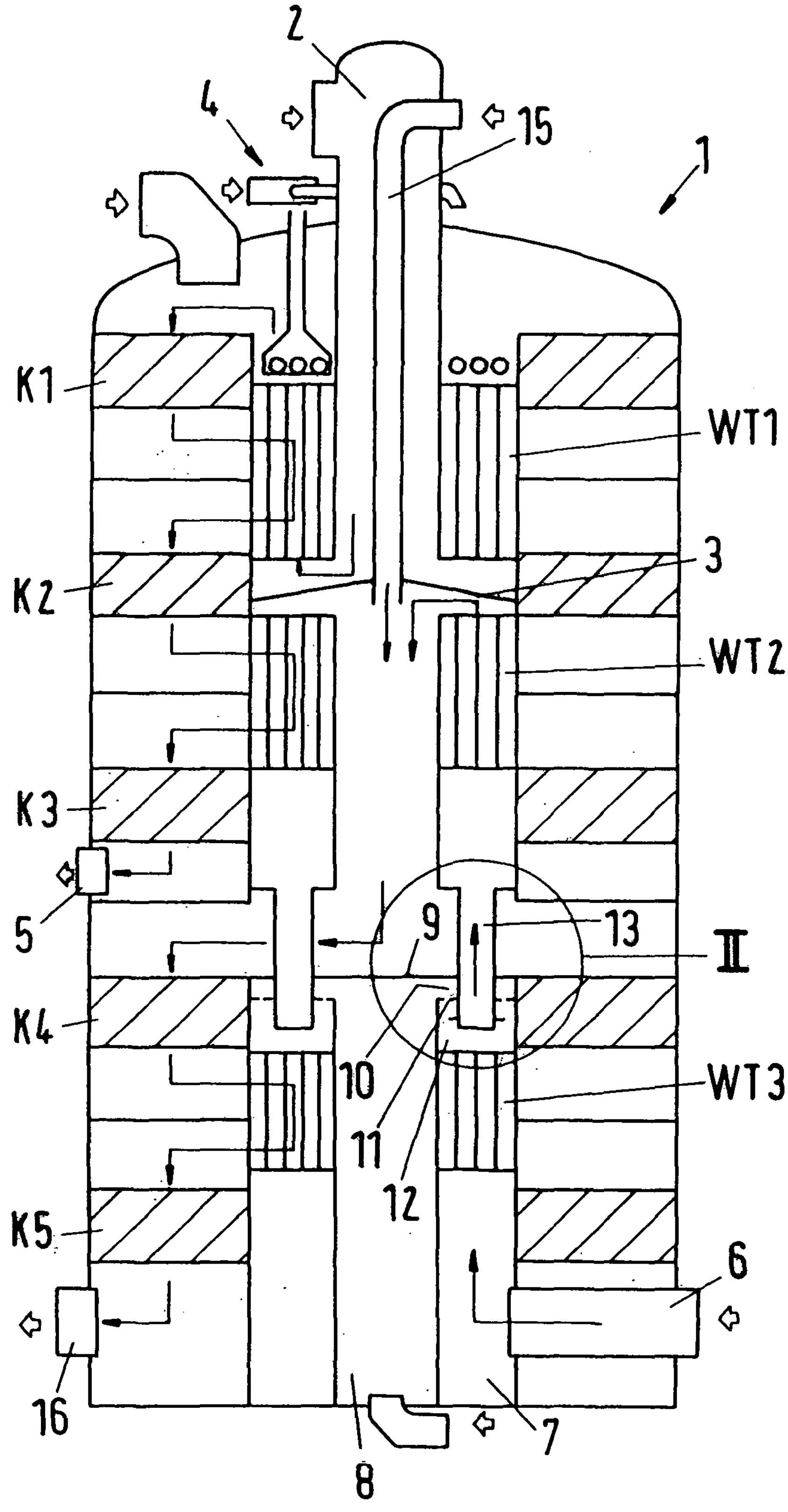

Fig.1

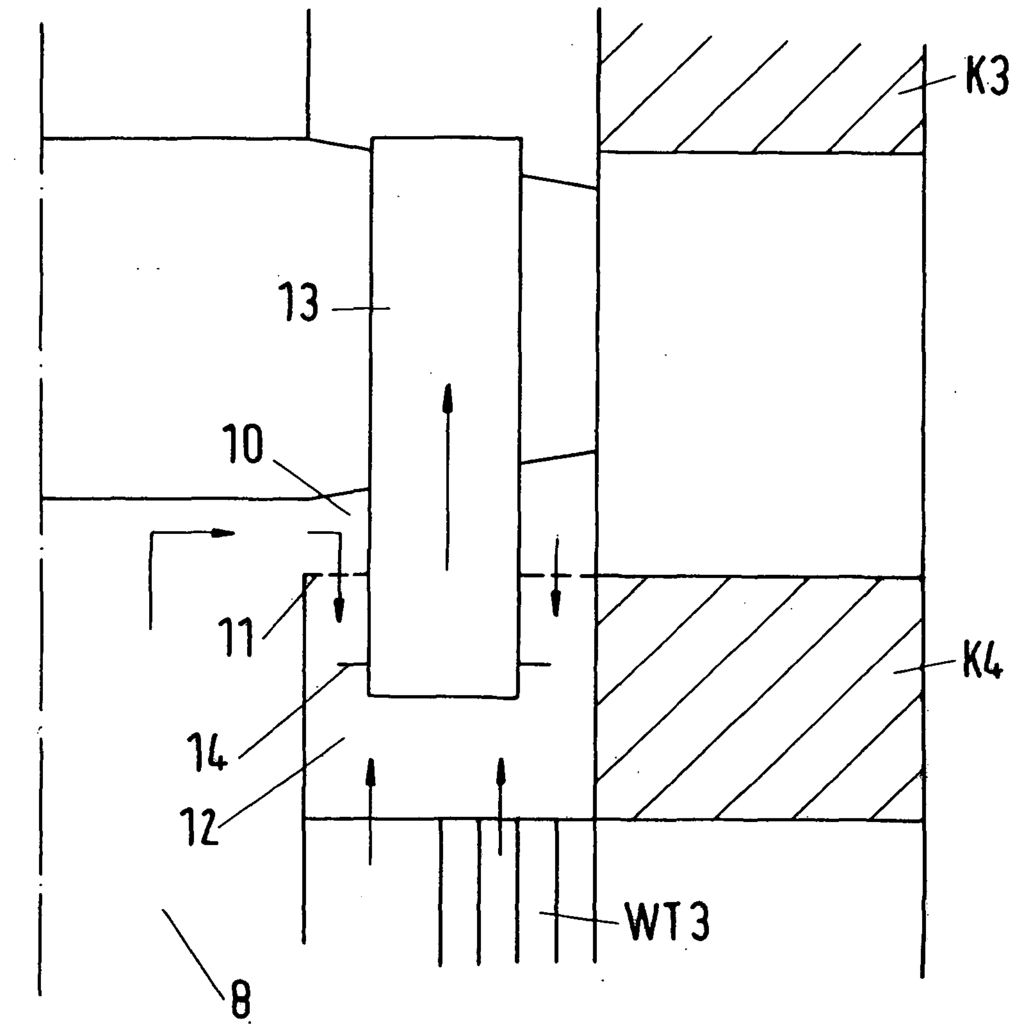

Fig.2