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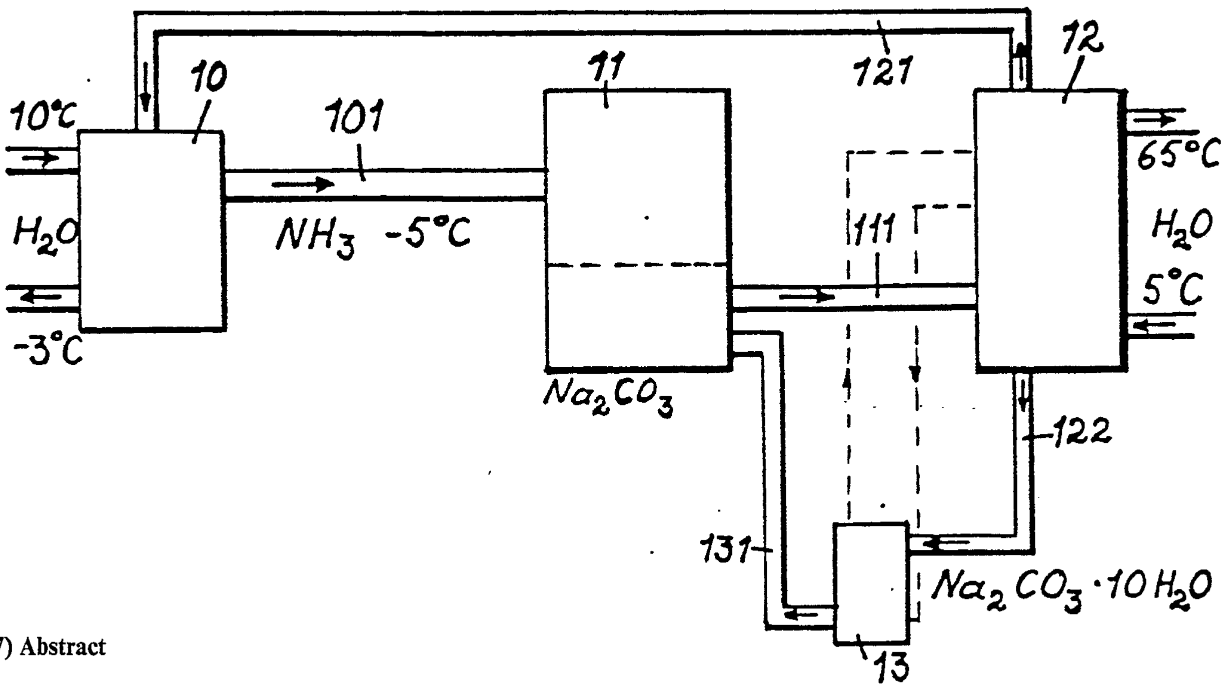
(54) Title: A CHEMO-THERMAL PLANT



(57) Abstract

A chemo-thermal plant for converting low-temperature thermal energy to high-temperature thermal energy includes a first heat exchanger for recovering low-temperature thermal energy, a processor for vaporizing a first chemical component, and a second heat exchanger for recovering the energy stepped-up by vaporization. The plant further includes a second processor which is connected to the firstmentioned processor and which is arranged to effect a reaction between the vaporized component and a second chemical component. The first chemical component may comprise ammonia and the second sodium carbonate. The second heat exchanger (12) is then connected to transfer liquid ammonia to the first processor (10) which simultaneously constitutes the first heat exchanger, and is connected for transfer of sodium carbonate solution to the second processor (11).

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A chemo-thermal plant

TECHNICAL FIELD

The present invention relates to a chemo-thermal plant for converting low temperature thermal energy to high-temperature thermal energy. The object of the invention is to recover low-temperature thermal energy, which is abundantly found in water (the seas, the oceans), the air, industrial waste-heat, etc., and to utilize this thermal energy by stepping it up to high-temperature thermal energy, i.e. to temperatures useful for the large scale heating of domestic dwellings, for energy-consuming industries (power stations) etc.. The plant is of a kind comprising two heat exchangers and a processor for vaporizing a chemical component.

BACKGROUND PRIOR ART

Coal, oil, peat, water power and nuclear power are all utilized in an attempt to solve the energy problems of today. These energy sources are controversial to varying degrees for different reasons, owing to the fact that they constitute a drain on natural resources and present a hazard to the well being of humans, animals and the environment.

Much effort has been expended in finding environmentally gentle solutions to the problem of meeting present day energy requirements. Wind power can be said to be one such solution. Another solution is the heat pump, a device for "transferring heat from one heat source abundantly flowing in the environment to an object requiring heat". In short, the heat pump can be said to operate in a manner to supply heat (e.g. from ambient air) to a container containing a liquid under low pressure, this liquid being caused to boil thereby. The pressure and the temperature of the resultant liquid vapor are raised by means of a compressor, this liquid vapor being allowed to condensate in a further container and therewith deliver heat to a medium cooled by the other container, for example hot water for heating a domestic dwelling. Recovered liquid is recycled to the firstmentioned container via a pressure reducing valve, and can then be re-boiled by supplying heat from the air, etc..

Thus, in this case energy is transferred by vaporization, although electrical or mechanical energy must constantly be supplied to the compressor, which naturally reduces the efficiency of the system.

The object of the present invention is to provide a novel heat plant which is both environmentally gentle and highly efficient. This object is achieved by causing the plant to transform low-temperature thermal energy to high-temperature thermal energy with the aid of processes operating with both vaporization heat from a vaporization process and with reaction heat from a purely chemical process.

DISCLOSURE OF THE INVENTION

As beforementioned, a heat plant according to the invention incorporates a first and a second heat exchanger, and a processor for vaporizing a first chemical component.

The plant is characterized in that it further incorporates a second processor connected to the first processor and arranged to effect a reaction between the vaporized first chemical component and a second chemical component. By means of this reaction the temperature can be stepped-up to a level much higher than the level achieved solely by the actual vaporization process.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail with reference to the accompanying schematic drawings, in which

Figure 1 is a heat plant for transforming thermal energy from a temperature of about 10°C to about 65°C, and comprising a mixer for mixing together two chemical components;

Figure 2 is a heat plant for transforming energy from a temperature of about 10°C to about 50°C, and includes a chemical reactor and a disintegrator for two chemical components; and

Figure 3 is a heat plant for transforming energy from a temperature of about 45°C to about 520°C, and includes a chemical reactor and a disintegrator for two chemical components.

PREFERRED EMBODIMENTS

The heat plant illustrated in Figure 1 incorporates a combined heat-exchanger/processor 10, a second processor 11, a second heat-exchanger 12 and a heater 13.

Sea water at a temperature of 10°C is supplied to the heat exchanger 10, the pressure of which reaches to about 3.5 - 5 atmospheres. Subsequent to heating liquid ammonia, the temperature of outgoing sea water has dropped to a temperature of -3°C. The liquid ammonia flowing through a conduit 121 is vaporized in the processor 10 and is conducted in the form of ammonia vapor, having a temperature of -5°C, through a conduit 101 to a second processor 11. The ammonia vapor is mixed in the second processor 11 with a sodium carbonate solution having a temperature in excess of 31°C, this solution being supplied to the processor 11 through a conduit 131. More specifically, there now takes place an increase in temperature, due to ammonia vapor dissolving in the free water of crystallisation deriving from the crystal soda melt (temperature above 31°C). The end product obtained from the second processor 11 is a liquid ammonia + sodium-carbonate-solution having a temperature of about 65°C. This product is passed through a conduit 111 to the second heat exchanger 12, where cooling water supplied to said heat exchanger and having a temperature of 5°C is heated to a temperature of 65°C and passed to a consumer point, e.g. the central heating system of one or more dwelling places. The sodium-carbonate solution transforms to crystal soda having a temperature below 31°C, while absorbing the water of crystallization and is led via a conduit 122 to the heater 13 in which it is melted. The energy put into the heater 13 can be obtained through a loop extending from a high-temperature side of the heat exchanger 12, or with the aid of electrical heating means. It should be mentioned perhaps that the sodium carbonate rebinds the water as water of crystallization when cooling in the heat exchanger 12, and the ammonia is therewith void of solvent and is released in liquid form.(The solution of ammonia in water and the subsequent reabsorption of the water by the sodium carbonate can be compared, to some extent, with a conventional heat pump function).

A cooling device provided with a filter for optional cleansing of the liquid ammonia is preferably placed in the conduit 121. The cooling water is taken, for example, through a loop passing from the low-temperature side of the first heat exchanger 10, the lower conduit, and is recycled (shunted) to the upper conduit.

The heat plant illustrated in Figure 2 comprises a combined heat-exchanger/processor 20, a combined processor/heat exchanger 21, a heat consuming unit 22, a disintegrator 24 and a cooler 25.

Sea water having a temperature of 10°C is supplied to the heat exchanger 20. Subsequent to heating liquid ammonia, the departing sea water has a temperature of -3°C, The liquid ammonia supplied through a conduit 241 is vaporized in the processor 20 and conducted in vapor form, temperature -5°C, through a conduit 201 to the second processor 21. The ammonia vapor, temperature -5°C, chemically reacts in the second processor 21 with carbon dioxide (CO_2) having a temperature of 65°C and supplied to the processor 21 through a conduit 242. The exothermic reaction provides hot water, temperature 50°C, on the high-temperature side of the heat exchanger 21, said high-temperature side being connected to a consumer unit 22 of some kind or other, through a conduit 211; the low-temperature side of the consumer unit obtains return water, temperature 5°C, through a conduit 212. The aforesaid reaction results in ammonium carbamate (NH_2COONH_4), which is transferred to the disintegrator 24, via a centrifuge 23, and is there converted back to liquid ammonia, which is passed to the first processor 20 through the conduit 241, and carbon dioxide, which is passed to the second processor 21 through the conduit 242. Additional heat is supplied to the disintegrator through a heater 26, which may be an electric heater.

The function in conjunction with the centrifuge 23 can be described in detail in the following manner. Inert oil, for example thin paraffin oil, is supplied to the reactor 21, through a pump 27, and serves to absorb and transport the formed carbamate. The purpose of the centrifuge 23 is to concentrate the carbamate-oil mixture arriving from the reactor 21, to a thick, viscous consistency. The mixture is pumped into the disintegrator 24, and surplus oil is returned to the reactor 21, via the pump 27. Oil accompanying the mixture to the disintegrator 24 will lie on the bottom of the disintegrator upon completion of the disintegration process. A layer of liquid ammonia will lie above the oil, while gaseous carbon dioxide is collected above the ammonia. Oil, ammonia and carbon dioxide are tapped off continuously during operation.

The conduit 241 incorporates the cooling device 25, the low-temperature side of which is connected to the high-temperature side of the first heat-exchanger 20, via a conduit 251, whereas the high-temperature side of the cooling device 25 is connected to the high-temperature side of the second heat exchanger 21, via a conduit 252.

The high-pressure and high-temperature carbon dioxide gas deriving from the disintegrator 24 is an important, available source of energy for operation of auxiliary apparatus, such as the pump 27 and heater 26 for example. When the gas is caused to expand, the temperature falls, this drop in temperature being driven to an extent such that the carbon-dioxide gas can also function as an energy absorber from the heat exchanger 20. It should be noted that when cold ammonia vapor and cold carbon-dioxide vapor are again mixed in the processor 21 and thereby combined to form ammonium carbamate, heat will be released in such large quantities that if insufficient heat is led away in the consumer unit 22, the reaction will cease almost immediately, thereby preventing the temperature from exceeding the critical temperature (about 60°C), i.e. the system is, in the main, self-regulating.

The heat plant illustrated in Figure 3 incorporates a combined heat-exchanger/processor 30, a second processor 31, a second heat-exchanger 32, a heat consumer unit (turbine) 33, a chemical reactor 34, a disintegrator 35 and a capacitor 36.

Water having a temperature exceeding 45°C enters the heat exchanger 30 and is used to vaporize liquid sulphur trioxide, SO_3, which is introduced from the disintegrator 35 through a conduit 351. The vaporized sulphur trioxide is supplied to the second processor 31, through a conduit 301, to which processor steam from the disintegrator 35 is also supplied, through a conduit 352.

A hydration process according to the following formulae takes place in the processor 31:

$SO_3 + H_2O \rightarrow H_2SO_4$ (monohydrate, sulphuric acid)

$SO_3 + 2H_2O \rightarrow H_4SO_5$ (dihydrate)

The ratios between the two products obtained is contingent on the amount of ingoing steam. The products are passed through a conduit 311 to the heat exchanger 32, where the water is heated to steam of temperature 520°C, which is supplied to a turbine 33 through a conduit 321. Return steam of low temperature and low pressure from the turbine is supplied through a conduit 331 to a condensor 36, and the resultant liquid is recycled to the heat exchanger 32, through a conduit 361.

The cooling loop of the condensor 36 is connected, via a conduit 301 and a conduit 362, to the water outlet (low-temperature side) of the heat exchanger 30 and the outlet of the plant respectively.

The products H_2SO_4 and H_4SO_5 are supplied, through a conduit 322 to the reactor 34, to which iron oxide, Fe_2O_3, is also supplied from the disintegrator 35 through a conduit 353. A salt is formed in the reactor 34 in accordance with the formulae:

$$Fe_2O_3 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 3H_2O \text{ and}$$

$$Fe_2O_3 + H_4SO_5 \rightarrow Fe_2(SO_4)_3 + 6H_2O,$$

which ferri salts (with water of crystallization) are then disintegrated in the disintegrator 35 in accofdance with the formula:

$$Fe_2(SO_4)_3 + nH_2O \rightarrow Fe_2O_3 + 3(SO_3) + \text{steam.}$$

The iron oxide is recycled to the reactor 34, and the highly concentrated sulphur trioxide and steam are fed to the heat exchanger 30 and to the second processor 31 respectively, as beforementioned. More specifically, the disintegration process proceeds in a manner such that water of crystallization is expelled at a certain temperature in a first stage, whereafter the ferri sulphate is disintegrated at higher temperature. The expelled water of crystallization is obtained in vapor form, and the vapor can be introduced directly into a new cycle.

It will be understood that the embodiments described with reference to Figures 1-3 do not limit the invention in any way, and that various modifications can be made within the scope of the claims. For example, the amount of steam, or water vapor, in relation to the amount of sulphur trioxide SO_3, passing to the processor 31 can be chosen so that solely sulphuric acid, H_2SO_4, is obtained. When the sulphuric acid is caused to act in the heat exchanger 32, it can be led directly to a disintegrator and there split-up into sulphur trioxide, SO_3, and water vapor, which is then used in accordance with the aforegoing.

CLAIMS

1. A chemo-thermal plant intended for converting low-temperature thermal energy to high-temperature thermal energy, comprising a first heat exchanger for recovering thermal energy from a low-temperature source; a processor for vaporizing a first chemical component; and a second heat exchanger for recovering the thermal-energy stepped-up to elevated temperature by said vaporization process, characterized in that the plant further comprises a second processor connected to the firstmentioned processor and arranged to effect a reaction between the vaporized first chemical component and a second chemical component; the second heat exchanger being used to recover vaporization heat at a temperature substantially higher than the temperature resulting from solely the actual vaporization process.

2. A heat plant according to Claim 1, characterized in that the first chemical component is ammonia; in that the second chemical component is sodium carbonate; and in that the second heat exchanger (12) is connected to the first processor (10), which simultaneously constitutes said first heat exchanger, for transferring liquid ammonia and to the second processor (11) for transferring sodium carbonate solution.

3. A heat plant according to Claim 2, characterized in that a cooling device is incorporated in a branch line for liquid ammonia extending between the second heat exchanger (12) and the first processor (10), said cooling device operating with cooling water obtained from the low-temperature side of the first heat exchanger (10).

4. A heat plant according to Claim 1, characterized in that the first chemical component is ammonia, in that the second chemical component is carbon dioxide, in that the second processor (21), which simultaneously constitutes the second heat exchanger, is connected to a disintegrator (24) for

reconstituting the two chemical components; and in that the disintegrator (24) is connected to the first processor (20), which simultaneously constitutes the first heat exchanger, for transfer of liquid ammonia, and to the second processor (21) for transfer of carbon dioxide.

5. A heat plant according to Claim 4, characterized in that a cooling device (24) is incorporated in a conduit (241) extending between the disintegrator (24) and the first processor (20); and in that the cooling device has a low-temperature side which is connected to the high-temperature side of the first heat exchanger, and a high-temperature side which is connected to the high-temperature side of the second heat exchanger (21).

6. A heat plant according to Claim 1, characterized in that the first chemical component is sulphur trioxide; in that the second chemical component is steam or water vapor; in that the second processor (31) is arranged to effect a hydration process and is connected, via the second heat exchanger (32) to a chemical reactor (34) for forming a ferri salt with a starting point from resultant hydration products; and in that a disintegrator (35) is connected to the output side of the chemical reactor (34) for re-forming and re-cycling sulphur trioxide, steam (water vapor) and iron oxide.

7. A heat plant according to Claim 6, characterized in that the output side of the second heat exchanger (32) is connected to a consumer unit (33) and a condensor (36), the cooling loop of which is connected to the low-temperature output of the first heat exchanger (30).

8. A heat plant according to Claim 1, characterized in that the first chemical component is sulphur trioxide, in that the second chemical component is steam (water vapor) and in that the second processor (31) is arranged to effect a hydration process and is connected, via the second heat exchanger (32) to a disintegrator (35) for re-forming and re-cycling sulphur trioxide and steam (water vapor).

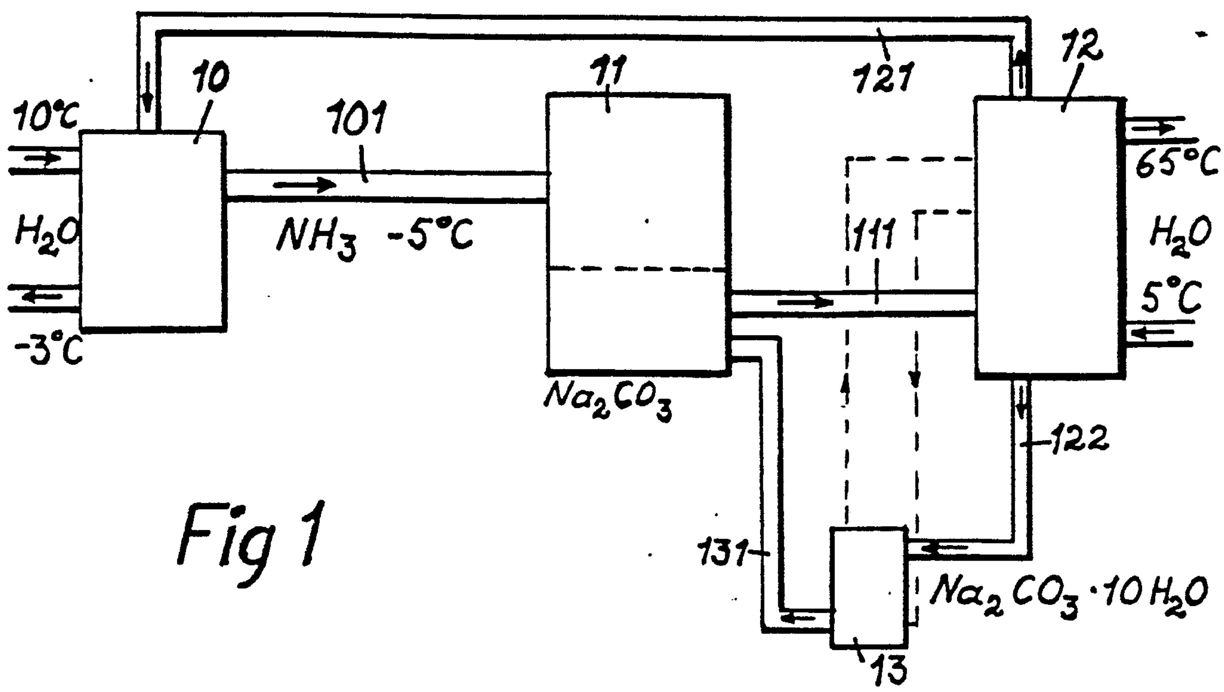
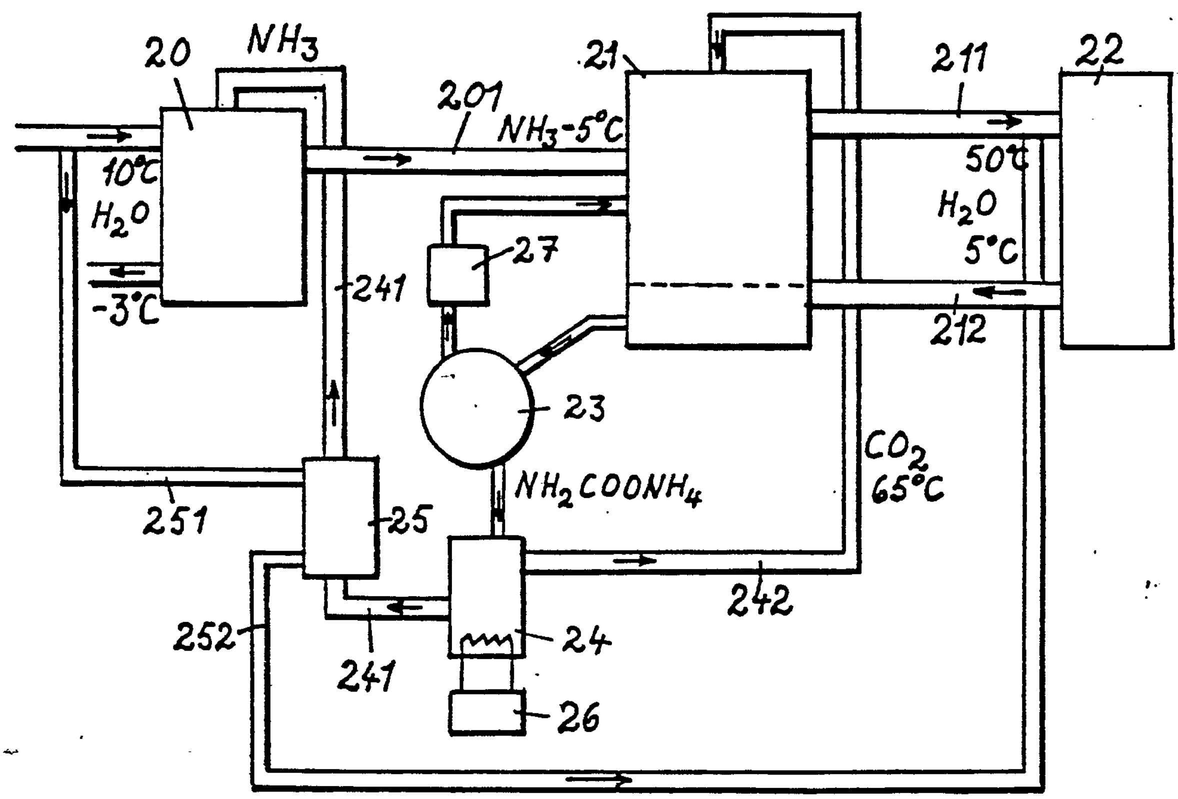

10
101
11
121
12
10°C
H2O
-3°C
NH3 -5°C
111
65°C
H2O
5°C
Na2CO3
122
131
Na2CO3·10H2O
13

Fig 1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NH3
201
NH3-5°C
21
211
22
10°C
H2O
-3°C
50°C
H2O
5°C
27
241
212
23
CO2
65°C
NH2COONH4
251
25
242
252
24
241
26

Fig 2

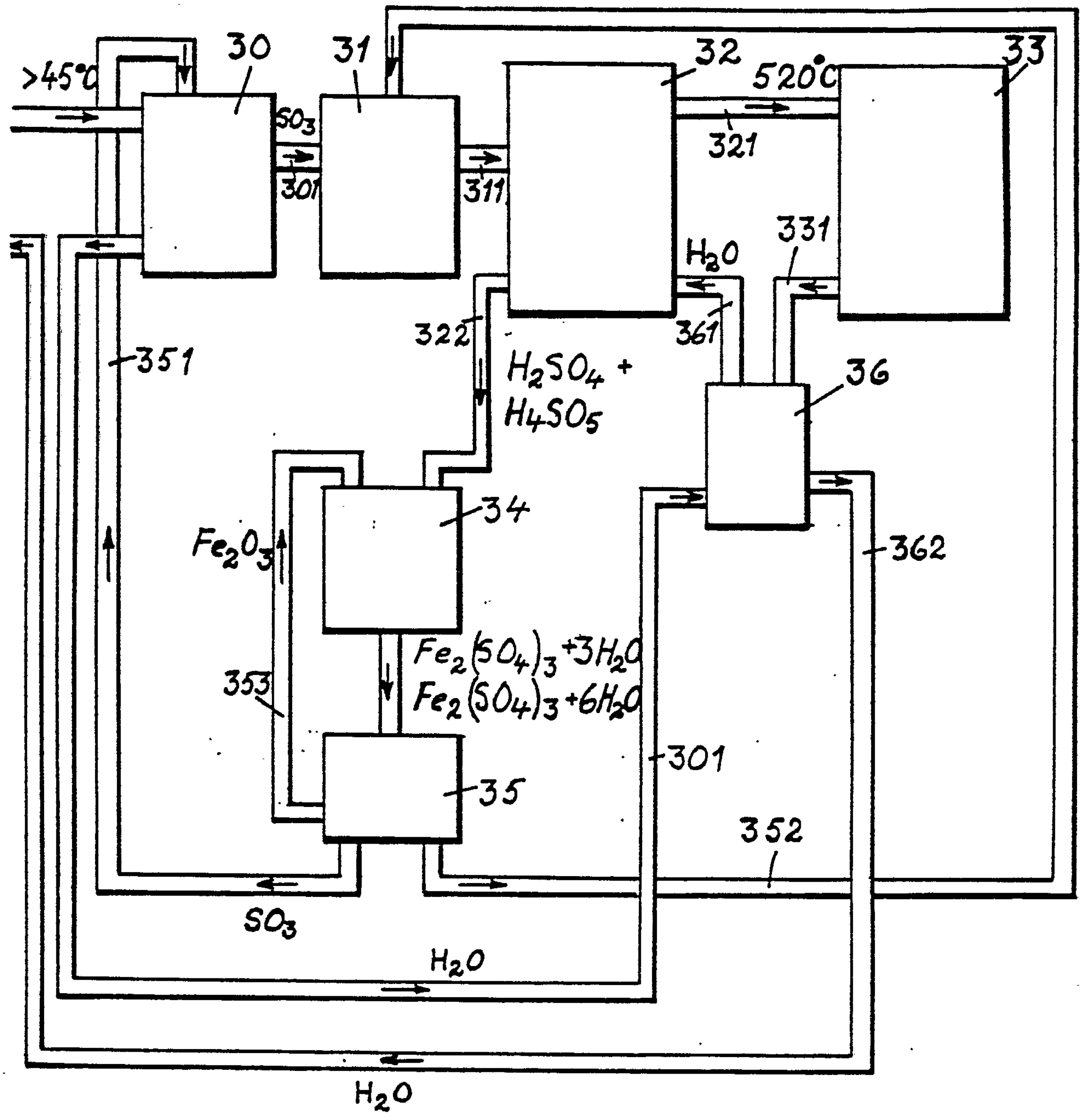
>45°C
30
31
32
33
520°C
SO_3
301
311
321
331
H_2O
361
322
H_2SO_4 +
H_4SO_5
36
351
34
Fe_2O_3
$Fe_2(SO_4)_3+3H_2O$
$Fe_2(SO_4)_3+6H_2O$
353
35
301
362
352
SO_3
H_2O
H_2O

Fig 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE85/00340

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

F 24 J 1/00, F 25 B 29/00, C 09 K 5/02

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	C 01 B 17/69, /74, 21/12; C 01 C 1/26, /28; C 01 D 7/00, /35, /37; C 09 K 5/00-/06; F 24 J 1/00-/04, 3/00, /04; F 25 B 13/00, .../...

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X,Y	US, A, 4 386 501 (MARTIN MARIETTA CORPORATION) 7 June 1983	1, 4-8
X,Y	US, A, 4 413 480 (INSTITUTE OF GAS TECHNOLOGY) 8 November 1983 & US, 4487027	1, 4-8
Y	GB, B, 1 506 129 (SNAMPROGETT SPA) 5 April 1978 & NL, 7604303 FR, 2308615 DE, 2617185 US, 4082797	4-5
Y	DE, A, 1 922 788 (HUMPHREYS & GLASGOW LTD) 20 November 1969 & FR, 2007886	6-8
Y	DE, A1, 3 303 287 (METALLGESELLSCHAFT AG) 2 August 1984 & EP, 0115880	6-8

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1985-11-18	1985-11-25
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	Bertil Dahl

L.E

Form PCT/ISA/210 (second sheet) (January 1985)

International Application No. PCT/SE85/00340

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II Fields searched (cont).

IPC 4 15/00-/02, /16, 17/00, 29/00

US Cl 62:4, 112, 114;
126:263;
165:29;
252:67-70

V.☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers ...., because they relate to subject matter not required to be searched by this Authority, namely:

2.☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.☐ Claim numbers ...., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI.☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4.☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.