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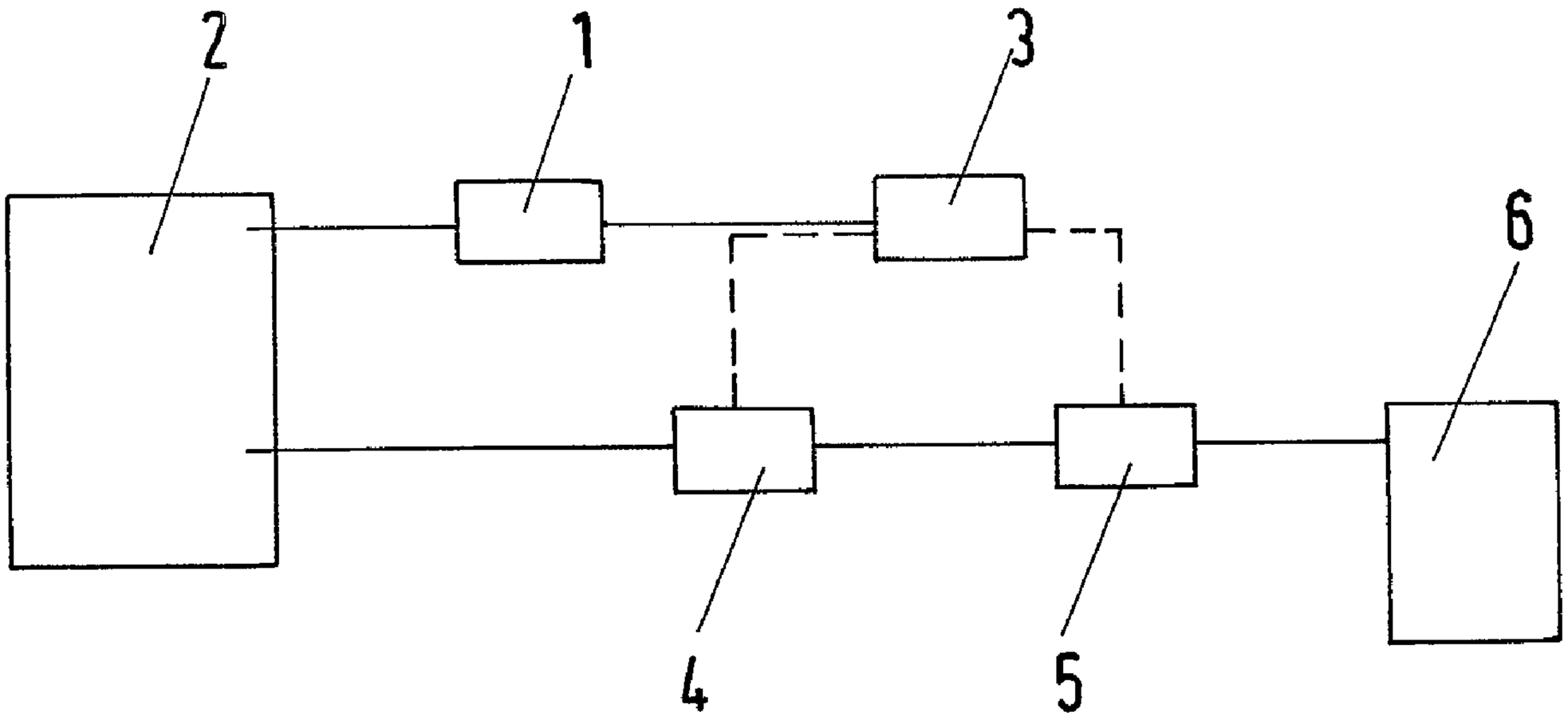
(54) Titre : PROCEDE ET DISPOSITIF POUR LE REGLAGE DE LA TENEUR EN MONOXYDE DE CARBONE DANS UN FOUR DE CEMENTATION ET DE CARBONITRURATION DES METAUX

(54) Title: PROCESS AND DEVICE FOR CONTROLLING THE CARBON MONOXIDE CONTENT OF A FURNACE ATMOSPHERE FOR CARBURIZING AND CARBONITRIDING METAL WORKPIECES



(57) Abrégé/Abstract:
The invention concerns a process and a device for controlling the CO content of a furnace atmosphere for carburizing and carbonitriding metal workpieces in a furnace, whereby the furnace atmosphere is produced by direct feeding of a mixture consisting of an oxidizing agent and a hydrocarbonaceous fuel as well as perhaps ammonia into the furnace. To ensure a continuous and trouble-free operation of the installation without sooting of the furnace, it is proposed that the CO content of the furnace atmosphere be ascertained and that a CO forming substance is added when a freely adjustable minimum CO content of the furnace atmosphere is attained. The device for carrying out this process has a CO analyzer 1 for ascertaining the CO content in the furnace atmosphere and a programmable CO control 3 for actuating a valve 4 and, if applicable, a pump 5 in dependency on the CO content in the furnace atmosphere.

Abstract

The invention concerns a process and a device for controlling the CO content of a furnace atmosphere for carburizing and carbonitriding metal workpieces in a furnace, whereby the furnace atmosphere is produced by direct feeding of a mixture consisting of an oxidizing agent and a hydrocarbonaceous fuel as well as perhaps ammonia into the furnace. To ensure a continuous and trouble-free operation of the installation without sooting of the furnace, it is proposed that the CO content of the furnace atmosphere be ascertained and that a CO forming substance is added when a freely adjustable minimum CO content of the furnace atmosphere is attained. The device for carrying out this process has a CO analyzer 1 for ascertaining the CO content in the furnace atmosphere and a programmable CO control 3 for actuating a valve 4 and, if applicable, a pump 5 in dependency on the CO content in the furnace atmosphere.

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Process and Device for Controlling the Carbon Monoxide Content of a Furnace Atmosphere for Carburizing and Carbonitriding Metal Workpieces

The invention concerns a process for controlling the carbon monoxide concentration of an atmosphere in a furnace for carburizing or carbonitriding metal workpieces in the furnace, wherein the atmosphere in the furnace is produced by feeding into the furnace a mixture consisting of an oxidizing agent, e.g. air, and a carbon-containing fuel and when required ammonia into the furnace.

The invention also concerns a device for carrying out said process.

In carburizing or carbonitriding processes, the required carburizing or carbonitriding atmosphere is produced either in separate gas generators (endogas) or by feeding nitrogen with methanol into the furnace. With both processes for producing gas, a relatively stable CO concentration results in the furnace, which is produced, in the first case, by adjusting the gas generator and the fuel used for the gas generator and, in the second case, by the percentage of methanol fed into the furnace. A third variation is the direct gassing with hydrocarbons and an oxidizing gas constituent, such as e.g. air or CO_2. When using this technique, liquid or gaseous fuels are mixed with the oxidizing agent and conveyed into the furnace. In this case, the CO portion required for the carburizing is produced in the furnace by direct reaction of the

fuel with the oxygen of the oxidizing agent. Of these direct gassing methods, the mixing of natural gas with air is currently most widely used. This is due to the ready availability and reasonable price of natural gas.

In this case, reaction of natural gas in the furnace with atmospheric oxygen takes place according to the equation

$$CH_4 + 0.5\ O_2 + 1.88\ N_2 \rightarrow CO + 2H_2 + 1.88\ N_2$$

When methane is completely reacted, according to the above equation, in the furnace with atmospheric oxygen, then a maximum CO concentration is attained in the furnace atmosphere of 20.5 % by volume. This high CO portion is only attained under ideal conditions (very high furnace temperature).

At low furnace temperatures, in particular below approx. 870°C, the above noted reaction is very slow and the conversion of methane into CO is correspondingly slight.

Moreover, the aforementioned CO formation reaction is further hindered by the presence of ammonia (required for the carbonitriding).

A low CO concentration has the results that the carbon transfer to the metal workpiece decreases, the furnace atmosphere for the carburizing or carbonitriding can be regulated only with difficulty and, in addition, the furnace very quickly becomes sooty. This sooting of the furnace, in turn, results in production standstills, since the furnace must be shut down and burned out to remove the soot.

An o b j e c t of the invention is to create a

control for the CO concentration of the furnace atmosphere which permits continuous and trouble-free operation of the carburizing and carbonitriding furnace even at low carburizing temperatures (≤870°C) and also in the presence of ammonia (carbonitriding).

In one aspect the present invention provides a process for controlling carbon monoxide concentration in an atmosphere of a furnace for carburizing or carbonitriding metal, wherein the furnace atmosphere is produced by feeding a mixture of an oxidizing agent and a hydrocarbonaceous fuel and in the case of carbonitriding additionally feeding ammonia into the furnace, wherein the carbon monoxide concentration of the furnace is determined and a carbon monoxide forming substance is added to increase the carbon monoxide concentration of the furnace atmosphere when the carbon monoxide concentration is at or below a set value.

In another aspect the invention provides an apparatus for carrying the process defined above, which apparatus comprises: a) a furnace, b) a carbon monoxide analyzer for determining the furnace carbon monoxide concentration, c) a programmable carbon monoxide control for actuating a valve to feed a carbon monoxide forming substance into the furnace in response to the determined carbon monoxide concentration in the furnace atmosphere.

In a further aspect, the invention provides a method for controlling CO contents of a furnace atmosphere for carburizing and carbonitriding metallic workpieces in a furnace, said method comprising the steps of: directly feeding a mixture of an oxidizing reagent and a hydrocarbon-containing fuel into the furnace for producing a CO-containing furnace atmosphere; measuring the CO contents of the furnace atmosphere; comparing the measured CO contents to a preset minimal CO value; introducing methanol into the furnace atmosphere when the measured CO contents is no longer greater than the preset minimal CO value.

In still another aspect, the invention provides a device for controlling CO contents of a furnace atmosphere for carburizing and carbonitriding metallic workpieces in a furnace by directly feeding a mixture of an oxidizing reagent and a hydrocarbon-containing fuel into the furnace for producing a CO-containing furnace atmosphere, by measuring the CO contents of the furnace atmosphere, by comparing the measured CO contents to a preset minimal CO value, and by introducing methanol into the furnace atmosphere when the measured CO contents is no longer greater than the preset minimal CO value; said device comprising: a CO analyzer for measuring the CO contents in the furnace atmosphere; a means for supplying methanol to the furnace, said means including a valve; and a programmable CO controller for controlling said valve depending on the measured CO contents in the furnace atmosphere.

According to a preferred embodiment, methanol is used as a CO forming substance. The methanol fed into the furnace atmosphere is broken down according to the reaction

$$CH_3OH \longrightarrow CO + 2H_2$$

(at a furnace temperature of ≥800°C), as a result of which the CO content in the furnace atmosphere increases again to above the set minimum CO content.

An alternative CO forming substance is CO_2.

In order to keep the amount of the CO forming substance to be added in each case small and the cost of the process reasonable, an upper value for the CO concentration can also be set. When this upper value is attained, the addition of the CO precursor is stopped until the CO concentration has again dropped to the minimum CO concentration in the course of the process.

In one preferred embodiment it was found that a CO concentration of about 12% is suitable as minimum CO concentration in the furnace atmosphere. If the concentration is below about 12% strong soot formation results and, in addition, the furnace atmosphere can no longer be accurately controlled. A bandwidth of between approx. 12% and 15% CO in the furnace has been proven to be especially suitable as range for the minimum and upper CO concentration. Since the course of the CO reduction is gradual below a CO concentration of 15%, an increase of the CO concentration by the addition of the CO precursor up to a limit of about 15% is sufficient to run the process for a longer time with a CO concentration above the minimum limit. Moreover, this narrow bandwidth results that only a small amount of the CO precursor must be used to increase the CO concentration, which in turn permits keeping the cost of the process low.

A device for carrying out the described process has a CO analyzer for determining the CO concentration in the furnace atmosphere and a programmable CO control in order to regulate a valve and, if applicable, a pump in dependency on the CO concentration. The valve and, if applicable, pump are switched to allow flow of material or operation when the set minimum CO concentration is attained. When the set upper limit of the CO concentration is attained, the valve is closed again and, if applicable, the pump switched off.

Further particulars and advantages can be found in the following description of the attached drawings in which the process of the invention, as well as the device for carrying out this process, are schematically illustrated, by way of example, in the accompanying drawings showing one embodiment of the invention, in which:

Fig. 1 is a diagram about the course of the CO content in the furnace atmosphere in the process of the invention and

Fig. 2 is a schematic illustration of a device for carrying out the process of the invention.

The variation of the CO concentration during a carbonitriding process is shown in the diagram in Fig. 1. The CO concentration drops dramatically during the process with the addition of ammonia to the furnace atmosphere. As can be seen in Fig. 1, the curve of the CO concentration course is very flat below 15% CO. Below the 12% line shown as a minimum CO concentration limit, when the CO concentration in the atmosphere of a furnace is too low, there occurs rapid sooting of the

furnace. When this lower limit is attained, a CO forming substance, e.g. methanol, is added to the furnace atmosphere which, due to the high process temperature, is broken down according to the reaction

$$CH_3OH \rightarrow CO + 2H_2$$

As a result of this CO formation due to the methanol breakdown, the CO concentration in the furnace atmosphere rises very quickly, as indicated by the steep rise of the CO curve in Fig. 1. When a freely adjustable upper limit is attained - 15% in Fig. 1 - the methanol supply is shut off again, so that the CO concentration in the furnace atmosphere decreases again due to the steadily continuing process.

It can be seen in Fig. 1 that the slight increase of the CO concentration from 12% to 15% already enables a trouble-free continuation of the process above the sooting limit for a longer period of time, since the slope of the CO curve is very flat below 15%.

The construction of an apparatus for carrying out the aforementioned process is shown in Fig. 2. The apparatus comprises a carbon monoxide analyzer 1, a furnace chamber 2, a CO controller 3, a valve 4, a pump 5 and a tank 6. The CO concentration of the furnace atmosphere in a furnace chamber 2 is determined by means of a CO analyzer. The control unit also has a programmable CO control 3, into which freely adjustable values can be set for the upper and lower CO concentrations.

The CO control 3 actuates a valve 4 and, if

applicable, a pump 5 via the control system (shown by a broken line) as soon as a comparison of the CO concentration obtained from the CO analyzer 1 with the minimum CO concentration set in the CO control 3 shows that this minimum CO concentration has been attained. The pump 5, actuated by the CO control 3, then conveys the CO precursor from the tank 6 through the valve 4, switched to open, into the furnace chamber 2. In the furnace chamber 2, the CO precursor is dissociated, as described above, as a result of which the CO concentration in the furnace atmosphere again increases. When a comparison of the CO concentration in the furnace atmosphere, determined by the CO analyzer 1, with the values stored in the CO control 3 show that the set upper CO concentration has been attained, the valve 4 is closed and, if applicable, pump 5 is switched off again via the CO control 3. The process described above begins anew as soon as the CO analyzer 1 and CO control 3 determines that the set minimum CO concentration is again attained.

With a process thus controlled, it is, on the one hand, ensured that the CO concentration of the furnace atmosphere never drops below the set minimum CO concentration which causes a strong sooting of the furnace and, on the other hand, that only as much CO former is fed into the furnace atmosphere as is required for a cost-efficient and trouble-free operation of the process.

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CLAIMS:

1. A method for controlling CO contents of a furnace atmosphere for carburizing and carbonitriding metallic workpieces in a furnace, said method comprising the steps of:

directly feeding a mixture of an oxidizing reagent and a hydrocarbon-containing fuel into the furnace for producing a CO-containing furnace atmosphere;

measuring the CO contents of the furnace atmosphere;

comparing the measured CO contents to a preset minimal CO value;

introducing methanol into the furnace atmosphere when the measured CO contents is no longer greater than the preset minimal CO value.

2. A method according to claim 1, wherein the step of directly feeding includes introducing ammonia into the furnace.

3. A method according to claim 1, wherein the step of comparing includes comparing the measured CO contents to a preset maximal CO value and wherein said step of introducing is continued until the measured CO contents reaches the preset maximal CO value.

4. A method according to claim 3, wherein the preset maximal CO value is 15%.

5. A method according to claim 1, wherein the preset minimal CO value is 12%.

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6. A device for controlling CO contents of a furnace atmosphere for carburizing and carbonitriding metallic workpieces in a furnace by directly feeding a mixture of an oxidizing reagent and a hydrocarbon-containing fuel into the furnace for producing a CO-containing furnace atmosphere, by measuring the CO contents of the furnace atmosphere, by comparing the measured CO contents to a preset minimal CO value, and by introducing methanol into the furnace atmosphere when the measured CO contents is no longer greater than the preset minimal CO value; said device comprising:

a CO analyzer for measuring the CO contents in the furnace atmosphere;

a means for supplying methanol to the furnace, said means including a valve; and

a programmable CO controller for controlling said valve depending on the measured CO contents in the furnace atmosphere.

7. A device according to claim 6, wherein said means for supplying includes a pump and wherein said CO controller controls said pump.

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Fig.1

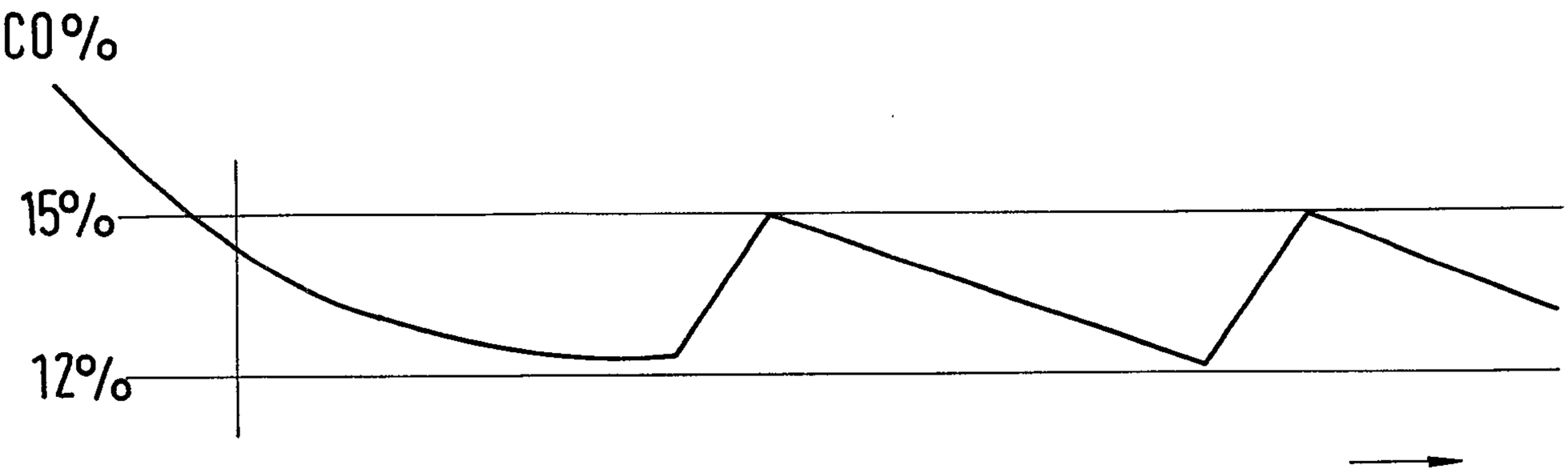
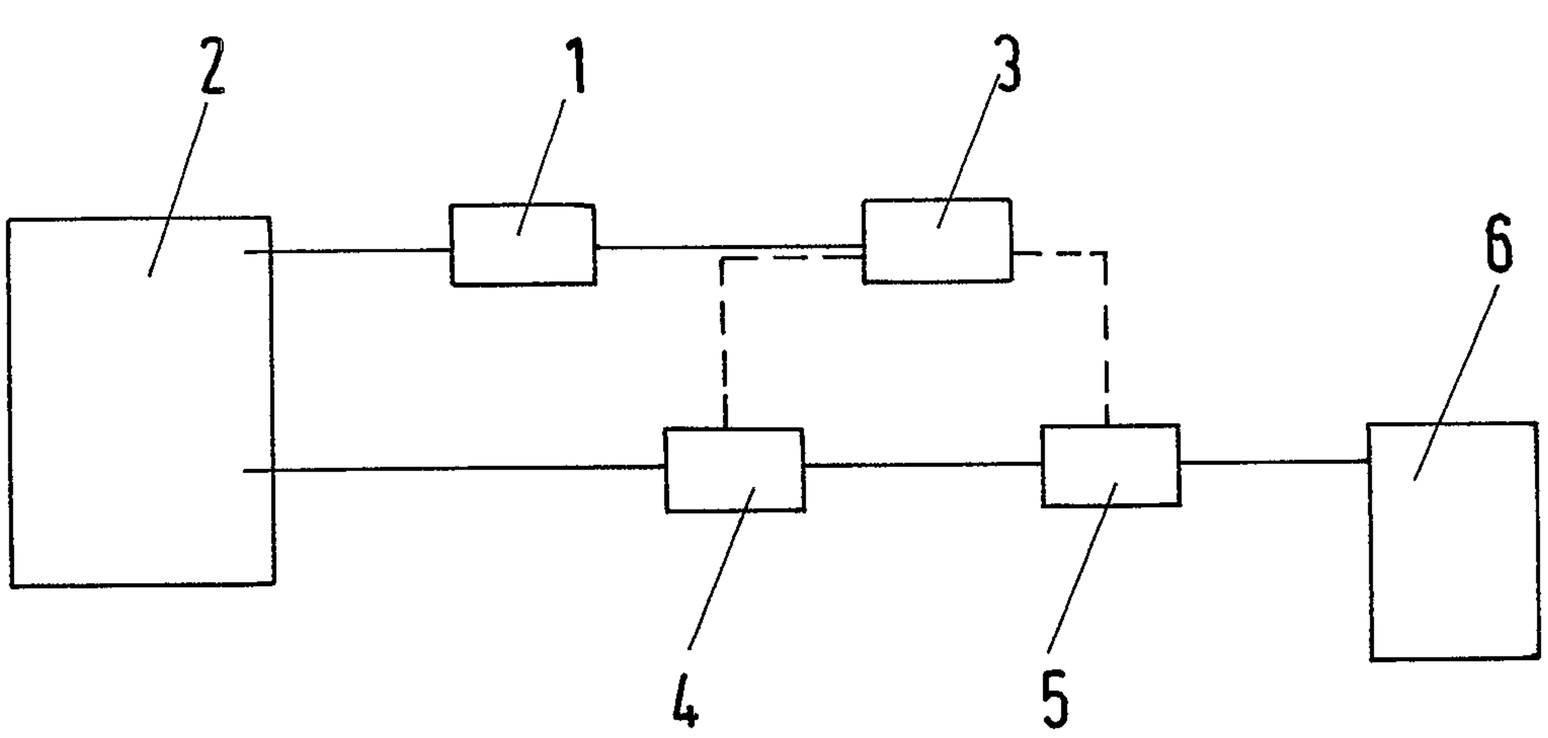
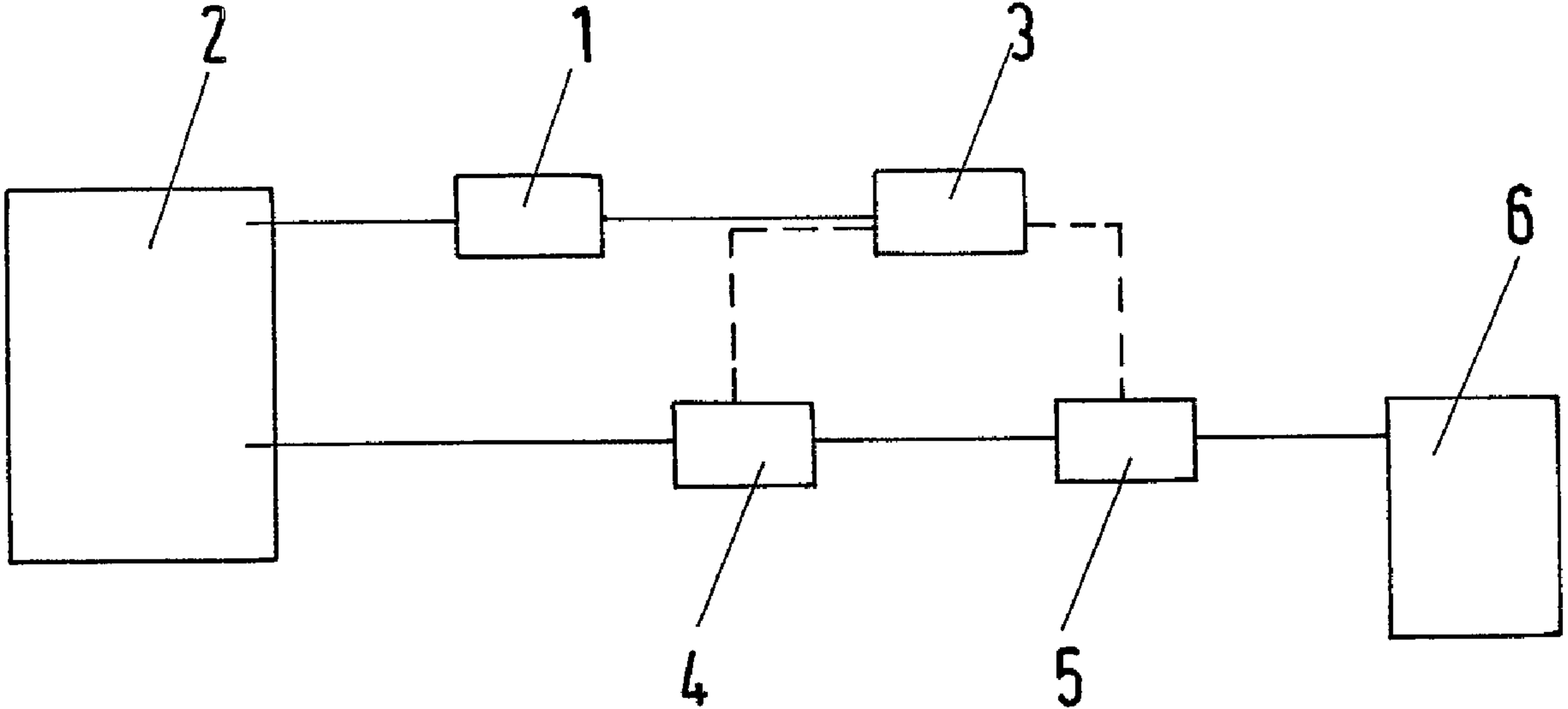


Fig.2

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