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CA 2433291 C 2011/08/16

(11)(21) **2 433 291**

(12) **BREVET CANADIEN**
CANADIAN PATENT

(13) **C**

(22) Date de dépôt/Filing Date: 2003/06/19

(41) Mise à la disp. pub./Open to Public Insp.: 2003/12/20

(45) Date de délivrance/Issue Date: 2011/08/16

(30) Priorité/Priority: 2002/06/20 (DK PA 2002 00950)

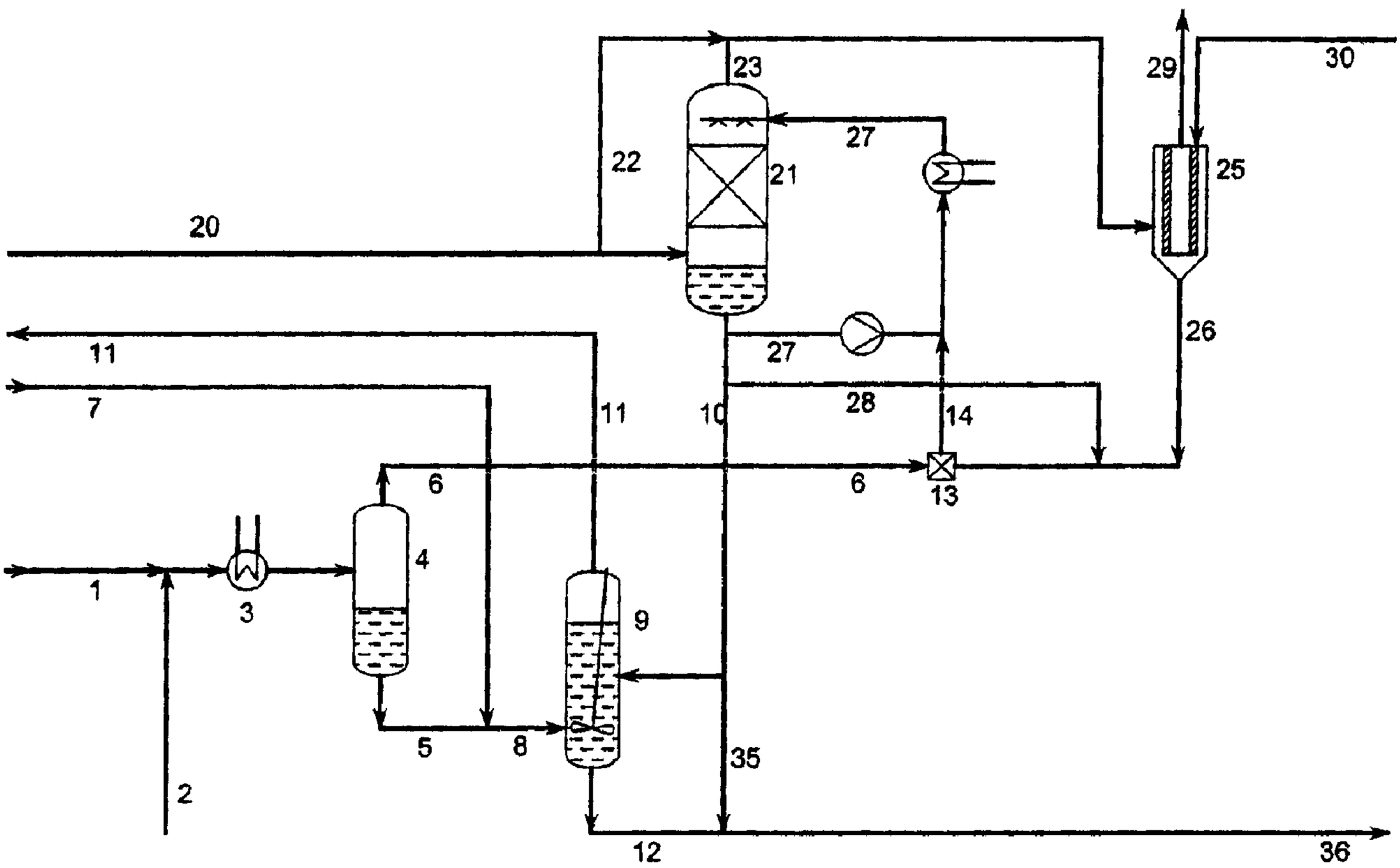
(51) Cl.Int./Int.Cl. *C01B 17/64* (2006.01),
C01C 1/24 (2006.01)

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(54) Titre : METHODE DE PRODUCTION DE THIOSULFATE D'AMMONIUM
(54) Title: PROCESS FOR PRODUCTION OF AMMONIUM THIOSULPHATE



(57) Abrégé/Abstract:
A process for continuous production of ammonium thiosulphate, $(NH_4)_2S_2O_3$ (ATS) from NH_3, H_2S and SO_2 comprising steps of: (a) partial condensation in a partial condenser 4 of a first gaseous or partial liquid feed stream comprising H_2O, H_2S and NH_3 with a molar H_2S:NH_3 ratio < 0.4; (b) passing the aqueous condensate comprising NH_4HS and NH_3 from the partial condenser 4 to a reactor 9 in which said condensate is contacted with a third feed gas stream 7 comprising H_2S and with an aqueous solution 10

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(57) **Abrégé(suite)/Abstract(continued)**:
comprising NH_4HSO_3 and $(NH_4)_2SO_3$ under formation of an aqueous solution of $(NH_4)_2S_2O_3$; (c) passing the gas stream comprising NH_3 and H_2S from the partial condenser 4 to a mixing device 13 in which said gas stream is completely dissolved in the water drained off from the aerosol filter 25; (d) passing a second feed gas stream 20 comprising approximately 2/3 mole SO_2 per mole of NH_3 contained in the first feed stream to a SO_2 absorber 21 and the aerosol filter 25; (e) passing the aqueous solution produced in mixing device 13 to the SO_2 absorber 21; (f) passing the off gas from the absorber 21 to the aerosol filter 25 and (g) adding to the aerosol filter 25 a balance amount of water required for obtaining approximately 40-65 wt% $(NH_4)_2S_2O_3$ in the aqueous of solution of $(NH_4)_2S_2O_3$ being withdrawn from the reactor 9.

ABSTRACT

A process for continuous production of ammonium thiosulphate, $(NH_4)_2S_2O_3$ (ATS) from NH_3, H_2S and SO_2 comprising steps of:

(a) partial condensation in a partial condenser 4 of a first gaseous or partial liquid feed stream comprising H_2O, H_2S and NH_3 with a molar H_2S:NH_3 ratio < 0.4;

(b) passing the aqueous condensate comprising NH_4HS and NH_3 from the partial condenser 4 to a reactor 9 in which said condensate is contacted with a third feed gas stream 7 comprising H_2S and with an aqueous solution 10 comprising NH_4HSO_3 and $(NH_4)_2SO_3$ under formation of an aqueous solution of $(NH_4)_2S_2O_3$;

(c) passing the gas stream comprising NH_3 and H_2S from the partial condenser 4 to a mixing device 13 in which said gas stream is completely dissolved in the water drained off from the aerosol filter 25;

(d) passing a second feed gas stream 20 comprising approximately 2/3 mole SO_2 per mole of NH_3 contained in the first feed stream to a SO_2 absorber 21 and the aerosol filter 25;

(e) passing the aqueous solution produced in mixing device 13 to the SO_2 absorber 21;

(f) passing the off gas from the absorber 21 to the aerosol filter 25 and

(g) adding to the aerosol filter 25 a balance amount of water required for obtaining approximately 40-65 wt% $(NH_4)_2S_2O_3$ in the aqueous of solution of $(NH_4)_2S_2O_3$ being withdrawn from the reactor 9.

PROCESS FOR PRODUCTION OF AMMONIUM THIOSULPHATE

INTRODUCTION

The present invention relates to a process for continuous production of a concentrated solution of ammonium thiosulfate (ATS) from off gases comprising H_2S and NH_3 such as refinery SWS (Sour Water Stripper)-gas, which contains NH_3 as well as H_2S and H_2S gas streams.

The process according to the invention is distinguished by utilizing only the NH_3 in the SWS gas for the production of high purity ATS solution, thus producing 7.25 kg 60% ATS solution per kg of NH_3 in the SWS gas treated in the process. Furthermore, when the process according to the invention uses the effluent gas of a Claus plant as SO_2-source for the process, the total sulphur-recovery of the Claus plant and the ATS plant taken together is increased to more than 99.95% with only 86-95% sulphur recovery being required in the Claus plant.

It is known to produce aqueous solutions of ATS by reacting a solution of ammonium sulphite with sulphur in liquid form or with sulphides or polysulphides in aqueous solution as described in Kirk-Othmer Encyclopedia of Chemical Technology, 4th edition, 1997, vol 24, page 62 and in US Patent Nos. 2,412,607; 3,524,724 and 4,478,807.

It is furthermore known from US Patent No. 3,431,070 to produce ATS in a continuous process from gaseous feed streams comprising H_2S, NH_3 and SO_2. By the process of this invention ATS and sulphur is produced from a first feed gas

stream comprising H_2S and NH_3 and a second feed gas stream comprising SO_2 in three absorption steps. In a first absorber, NH_3 and H_2S are separated in a H_2S off-gas stream and an NH_3-rich solution of ATS. The main part of the solution is passed to a second absorber, in which it is contacted with the SO_2-rich feed gas stream under formation of an off-gas that is vented and a solution rich in ATS and ammonium sulphites, which in a third absorber is contacted with the H_2S-gas from the first absorber and, optionally, with additional H_2S. After removal of sulphur being formed in the third absorber, the major part of the ATS-solution formed in the third absorber is recycled to the first absorber, while a minor part is mixed with a fraction of the NH_3-rich solution of ATS formed in the first absorber forming the product solution of ATS.

There are three major disadvantages of this process: Elementary sulphur is formed in the third absorber and must be separated from the solution, the off-gas vented from the third absorber has a high concentration of H_2S and the process is complicated with three integrated absorption steps.

It is also known from EP 0 928 774 A1 to produce an aqueous solution of ATS from gaseous feed streams comprising NH_3, H_2S and possibly SO_2. By the process of this patent, a concentrated solution of ammonium hydrogen sulphite (AHS) is produced from NH_3 and SO_2 in a first absorption step comprising one or two absorbers in series. Said solution is contacted in a second absorption step with a gaseous mixture of H_2S and NH_3 forming the product solution of ATS.

The major disadvantage of this process is that it requires import of NH_3 for the process.

Furthermore, a process is known from Danish Patent No. 174407, wherein ATS is produced by using only the NH_3 contained in the SWS-gas stream as the NH_3 source for ATS-production.

In said process a first feed stream, typically SWS-gas, comprising more than 0.33 mole H_2S per mole of NH_3 is contacted with a stream of sulphite solution in a reactor for formation of ATS. However, experiments have shown that the presence of excess H_2S for the formation of ATS from sulphites in the reactor will lead to the presence of free sulphide in the product solution, part of which is recycled to the SO_2 absorber, in which the sulphide will be decomposed to give H_2S in the absorber effluent gas. Furthermore, the large recycle of solution to the SO_2 absorber and back to the reactor is also a disadvantage of the process.

An aim of the invention is to establish an improved process for the production of ATS in which over 99.9% of all sulphur and all NH_3 in the feed streams are recovered as ATS without any of the above mentioned disadvantages.

This invention relates to a process for continuous production of ammonium thiosulphate, $(NH_4)_2S_2O_3$ (ATS) from NH_3, H_2S and SO_2 comprising following steps:

(a) partial condensation in a partial condenser 4 of a first gaseous or partial liquid feed stream comprising H_2O, H_2S and NH_3 with a molar H_2S:NH_3 ratio <0.4, preferably in the range 0.1-0.25;

(b) passing the aqueous condensate comprising NH_4HS and NH_3 from the partial condenser 4 through line 5 to a reactor 9 in which said condensate is contacted with a third feed gas stream comprising H_2S supplied through line 7 and with an aqueous solution comprising NH_4HSO_3 (AHS) and $(NH_4)_2SO_3$ (DAS) supplied through line 10 under formation of an aqueous solution of ATS being removed from the reactor through line 12;

(c) passing the gas stream comprising NH_3 and H_2S from the partial condenser 4 through line 6 to a mixing device 13 in which said gas stream is completely dissolved in the water that is drained off from the aerosol filter 25 and passed to 13 through the line 26;

(d) passing a second feed gas stream in line 20 comprising in principle 2/3 mole SO_2 per mole of NH_3 comprised in the first feed stream to a SO_2 absorber 21 and the aerosol filter 25;

(e) passing the aqueous solution produced in mixing device 13 through line 14 to the SO_2 absorber 21;

(f) passing the off gas from absorber 21 through line 23 and 24 to an aerosol filter 25 to which is added, through line 30, the balance amount of water required for obtaining about 60 wt% (40-65 wt%) ATS in the aqueous solution removed from the reactor 9 in line 12.

Step (e) can preferably be carried out by adding said aqueous solution to the liquid recycle loop 27 of the SO_2-absorber.

The invention will be further described with reference to the accompanying drawings in which:

Figure 1 represents schematically an apparatus for carrying out a process according to the invention; and

Figure 2 is a schematic overview of sulphur recovery with a Claus process.

Referring to the drawing Fig. 1, a first feed stream of fractionated SWS-gas in line 1 comprising, for example, 6 kmole/h NH_3 associated with 1.1 kmole/h H_2S and 2 kmole/h H_2O, is treated with a second feed gas stream in line 20 comprising SO_2 associated with water vapor and inert components such as N_2, CO_2 and O_2 and a third feed gas stream comprising H_2S in line 7. Feed water required for the process is fed in line 30 to the aerosol filter 25. Some feed water may also be added in line 2 to the first feed gas stream. More than 99.95% of the amounts of NH_3 and SO_2 in the feed streams are recovered in the product ATS stream exiting the process in line 36. Thus, the off gas from the process in line 29 contains a negligible amount of SO_2 and essentially no NH_3 and H_2S.

The original SWS-gas available in refineries usually have a molar H_2S:NH_3 ratio of about 1:1, which is higher than directly acceptable for the process. Therefore, the original SWS-gas must first be fractionated by known methods in col-

umns not shown on the figure to give a feed gas stream in line 1 with less than about 0.35 mole H_2S per mole of NH_3 in the feed gas, preferably with a H_2S:NH_3 molar ratio in the range of 0.1-0.25. The two other off streams (not shown in Fig. 1) from said fractionation are H_2S, which can be used as make-up for stream 7, and practically pure water. Experiments with the process have shown that with H_2S:NH_3 > about 0.35 in stream 1, it will be very difficult or impossible to avoid presence of free sulphide in the ATS product stream in line 36 and/or presence of H_2S in the process exit gas in line 29. A H_2S:NH_3 ratio of about 1.1:6 = 0.18 in feed stream 1 seems very suitable for conducting the process according the invention.

The amounts of H_2S, SO_2 and H_2O comprised in the feed streams for production of a 60% ATS solution from 6 kmole NH_3 in the first feed stream are calculated from the mass balance of the over-all process:

Eguation (1):

$$6\ NH_3 + 4\ SO_2 + 2\ H_2S + 17.5\ H_2O \Rightarrow 3\ (NH_4)_2S_2O_3 + 16.5\ H_2O,$$

corresponding to the following amounts in kg:

Equation (1a):

102.14 kg NH_3 + 256.24 kg SO_2 + 68.16 kg H_2S + 315.32 kg H_2O.

give 741.86 kg 60% ATS solution.

The first feed stream comprising 6 kmole NH_3, 1.1 kmole H_2S and 2 kmole H_2O in line 1 is cooled in the cooler 3 to a

temperature between 20°C and 60°C, or well below its dew point upstream of the separator 4. In the separator 4 the first feed stream is separated in an aqueous solution exiting in line 5 comprising NH_4HS and some NH_3 dissolved in practically all of the water in the feed stream 1, and in a gas phase exiting in line 6 comprising most of the NH_3 (approximately 4.6 kmole NH_3) and a small amount of H_2S (approximately 0.1 kmole H_2S). Water may be added in line 2 upstream of 4, but in the example the amount of water added to the process at this point is chosen to be zero. The liquid stream 5 comprising in the example 1.0 kmole NH_4HS, 0.4 kmole NH_3 and 2 kmole H_2O goes to the reactor 9 in which it is reacted with (0.9 + x) kmole H_2S, the third feedstream and as defined below, introduced in line 7 and with the liquid sulphite stream 10 comprising 0.15 kmole ATS, 3.3 kmole AHS (NH_4HSO_3), 0.5 kmole DAS ($(NH_4)_2SO_3$) and 11.65 kmole H_2O. In the reactor 9 ATS will be formed by the principal reactions:

Equation(2):

$$4\ NH_4HSO_3 + 2\ NH_3 + 2H_2S \Rightarrow 3\ (NH_4)_2S_2O_3 + 3H_2O$$

Equation(3):

$$4\ (NH_4)_2SO_3 + 2\ H_2S \Rightarrow 3\ (NH_4)_2S_2O_3 + 2\ NH_3 + 3H_2O$$

resulting in formation of 741.8 kg of 60% ATS solution leaving the reactor through line 12.

An excess amount of x kmole H_2S may be added to the feed stream of 0.9 kmole H_2S, which constitutes the third feed gas stream, in line 7 in order to increase the rates of reactions 2 and 3. The x kmole H_2S, which may constitute 0-

10% of equivalent amount of H_2S required for the process, is vented from the reactor through the vent line 11.

Additional sulphite solution may be added through line 35 to the ATS product solution having e.g. a composition of 60% ATS (3 kmol ATS and 16.5 kmol water), in order to complete the conversion to ATS of possible traces of sulphide or H_2S in the stream 12 and/or to add 0-2% DAS to the product ATS solution exiting the process in line 36. For simplicity, no sulphite is added through line 35 in the present example. pH of the solution in line 12 and in the reactor 9 will typically be in the range 7.6-8.6.

The off gas from 4 (4.6 kmol NH_3 and 0.1 kmol H_2S) is passed to the mixing device 13 in which it is completely dissolved in the aqueous stream 26 from the aerosol filter 25. Stream 26 will usually comprise at least 0.1 kmole AHS which reacts with the H_2S and NH_3 in stream 6 under formation of ATS according to for instance equation 2. A minor fraction of the sulphite solution exiting the SO_2-absorption is added to stream 26 through line 28 in order to ensure complete removal of all H_2S or sulphide in the aqueous stream 14 before it is added to the SO_2 absorption loop 27. Addition of excess ammonium sulphites through 28 will also keep pH in stream 14 below of about 9.2. If pH is higher than 9.2 in stream 14 (due to the high concentration of NH_3 in said stream), the formation of ATS from the sulphide may be inhibited leading to liberation of H_2S in the SO_2-absorber 21 and to presence of H_2S in the absorber off gas.

The flow of SO_2 (second feed gas stream) required for the process is in line 20 fed to the SO_2-absorber 21 in which the SO_2 is in principle absorbed by the NH_3 comprised in the NH_3-rich off gas in line 6 from the partial condensation in 4 of the feed stream 1. According to the over-all mass balance of the present example given in equation 1, 4.0 kmole SO_2 is required for the process. As the SO_2 feed stream is produced by upstream combustion of H_2S or other sulphurous components, the SO_2 in line 20 will be diluted with inert gas comprising N_2, CO_2 and O_2 and with water vapor. In Fig. 1 it is assumed that the 4 kmole SO_2 is diluted with approximately 100 kmole inert gases and 6 kmole H_2O corresponding to a H_2O dew point of 35-36°C.

The SO_2 absorber 21 is typically a fixed bed absorber where the absorption liquid is recycled in a loop 27 comprising a circulating pump and a cooler which maintains the temperature of absorption preferably at 35-40°C, whereby no net condensation or net evaporation of H_2O takes place in the absorber and in the subsequent aerosol filter 25.

In the example in Fig. 1, 15.5 kmole/h water is supplied to the aerosol filter 25 for instance by spraying the water on the filter candles. As there will be practically no NH_3, SO_2 or aerosols in the process off gas in line 29, the aqueous solution exiting the absorber in line 10 (after subtraction of the fraction taken out in line 28) can be calculated from the mass balances to be 617.2 kg/h solution comprising 0.15 kmole/h ATS, 3.3 kmole/h AHS, 0.5 kmole/h DAS and 11.65 kmole/h H_2O. The equilibrium partial pressures of NH_3 of this solution at 40°C have been found to be approximately 10^{-3} bars higher than that of SO_2.

In order to recover this NH_3, 0.1 kmole SO_2 is added to the SO_2 absorber effluent gas by bypassing in line 22 about 0.1/4 = 2.5% of the gas flow in line 20 around the SO_2 absorber and adding said bypass stream to the absorber effluent gas in line 23. The NH_3 and SO_2 react in the gas phase forming an aerosol of AHS, which is removed in the filter 25. All aerosols present in the gas leaving the SO_2-absorber will also be removed and dissolved in the water supplied to the filter. The filter off gas in line 29 contains typically about 40 ppm SO_2, less than 2 ppm NH_3 and essentially no H_2S.

Separation in the partial condenser 4 of the fractionated SWS-feed gas stream in a gaseous NH_3-rich stream 6 and a liquid stream 5 is very advantageous but not strictly necessary for the process.

The separation can in principle be replaced by splitting stream 1 in a stream 5 being passed to 9 together with stream 7 and a stream 6 being mixed in 13 in principle as seen in Fig 1.

The SO_2-absorption may also be carried out with two SO_2-absorbers connected in series, or the SO_2-absorber 21 may be a bubbling SO_2-absorber in which the feed gas in line 20 is bubbled through the absorbing solution with or without external circulation in a loop 27 as shown in Fig 1.

A fraction of the second feed gas stream can be by-passed the absorber 21 and mixed with the effluent gas from the absorber 21 upstream of the aerosol filter 25. The fraction

can contain 0.7 - 1.3 moles of SO_2 per mole of NH_3 contained in the off gas from the SO_2-absorber 21.

Essentially complete conversion of sulphide to $(NH_4)_2S_2O_3$ in the process and a desired concentration of excess $(NH_4)_2SO_3$ and NH_4HSO_3 of 0-2 wt% in the product exit stream 36 are achieved (1) by adjusting the feed rate of H_2S in line 7 to give a small stream in line 11 of excess H_2S in the range of 0-10% of the equivalent amount of H_2S for the production of ATS and (2) by bypassing a minor fraction of stream 10 through line 35 to stream 12. In other words, the feed rate of H_2S in the third feedstream 7 is adjusted to give an excess effluent H_2S stream from the reactor 9 of 0-10% of the equivalent amount of H_2S for the production of $(NH_4)_2S_2O_3$ and a fraction 10 of the solution produced in the SO_2 absorber 21 is bypassed to the $(NH_4)_2S_2O_3$ solution withdrawn from the reactor 9.

Use of the present ATS process is in particular advantageous when the off gas from a Claus plant is used as source for the SO_2 required for the process. This is seen in the overview in Fig. 2 of sulphur recovery with a simple Claus process combined with the present ATS process in a refinery producing H_2S and SWS-gas from various hydrogenation and cracking treatments of hydrocarbons. Without use of the ATS process all H_2S and SWS gas had to be treated in the Claus plant and the ammonia had to be decomposed at substantial costs. No more than 95-97% sulphur recovery can be achieved in simple 2 or 3-bed Claus plants. Higher degrees of sulphur recovery require expensive processes for tail gas treatment. Increasing the sulphur recovery to more than 99% by known processes is very expensive investment wise as

well as with regard to operating costs and energy consumption. However, 99.95% total sulphur recovery or more is automatically achieved with no increase in operating costs and energy consumption by utilizing the off gas from a simple 2-bed Claus plant as the SO_2-source for the present ATS process utilizing the SWS-gas for ATS-production, as shown in the schematic drawing in Fig. 2.

Referring to Fig. 2, the SWS gas containing e.g. 1 kmol ammonia and 1 kmol hydrogen sulphide, in line 201 is sent to a fractionation unit 202, in which it is split into an H_2S-rich stream 203 having e.g. 2/3 kmol hydrogen sulphide, and an NH_3-rich stream 204 containing all the NH_3 and approximately 0.33 mole H_2S per mole NH_3. The H_2S-rich stream 203 is mixed with an H_2S gas having e.g. 9 kmol hydrogen sulphide, in line 205 and sent to a Claus plant 206, in which most of the H_2S is recovered as sulphur in line 207. Air is also required in the Claus plant 206 and steam is produced. The sulphur recovery can be e.g. more than 93.1%. The off-gas from the Claus plant is sent to a tail gas incinerator 208, in which the H_2S is combusted to SO_2 with an excess of air. Steam is produced. A fraction of the Claus feed gas is bypassed (hydrogen sulphide bypass) around the Claus plant in line 209 to the tail gas incinerator and combusted to SO_2. The bypass flow in line 209 is adjusted to give approximately 2/3 mole SO_2 in the off-gas from the incinerator in line 210 per mole NH_3 contained in the SWS gas in line 201. In order to produce concentrated ATS solution, a fraction of the water contained in the off-gas from the incinerator is removed in a condensation step 211. The off-gas from the condensation step containing approximately 2/3 mole SO_2 is sent to the ATS process 212 according to the present invention, in which

the SO_2 is removed by reaction with the NH_3-rich stream 204 from the fractionation unit 202. The purified gas stream 213 is vented through the stack and the product ATS solution (e.g. a 60% solution with 0.5 kmol ATS) is recovered in line 214.

CLAIMS:

1. A process for continuous production of ammonium thiosulphate, $(NH_4)_2S_2O_3$ (ATS) from NH_3, H_2S and SO_2 comprising steps of:

(a) partial condensation in a partial condenser of a first gaseous or partial liquid feed stream comprising H_2O, H_2S and NH_3 with a molar H_2S:NH_3 ratio < 0.35;

(b) passing the aqueous condensate comprising NH_4HS and NH_3 from the partial condenser to a reactor in which said condensate is contacted with a third feed gas stream comprising H_2S and with an aqueous solution comprising NH_4HSO_3 and $(NH_4)_2SO_3$ under formation of an aqueous solution of $(NH_4)_2S_2O_3$;

(c) passing the gas stream comprising NH_3 and H_2S from the partial condenser to a mixing device in which said gas stream is completely dissolved in the water drained off from an aerosol filter;

(d) passing a second feed gas stream comprising approximately 2/3 mole SO_2 per mole of NH_3 contained in the first feed stream to a SO_2 absorber and the aerosol filter;

(e) passing the aqueous solution produced in the mixing device to the SO_2 absorber;

(f) passing the off gas from the absorber to the aerosol filter, and

(g) adding to the aerosol filter a balance amount of water required for obtaining approximately 40-65 wt% $(NH_4)_2S_2O_3$ in the aqueous of solution of $(NH_4)_2S_2O_3$ being withdrawn from the reactor.

2. A process of claim 1, wherein the first feed stream of step (a) is divided into a substream being passed to the mixing device and a further substream which is contacted in the reactor with the third feed stream comprising H_2S and with the aqueous solution comprising NH_4HSO_3 and $(NH_4)_2SO_3$ under formation of the aqueous solution of $(NH_4)_2S_2O_3$.

3. A process of claim 1 or 2, wherein a fraction of the second feed gas stream is by-passed the absorber and mixed with the effluent gas from the absorber upstream of the

aerosol filter, said fraction containing 0.7 - 1.3 moles of SO_2 per mole of NH_3 contained in the off gas from the SO_2-absorber.

4. A process of claim 1, 2 or 3, wherein the SO_2-absorber is a packed column.

5. A process of any one of claims 1 to 4, wherein the SO_2-absorber is a bubbling SO_2-absorber with or without external liquid recycle.

6. A process of any one of claims 1 to 5, wherein a fraction of the solution comprising NH_4HSO_3 and $(NH_4)_2SO_3$ produced in the SO_2 - absorber is passed to the mixing device, said fraction of the solution comprising a flow of sulphite (NH_4HSO_3 and $(NH_4)_2SO_3$) which together with the sulphite in the off stream from the aerosol filter relates to the flow of sulphide ($H_2S + NH_3HS$) in the stream from the condenser by a molar ratio of 2:1 or more.

7. A process of any one of claims 1 to 6, wherein the second feed gas stream is an effluent gas stream from a Claus plant which is incinerated and its H_2O-content reduced to 3-10 vol% H_2O, by cooling and partial condensation of its content of H_2O upstream of the present process.

8. A process of any one of claims 1 to 6, wherein the second feed gas stream is an effluent gas stream from a Claus plant which is incinerated and its H_2O-content reduced to 3-6 vol% H_2O, by cooling and partial condensation of its content of H_2O upstream of the present process.

9. A process of any one of claims 1 to 8, wherein the first feed stream is Sour Water Stripper gas having been fractionated and adjusted to contain H_2S and NH_3 to a molar ratio of H_2S:NH_3 of < 0.35.

10. A process of any one of claims 1 to 9, wherein the pH value of the aqueous solution comprising NH_4HSO_3 and $(NH_4)_2SO_3$ used for absorption of SO_2 in the absorber is adjusted to between about 5 and about 7.5.

11. A process of any one of claims 1 to 10, wherein the feed rate of H_2S in the third feedstream is adjusted to give an excess effluent H_2S stream from the reactor of 0-10% of the equivalent amount of H_2S for the production of $(NH_4)_2S_2O_3$ and a fraction of the solution produced in the SO_2 absorber is bypassed to the $(NH_4)_2S_2O_3$ solution withdrawn from the reactor.

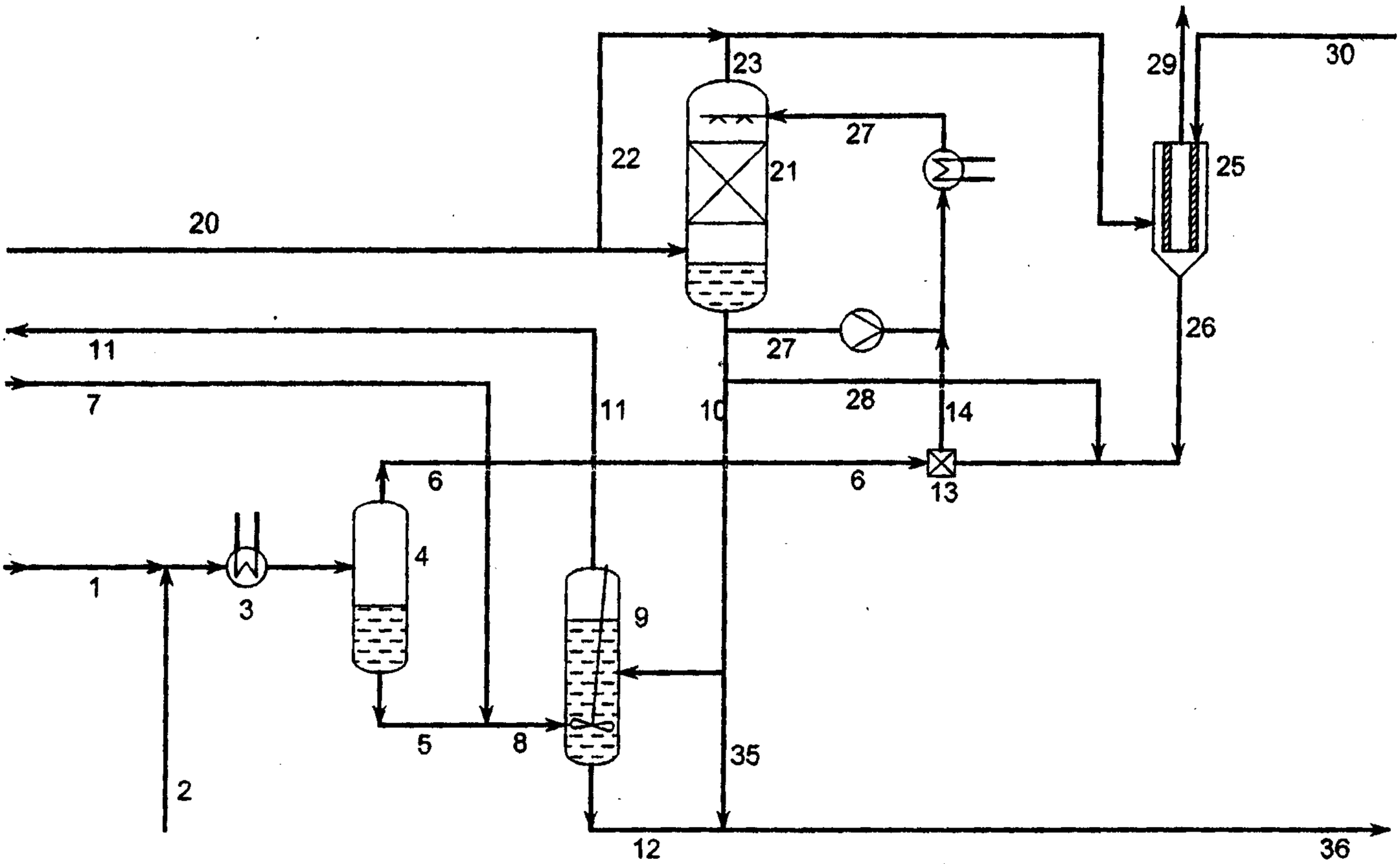


Fig.1

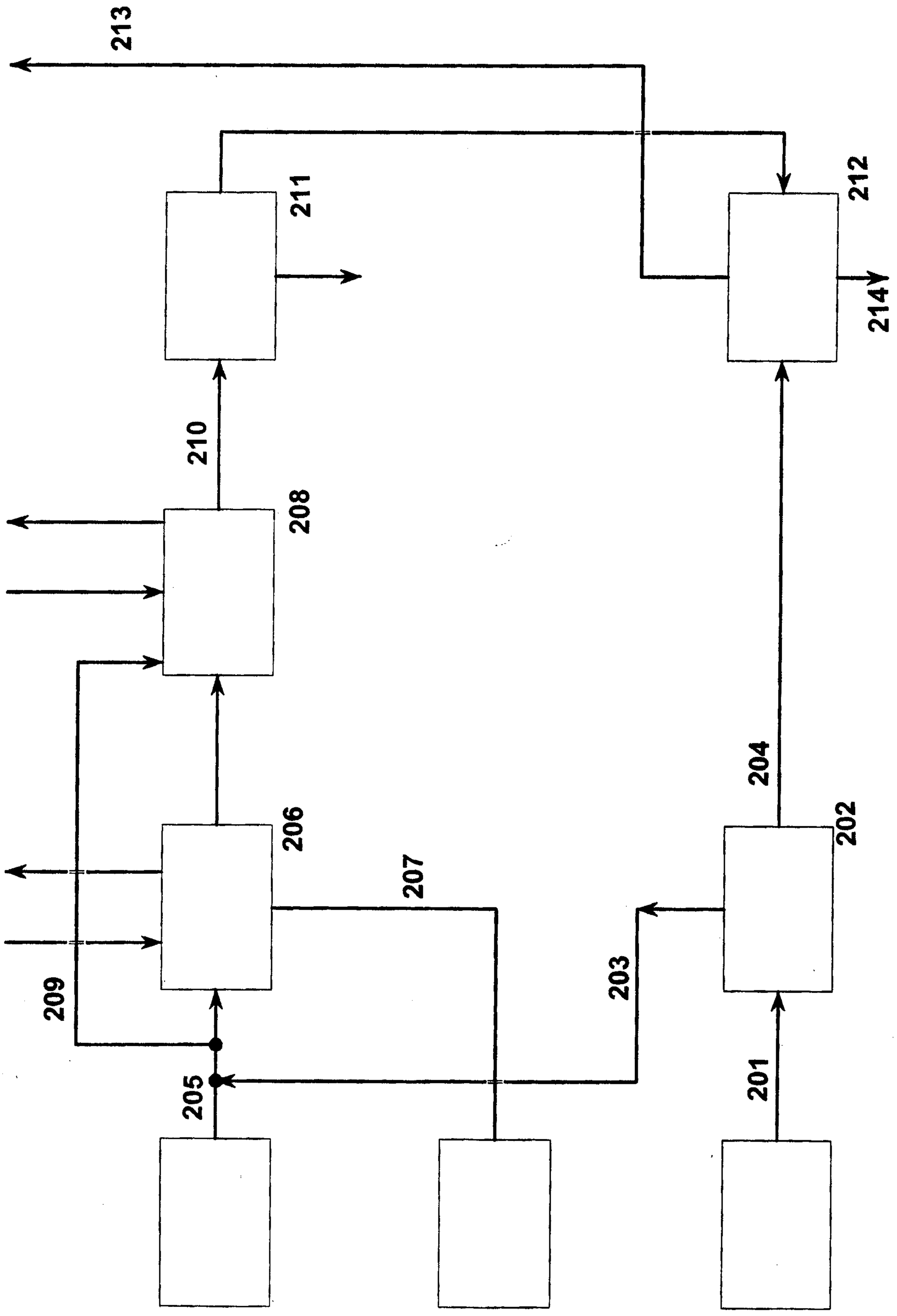
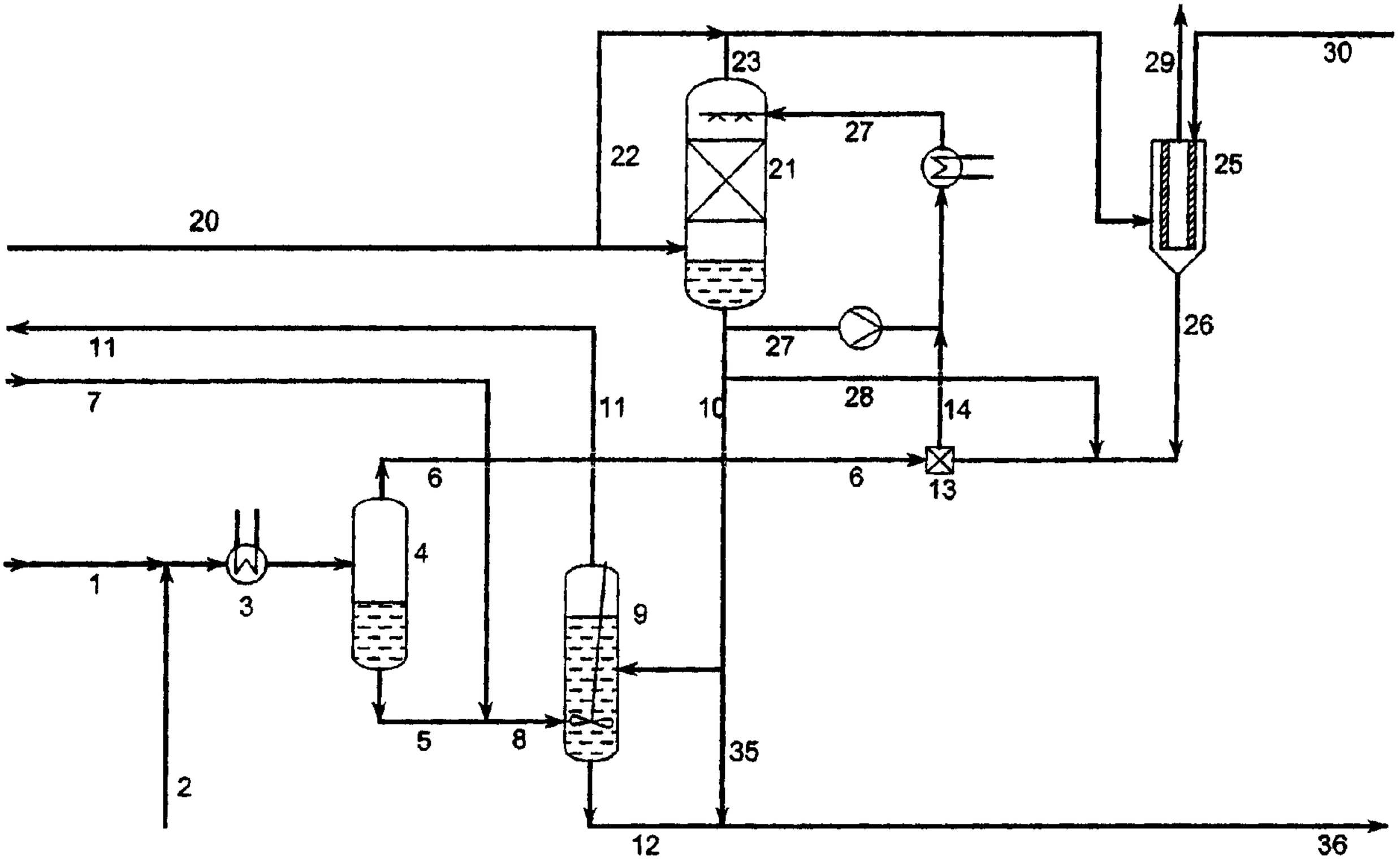


FIG. 2


23
29
30
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27
21
25
20
11
27
26
7
11
10
28
14
6
6
13
4
1
3
9
5
8
35
2
12
36