

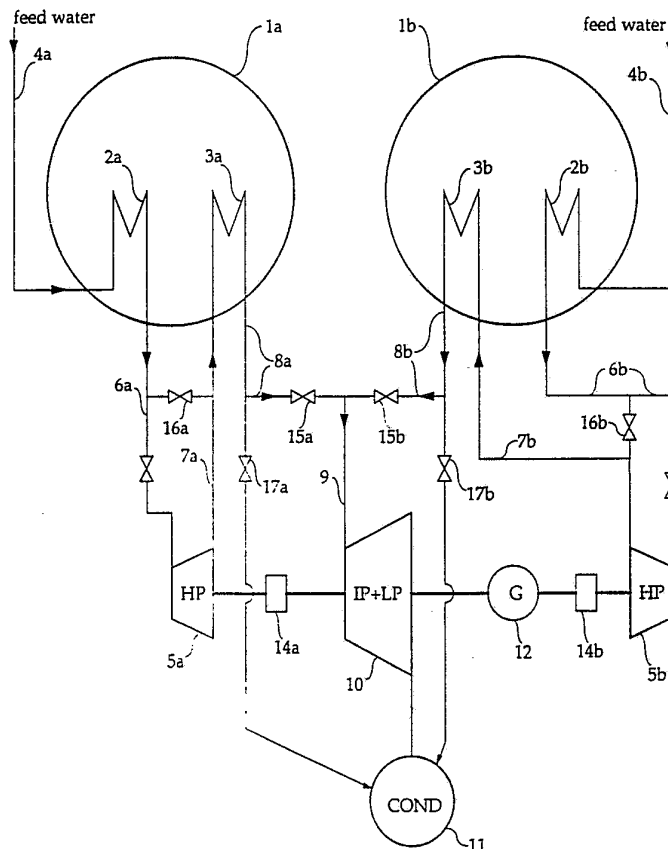


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(54) Title: STEAM SYSTEM IN A MULTIPLE BOILER PLANT

(57) Abstract

A number of boiler modules (1a, 1b) have an intermediate- and low-pressure turbine (10) which is common to these boiler modules as well as a separate high-pressure turbine (5a, 5b) for the respective boiler module (1a, 1b). The different high-pressure turbines (5a, 5b) are adapted in flow capacity to their respective boiler module.



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Steam system in a multiple boiler plant

TECHNICAL FIELD

5 The invention relates to a plant concept for power plants comprising boiler modules with reheating of steam for turbines in a common steam system.

BACKGROUND ART

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In power plants where more than one boiler module is used for generation of steam in separate steam generators for the respective boiler modules, steam from the respective steam generators may drive a steam turbine which is common to the boiler modules. If the steam generator in each boiler module comprises a high-pressure superheater and a reheater, the high-pressure steam from the different boiler modules is passed via valves to a common high-pressure turbine, where the steam expands and delivers energy, whereafter the steam is returned to the boiler modules for reheating in a re-heater in the respective boiler module. The steam from the different reheaters is then passed to an intermediate-pressure and low-pressure turbine common to the modules, whereafter the steam after condensing is passed to a tank for feedwater, from which the water is utilized for new steam generation.

One reason for utilizing fewer turbines than the number of boiler modules occurring is the considerable saving of costs for the installation of fewer steam turbine units in the plant.

In the normal operating range, that is, 30% to 100% power output from the plant, sliding pressure control is nowadays used. By this is meant that the pressure of the high-pressure steam, in the following called live steam, as well as the pressure of the reheater steam are approximately proportional to the steam flow. During start-up and shutdown

of the plant and in case of turbine trip (emergency stop of the turbine), the control of the boiler and the turbine, respectively, is performed in the most careful way. This means that the pressure in the reheater, determined by the
5 pressure in the intermediate-pressure and low-pressure turbine, and hence the volume flow (the steam rate) through the high-pressure superheater and the reheater in the load range vary within acceptable limits without any special control.

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If two boilers comprising reheaters are installed with a common steam turbine for both boilers, no problems arise for the high-pressure outlet of the steam turbine and for the reheaters of the boilers since the two boilers are driven
15 with the same power. The individual boilers and the steam turbine have the same load expressed as a percentage. On the other hand, the distribution of the steam flows of the reheaters in the two boilers must be controlled in relation to each other with the aid of valves.

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Control difficulties for a plant concept with two boilers and a common steam turbine arise when the two boilers are driven with different loads. The steam pressure before the intermediate-pressure turbine will then be the sum of the
25 current reheater steam flows of the respective boilers divided by the design flow of the two reheaters. Before the high-pressure turbine the same conditions apply for the steam pressure, that is, that the sum of the steam flows in the two superheaters for high-pressure steam in the
30 respective boilers divided by the design steam flows of these superheaters gives the pressure before the high-pressure turbine. If, for example, one boiler is driven with 50% load and the other boiler is driven with 100% load, the steam turbine will be driven with 75% of nominal full load.
35 This means that the steam turbine receives an inlet steam pressure which amounts to 75% of the full load pressure. The superheater for live steam in the boiler which is driven with 100% load is designed so as to have, at this load, a

volume flow and a steam rate which require full pressure in the superheater. Because of this it is required that a higher pressure is applied to the superheater in this full-load boiler than what is justified by the inlet pressure at the steam turbine. In this connection, a throttle valve, for example, is utilized at the boiler outlet of the superheater, whereby the pressure of this superheater is raised. A disadvantage of such a method is that an extra throttling loss is obtained.

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On the other hand, the superheater in the boiler which is driven with only 50% load is subjected to a pressure which is 50% too high, which provides a considerably lower volume flow of steam through the superheater compared with the case where the boilers are working under equivalent conditions.

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The steam pressure at the intermediate-pressure turbine, which is determined by the flow through the intermediate-pressure and low-pressure turbine, will also lie at 75% of the full-load pressure. The steam flow in the reheaters for the respective boiler must be distributed such that the reheater of each boiler is supplied with the correct steam flow in relation to the live steam flow out of the corresponding boiler. The steam pressure of the reheaters will be incorrect for both boilers in the same way as in the case of the above-described unbalance between the live steam pressures in the respective boilers. The pressure at the outlet of the high-pressure turbine, which is common to both boilers, must be maintained to avoid too high steam rates in the reheater belonging to the full-load boiler. As a result of this, the expansion line for the high-pressure turbine is reduced, which means that the output power from the plant is reduced compared with the output power which is achieved during parallel running of the two boilers with the same load, where the sum load for both boilers is the same as in the example described. Because of the reduced expansion, the temperature at the outlet from the high-pressure turbine is at the same time higher than the calculated temperature in

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the heat transfer area for the reheater. The temperature has to be reduced by, for example, water injection, which results in deteriorated efficiency. The boiler which is driven at only 50% of full load is, on the other hand, exposed to the opposite conditions. The reheater in this boiler senses too high a pressure which causes too low a volume flow whereas the temperature of the inlet steam is too low, which in turn contributes to the temperature of the outlet steam from the reheater becoming too low. These circumstances create demands for additional water injection into the reheater in this partial-load boiler, whereby a high pressure drop across the reheater is accomplished, also this contributing to a deterioration of the efficiency of the plant when the plant is not driven with equivalent loads in the two boilers. The lower temperature of the steam out of the reheater related to the steam turbine load may cause a problem for the steam turbine according to ruling standards.

20 SUMMARY OF THE INVENTION

The present invention comprises a number of boiler modules, an intermediate-pressure and low-pressure turbine common to these boiler modules, and a separate high-pressure turbine for the respective boiler module. The different high-pressure turbines are adapted in flow capacity to their boiler modules.

A generator which is driven by the different turbines may consist of a generator common to the turbines or of a generator for the intermediate- and low-pressure turbine with separate generators for each high-pressure turbine.

With an increase of the number of turbines according to the invention, the normal division between boiler and steam cycle is changed. In a boiler concept according to the invention, the gas cycle, the superheater for live steam, the high-pressure turbine and the reheater may be considered

to be part of the boiler whereas the intermediate and low-pressure turbine constitutes the steam side.

An advantage of a boiler concept according to the invention is that the high-pressure turbines may be driven independently of each other and be adapted to the load with which the boiler to the respective connected high-pressure turbine is utilized. In this way, the above-mentioned throttling losses, which are unavoidable in the prior art, are avoided when different boiler modules must be driven under varying load conditions. The pressure in the reheaters will also be adapted to that which corresponds to the load of the respective boiler module.

If, for example, a boiler concept according to the above is utilized in a PFBC plant, it is possible to connect the high-pressure steam turbine and the gas turbine which is driven by the flue gases from the combustion in a PFBC combustor to a common shaft, with the steam turbine being either disconnectible or not disconnectible.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 schematically shows a boiler plant with two boiler modules and the associated steam turbines according to the invention.

Figures 2 and 3 show variants of the connection between steam turbines and generators.

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DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will be described with reference to the accompanying drawings.

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Figure 1 shows a boiler plant comprising two boiler modules 1a, 1b. These boiler modules may be heated in an optional way, the manner of heating being left out of consideration

in this description. The first boiler module comprises a first superheater 2a for live steam and a reheater 3a. In a corresponding way, the second boiler module comprises a second superheater 2b for live steam and a second reheater 3b. Feedwater is brought via the conduits 4a and 4b to the respective superheaters 2a, 2b.

From the first superheater 2a for live steam in the first boiler module 1a, the steam is passed via a conduit 6a to a first high-pressure turbine 5a, which is driven by the steam. In a corresponding way, steam from the second superheater 2b for live steam is passed in the second boiler module 1b via a conduit 6b to a second high-pressure turbine 5b, which is driven by the steam from the second superheater 2b.

The steam expanded in the first high-pressure turbine 5a is returned to the reheater 3a of the first boiler module via a conduit 7a for reheating, whereafter the steam is passed out of the first boiler module via a conduit 8a. According to the same process, the steam expanded in the second high-pressure turbine 5b is returned to the reheater 3b of the second boiler module, whereafter the reheated steam is passed out of the second boiler module via a conduit 8b.

The reheated steam from the two reheaters 3a, 3b is brought together into a common steam conduit 9, which is connected to an intermediate- and low-pressure turbine 10 common to both boiler modules 1a, 1b. From this turbine 10 the low-tempered steam is fed to a condenser 11.

The two high-pressure turbines 5a, 5b and the common intermediate- and low-pressure turbine 10 may be mounted on a common shaft together with a generator 12, common to all three turbines 5a, 5b, 10, for generation of electric energy. In this case, the high-pressure turbines 5a, 5b are connected to the common intermediate- and low-pressure turbine 10 via couplings 14a, 14b.

In the steam conduits 8a, 8b for reheated steam there is a first reheater cut-off valve 15a for steam from the first boiler module 1a and a second reheater cut-off valve 15b for steam from the second boiler module 1b. Upon start-up, shutdown or trip of any of the boiler modules 1a, 1b in the plant, the desired boiler module can be separated from the rest of the plant by closing the above-mentioned first reheater cut-off valve 15a or, alternatively, the above-mentioned second reheater cut-off valve 15b. The necessary steam for the separated boiler module is then sluiced via a first high-pressure bypass valve 16a or a second high-pressure bypass valve 16b, belonging to the boiler module in question, through reheater 3a or 3b and is sluiced via a relevant first IP-, LP-bypass valve 17a or a second IP-, LP-bypass valve 17b to the condenser 11. Thus, the two boilers operate completely separately.

During partial-load operation of any of the boiler modules 1a, 1b, the high-pressure turbines 5a, 5b can be driven with the desired load quite independently of each other. By throttling either the first reheater cut-off valve 15a or the second reheater cut-off valve 15b, the pressure in the relevant reheater 3a, 3b can be maintained and hence allow running with different loads in the respective boiler modules 1a, 1b.

As is clear from the schematic Figures 2 and 3, there are alternative concepts for connecting generators to the different turbines. In Figure 2 a variant is shown in which a generator G1, G2, G3 is connected to each individual turbine 5a, 5b, 10. Another alternative variant is illustrated in Figure 3, in which a generator G1 is connected to one of the high-pressure turbines 5a, whereas another generator G2 is connected to the other high-pressure turbine 5a and the intermediate- and low-pressure turbine 10, the latter two turbines being mounted on a common shaft with an intermediate coupling 14b.

The plant concept described above only illustrates an example where two boiler modules utilize separate high-pressure turbines, whereas an intermediate- and low-pressure turbine is common to the two boiler modules. In a corresponding way, a plant can be arranged which comprises more than two boilers, in which each boiler drives separate high-pressure turbines, whereas the different boilers share a common intermediate- and low-pressure turbine.

CLAIMS

1. A boiler plant comprising at least two boilers (1a, 1b) with a common steam system, wherein in each separate boiler a superheater (2a, 2b) and a reheater (3a, 3b) are arranged for generation and/or heating of steam and wherein the steam from said superheaters drives high-pressure turbines (5a, 5b) and an intermediate- and low-pressure turbine (10), **characterized in that** steam from the high-pressure superheaters (2a, 2b) in the separate boilers (1a, 1b) drives separate high-pressure turbines (5a, 5b) whereas reheated steam from the respective reheaters (3a, 3b) is passed to and drives an intermediate-pressure/low-pressure turbine (10) which is common to the boilers (1a, 1b).
2. A boiler plant according to claim 1, **characterized in that** the high-pressure turbines (5a, 5b), the intermediate-pressure/low-pressure turbine (10) and a generator (12) common to the turbines are arranged on the same shaft with the high-pressure turbines (5a, 5b) connected to the shaft over couplings (14a, 14b).
3. A boiler plant according to claim 1, **characterized in that** at least one of the high-pressure turbines (5a, 5b) is arranged and drives a generator (G1, G3) on a separate shaft.
4. A boiler plant according to claim 2 or 3, **characterized in that** control valves (15a, 15b) are arranged in the steam system of the plant, such that each boiler (1a, 1b) and the high-pressure turbine (5a, 5b) belonging to the respective boiler can be driven at partial load to the same degree and independently of the degree of load of the other boilers.

Fig. 1

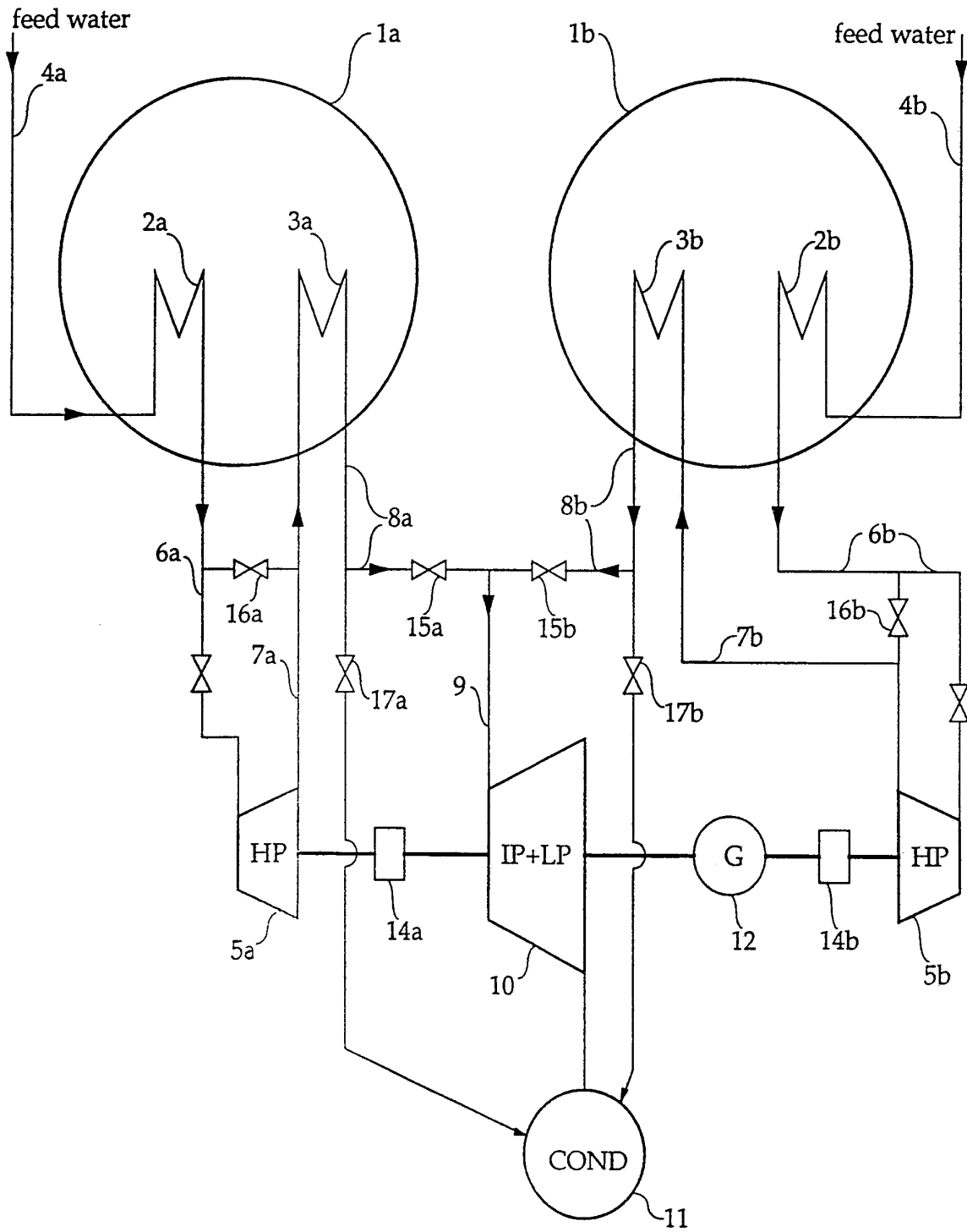


Fig. 2

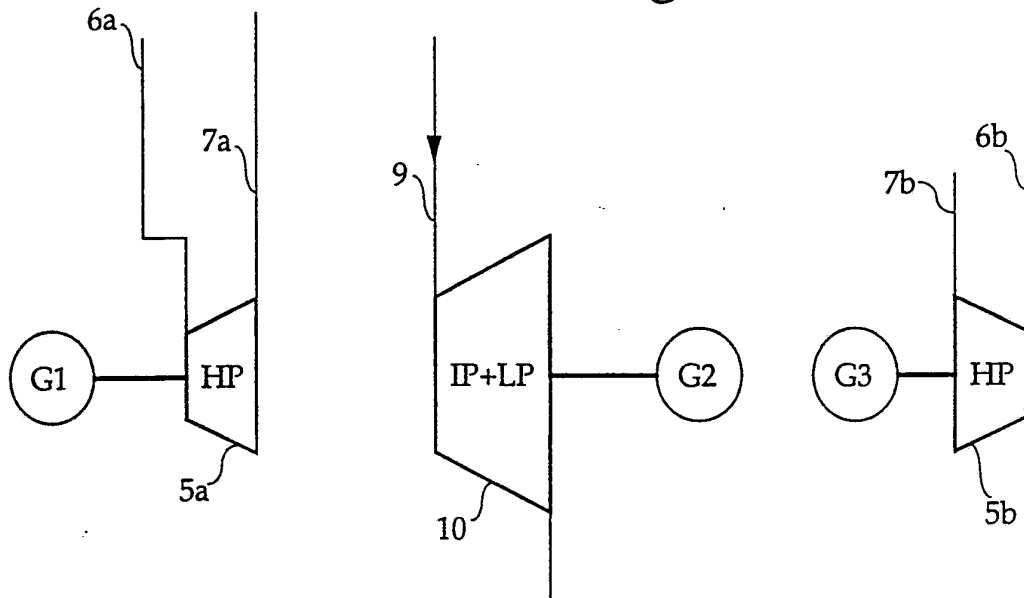
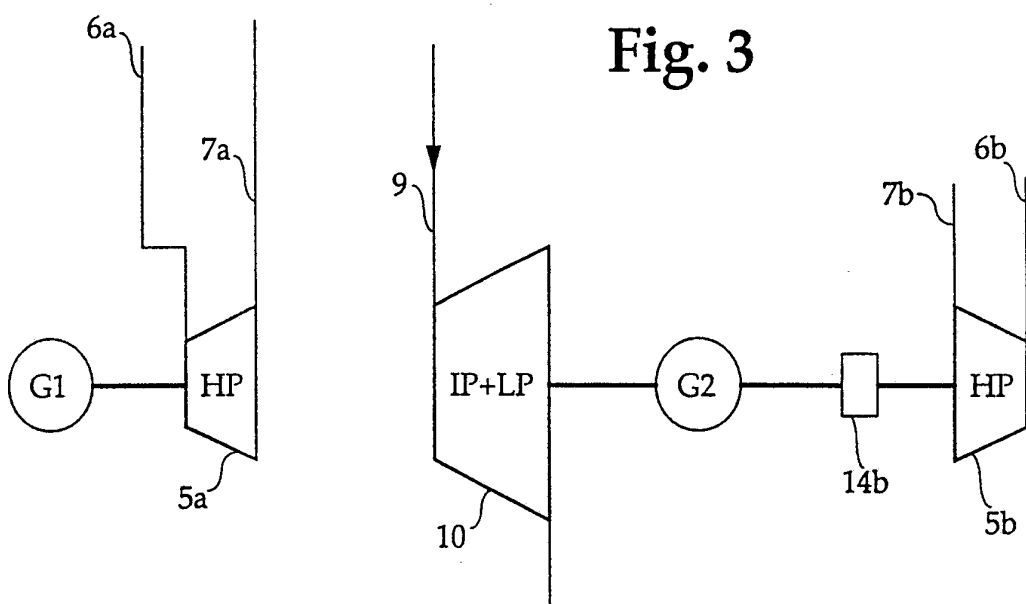


Fig. 3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 92/00837

A. CLASSIFICATION OF SUBJECT MATTER		
IPC5: F01K 7/22, F01K 11/02 According to International Patent Classification (IPC) or to both national classification and IPC		
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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB, A, 1473413 (GENERAL ELECTRIC COMPANY), 11 May 1977 (11.05.77) --	1
X	DE, A, 1239890 (SOCIETE RATEAU S.A.), 3 May 1967 (03.05.67) --	2-4
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Derwent's abstract, No 85- 43064/07, week 8507, ABSTRACT OF SU, C2, 1101565 (KRASD POLY), 7 July 1984 (07.07.84) ----- -----	2-4

INTERNATIONAL SEARCH REPORT
 Information on patent family members

26/02/93

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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DE-A- 1239890	03/05/67	FR-A- 1350026	00/00/00
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