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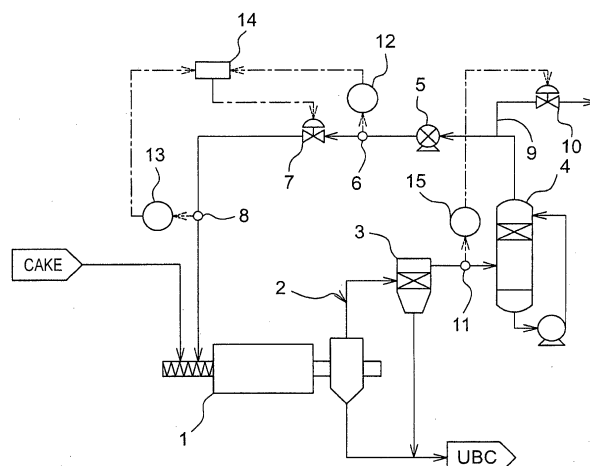
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(54) **SOLID FUEL MANUFACTURING METHOD AND MANUFACTURING DEVICE**

(57) A drying step is executed in a stable state regardless of the increase or decrease in the conveyance amount of porous coal. A disclosed method includes: a mixing step of mixing porous coal with a mixture oil containing solvent oil and heavy oil, to obtain material slurry; an evaporation step of heating the material slurry to promote dehydration of porous coal and impregnating the mixture oil into pores of porous coal, to obtain dehydrated slurry; a solid-liquid separation step of separating upgraded porous coal and the mixture oil from the dehy-

drated slurry; and the drying step of drying the upgraded porous coal by heating and conveying it while supplying carrier gas. The method includes: setting a target value of the circulation amount of carrier gas and a target value of the pressure of carrier gas at the drying step; calculating control outputs, based on deviations between the target values and measured values corresponding respectively thereto; and adjusting the supply amount of carrier gas, based on a smaller value between the control outputs obtained.

Fig.1



Description

TECHNICAL FIELD

[0001] The present invention relates to a method of and a device for manufacturing solid fuel using porous coal as a starting material. More particularly, the present invention relates to a method of and a device for manufacturing solid fuel, characterized by a stable operation of a drying step in which separated upgraded porous coal is heated and conveyed to be dried while being supplied with a carrier gas.

BACKGROUND ART

[0002] A conventional method of manufacturing solid fuel using porous coal as a starting material is for example a method described in Patent Document 1. In the method, porous coal (material coal) is first crushed at a crushing step, and then mixed with mixture oil containing heavy oil and solvent oil at a mixing step to obtain material slurry. After preheating, the material slurry is heated to dehydrate porous coal and impregnate its pores with mixture oil at an evaporation step, to obtain dehydrated slurry. The dehydrated slurry is separated into upgraded porous coal and mixture oil at a solid-liquid separation step and thereafter only the upgraded porous coal is dried at a drying step. At the drying step, the upgraded porous coal is conveyed and heated within a heating type rotary dryer so that it is dried by allowing carrier gas to flow. The dried upgraded porous coal is then cooled and molded to obtain solid fuel. On the other hand, mixture oil recovered at the solid-liquid separation step and the drying step is refluxed to the mixing step for reuse. Carrier gas recovered at the drying step is again refluxed into the dryer for reuse.

[0003] However, the conveyance amount of porous coal may vary due to a variation in the operation status at each step. For this reason, if the conveyance amount of upgraded porous coal rapidly increases at the drying step, the amount of evaporated oil may increase to raise the inner pressure. This may impair the sealing properties (sealability), with the result that gas may leak out. Ordinarily, although the main component of carrier gas is nitrogen, carrier gas contains solid in addition to solvent oil and moisture, so that there may occur increased running cost due to solvent oil loss and adverse effects on the ambient environment due to scattering of dust and generation of foreign odor.

[0004] On the other hand, if the conveyance amount of upgraded porous coal rapidly decreases at the drying step, the amount of evaporated oil may reduce to lower the inner pressure to a negative pressure. In consequence, the ambient atmosphere enters the inside and the internal oxygen concentration rises, with the result that the stability of high-temperature upgraded porous coal may be impaired.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0005] Patent Document 1: JP-A-7-233383

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006] Thus, an object of the present invention is to enable a drying step to be executed in a stable state regardless of the increase or decrease in the conveyance amount of porous coal.

MEANS FOR SOLVING PROBLEM

[0007] The present invention provides, as means for solving the problem, a method of manufacturing solid fuel including:

a mixing step of mixing porous coal with a mixture oil containing solvent oil and heavy oil, to obtain material slurry; an evaporation step of heating the material slurry to promote dehydration of porous coal and impregnating the mixture oil into pores of porous coal, to obtain dehydrated slurry; a solid-liquid separation step of separating upgraded porous coal and the mixture oil from the dehydrated slurry; and a drying step of drying the upgraded porous coal by heating and conveying it while supplying carrier gas, wherein the method includes:

setting a target value of the circulation amount of carrier gas and a target value of the pressure of carrier gas at the drying step;

calculating control outputs, based on deviations between the target values and measured values corresponding respectively thereto; and
adjusting the supply amount of carrier gas, based on a smaller value between the control outputs obtained.

[0008] According to this, the supply amount of carrier gas is adjusted based on a smaller one between control outputs that are calculated based respectively on the circulation amount and the pressure of carrier gas, so that carrier gas pressure at the drying step can be stabilized without significant changes.

[0009] Preferably, the target values are each decided based on the supply amount of upgraded porous coal to be dried at the drying step and on the amount of oil contained in upgraded porous coal subjected to the drying step.

[0010] Preferably, the target values are each decided such that the pressure of carrier gas at the drying step lies within a preset range.

[0011] The present invention provides, as means for solving the problem, a device for manufacturing solid fuel including:

a mixing vessel that mixes porous coal with a mixture oil containing solvent oil and heavy oil, to obtain material slurry;
an evaporator that heats the material slurry to promote dehydration of porous coal and that impregnates the mixture oil into pores of porous coal, to obtain dehydrated slurry;
a centrifuge that separates upgraded porous coal and the mixture oil from the dehydrated slurry;
a dryer that dries the upgraded porous coal by heating and conveying it while supplying carrier gas; and
a control unit that sets a target value of the circulation amount of carrier gas and a target value of the pressure of carrier gas in the dryer, that calculates control outputs, based on deviations between the target values and measured values corresponding respectively thereto, and that adjusts the supply amount of carrier gas, based on a smaller value between the control outputs obtained.

[0012] Preferably, the control unit decides the target values, each based on the supply amount of upgraded porous coal to be dried in the dryer and on the amount of oil contained in upgraded porous coal leaving the dryer.

[0013] Preferably, the control unit decides each of the target values such that the pressure of carrier gas at a drying step lies within a preset range.

EFFECT OF THE INVENTION

[0014] According to the present invention, the supply amount of carrier gas is adjusted based on a smaller one between control outputs that are calculated based respectively on the circulation amount and the pressure of carrier gas. For this reason, the circulation amount and the pressure of carrier gas can rapidly reach a stable state, thereby contributing to the stable operability at the drying step.

BRIEF DESCRIPTION OF DRAWINGS

[0015] Fig. 1 is a schematic diagram showing part of an upgraded brown coal manufacturing device according to an embodiment.

MODE FOR CARRYING OUT THE INVENTION

[0016] An embodiment according to the present invention will now be described with reference to the accompanying drawing.

[0017] Fig. 1 schematically shows part of an upgraded brown coal manufacturing device (an example of a solid fuel manufacturing device) according to the embodiment. Although not shown, the upgraded brown coal manufacturing device executes a mixing step in a mixing vessel, executes an evaporation step in an evaporator, and executes a solid-liquid separation step in a decanter centrifuge. The upgraded brown coal manufacturing device executes a drying step in a dryer 1, to obtain upgraded brown coal.

[0018] In the dryer 1, upgraded porous coal is heated and conveyed to be dried while being supplied with a carrier gas. Nitrogen (N₂) is used herein as carrier gas to prevent upgraded porous coal from firing. Upgraded porous coal supplied into the dryer 1 is assumed to contain 30-40 % of oil.

[0019] The dryer 1 used is of an indirect heating type having a heater not shown in which the temperature of the internal carrier gas is controlled to approximately 200°C. Upgraded porous coal is conveyed by a screw conveyor within the dryer 1. The screw conveyor has a tubular rotary shaft whose outer peripheral surface is formed with a plurality of small-diameter apertures. Carrier gas can newly be supplied via the rotary shaft into the dryer 1.

[0020] A circulation path 2 is connected to the dryer 1, for recovering carrier gas to again supply it into the dryer 1. Midway along the circulation path 2 there are arranged, in the mentioned order from the outlet side of the dryer 1, a dust

collector 3, a spray tower 4, a blower 5, a flow rate detection sensor 6, a first flow rate regulating valve 7, and a first pressure detection sensor 8. An exhaust pipe 9 is connected to a piping extending from the spray tower 4 to the blower 5 and is disposed with a second flow rate regulating valve 10. The pressure in the middle of a piping connecting the dust collector 3 and the spray tower 4 is detected by a second pressure detection sensor 11.

[0021] A detection signal from the flow rate detection sensor 6 is input to a flow indication controller (FIC) 12. A detection signal from the first pressure detection sensor 8 is input to a first pressure indication controller (PIC) 13. The FIC 12 and the PIC 13 calculate control output values from Math. 1 as will be described later. The control output values calculated by the FIC 12 and the PIC 13 are compared by a low select circuit (LS circuit) 14 so that the opening of the first flow rate regulating valve 7 is adjusted based on a lower one. In this case, the opening of the first flow rate regulating valve 7 is adjusted so that carrier gas pressure in the circulation path 2 is kept within the predetermined range (e.g., 1-2 kPa. Note that this value varies depending on the sealing designs and operation conditions for a conveyer, the dryer 1, etc.). A detection signal from the second pressure detection sensor 11 is input to a second PIC 215. Based on this input signal, the second PIC 15 regulates the opening of the second flow rate regulating valve 10 in a manner as described later, to thereby restrain the pressure in the circulation path 2 from rising.

[0022] The dust collector 3 serves to collect upgraded porous coal dust contained in carrier gas discharged from the dryer 1.

[0023] Upgraded brown coal (UBC) is discharged from the dryer 1 or the dust collector 3.

[0024] The spray tower 4 serves to condense and separate mixture oil from carrier gas passing through the dust collector 3.

[0025] The blower 5 serves to form a carrier gas flow from the circulation path 2 to the dryer 1.

[0026] Actions of the upgraded brown coal device having the above configuration will then be described.

[0027] Upgraded brown coal (an example of solid fuel) is obtained through a mixing step, an evaporation step, a solid-liquid separation step, and a drying step.

[0028] At the mixing step, porous coal is mixed with mixture oil containing solvent oil and heavy oil to obtain material slurry.

[0029] At the evaporation step, the material slurry obtained at the mixing step is heated to promote the dehydration of porous coal. At the same time, the mixture oil is impregnated into pores of porous coal to obtain dehydrated slurry.

[0030] At the solid-liquid separation step, upgraded porous coal and the mixture oil are separated from the dehydrated slurry by the decanter centrifuge.

[0031] At the drying step, the upgraded porous coal obtained at the solid-liquid separation step is heated and conveyed to be dried while being supplied with carrier gas within the dryer 1, to obtain upgraded brown coal.

[0032] The drying step featuring the present invention will hereinbelow be described in detail.

[0033] At the drying step, a target value of the carrier gas circulation amount and a target value of the carrier gas pressure at the inlet of the dryer 1 are set based on the supply amount of porous coal supplied into the dryer 1 and on the oil amount contained in the porous coal at the outlet side of the decanter centrifuge. In this case, the target value of the carrier gas circulation amount and the pressure target value are set such that the carrier gas pressure in the dryer 1 lies within a previously set pressure range (set pressure range) with respect to the supply amount of porous coal and the amount of oil contained therein. These target values to be set may be found in advance by experiment, etc.

[0034] A control output value is then calculated from Math. 1, based on the set target value of the carrier gas circulation amount and on a measured value of the carrier gas flow rate detected by the flow rate detection sensor 6 (hereinafter, this control output value is referred to as first control output value). Similarly, a control output value is calculated from Math. 1, based on the set target value of the carrier gas pressure and on a measured value of the carrier gas pressure detected by the first pressure detection sensor 8 (hereinafter, this control output value is referred to as second control output value).

[Math. 1]

$$MV = \frac{100}{PB} \times \left\{ e(t) + \frac{1}{Ti} \times \int e(t)dt + Td \times \frac{de(t)}{dt} \right\}$$

MV: control output

e(t): control deviation (target value SV-detected value PV)

PB: proportional band (%)

Ti: integral time (min.) control deviation regulating parameters

Td: derivative time (min.)

[0035] Subsequently, by a low select control, the calculated control output values are compared so that the opening of the first flow rate regulating valve 7 is adjusted in accordance with a smaller value.

[0036] When the flow rate and the pressure of carrier gas flowing through the circulation path 2 are stable, the control output value is calculated based on a flow rate detected by the flow rate detection sensor 6 and on the target value so that the opening of the first flow rate regulating valve 7 is adjusted.

[0037] If the amount of oil evaporating therein increases as a result of a temporary sudden increase in the amount of upgraded porous coal conveyed into the dryer 1, the flow rate of carrier gas detected by the flow rate detection sensor 6 does not vary so much, but the pressure detected by the first pressure detection sensor 8 rises. In consequence, the second control output value calculated from Math. 1 becomes smaller than the first control output value. Thus, the opening of the first flow rate regulating valve 7 is adjusted based on the second control output value. This suppresses the flow rate of carrier gas refluxed into the dryer 1 so that the pressure in the dryer 1 can stably be kept within a desired range.

[0038] At this time, a control output value is calculated from Math. 1, based on a pressure detected by the second pressure detection sensor 11 and on the previously set target value. The opening of the second flow rate regulating valve 10 is then adjusted based on the calculated control output value. This suppresses an excessive pressure rise attributable to carrier gas within the circulation path 2. Discharged carrier gas is directed to an off-gas treatment device not shown. Carrier gas delivered to the off-gas treatment device is properly supplied into the dryer 1 for reuse.

[0039] If the amount of oil occurring therein decreases as a result of a temporary sudden decrease in the amount of upgraded porous coal conveyed into the dryer 1, the internal pressure in the dryer 1 and the circulation path 2 lowers. Then, both the flow rate detected by the flow rate detection sensor 5 and the pressure detected by the first pressure detection sensor 8 become lower. As a result, the first control output value and the second control output value calculated from Math. 1 both become larger. Ordinarily, the change in the flow rate detected by the flow rate detection sensor 6 is not so large, and the first control output value becomes smaller than the second control output value. For this reason, the first control output value is selected by the low select control so that the opening of the first flow rate regulating valve 7 is adjusted based on this first control output value. In some cases, the second control output value may be smaller than the first control output value. In this case, the opening of the first flow rate regulating valve 7 is adjusted based on the second control output value.

[0040] At this time, similar to the above, a control output value is calculated from Math. 1, based on a pressure detected by the second pressure detection sensor 11 and on the previously set target value. The opening of the second flow rate regulating valve 10 is then adjusted based on the calculated control output value. In this case, since the detected pressure lowers to a large extent, the second flow rate regulating valve is fully closed, not permitting carrier gas to be discharged to the exterior.

[0041] In this manner, if the amount of upgraded porous coal conveyed into the dryer 1 temporarily increases or decreases, the opening of the first flow rate regulating valve 7 is adjusted correspondingly. In this case, by the low select control, a smaller value is used between the first control output value and the second control output value. Accordingly, it is possible to stabilize the pressure of carrier gas in the dryer 1, without a sudden change in the opening of the first flow rate regulating valve 7.

[0042] The present invention is not limited to the above configuration described in the embodiment, but may variously be modified.

[0043] For example, although the opening of the first flow rate regulating valve 7 is adjusted by a proportional integral derivative (PID) controller in the embodiment, it may be adjusted by another feedback control.

[0044] Although in the embodiment, a detection signal from the flow rate detection sensor 6 is processed by the FIC 12, a detection signal from the first pressure detection sensor 8 is processed by the first PIC 13, and a detection signal from the second pressure detection sensor 11 is processed by the second PIC 15, the configuration may be, for example, such that these are controlled together by a single control unit (microcomputer) or such that the FIC 12 and the first PIC 13 are controlled by a single control unit (microcomputer).

EXPLANATIONS OF LETTERS OR NUMERALS

[0045]

- 1 dryer
- 2 circulation path
- 3 dust collector
- 4 spray tower
- 5 blower

- 6 flow rate detection sensor
- 7 first flow rate regulating valve
- 8 first pressure detection sensor
- 9 exhaust pipe
- 5 10 second flow rate regulating valve
- 11 second pressure detection sensor
- 12 FIC
- 13 first PIC
- 14 LS circuit
- 10 15 second PIC

Claims

- 15 1. A method of manufacturing solid fuel comprising:

a mixing step of mixing porous coal with a mixture oil containing solvent oil and heavy oil, to obtain material slurry;
 an evaporation step of heating the material slurry to promote dehydration of porous coal and impregnating the
 mixture oil into pores of porous coal, to obtain dehydrated slurry;

- 20 a solid-liquid separation step of separating upgraded porous coal and the mixture oil from the dehydrated slurry;
 and

a drying step of drying the upgraded porous coal by heating and conveying it while supplying carrier gas, wherein
 the method comprises:

- 25 setting a target value of the circulation amount of carrier gas and a target value of the pressure of carrier
 gas at the drying step;
 calculating control outputs, based on deviations between the target values and measured values corre-
 sponding respectively thereto; and
 adjusting the supply amount of carrier gas, based on a smaller value between the control outputs obtained.

- 30 2. The method of manufacturing solid fuel according to claim 1, wherein
 the target values are each decided based on the supply amount of upgraded porous coal to be dried at the drying
 step and on the amount of oil contained in upgraded porous coal subjected to the drying step.

- 35 3. The method of manufacturing solid fuel according to claim 2, wherein
 the target values are each decided such that the pressure of carrier gas at the drying step lies within a preset range.

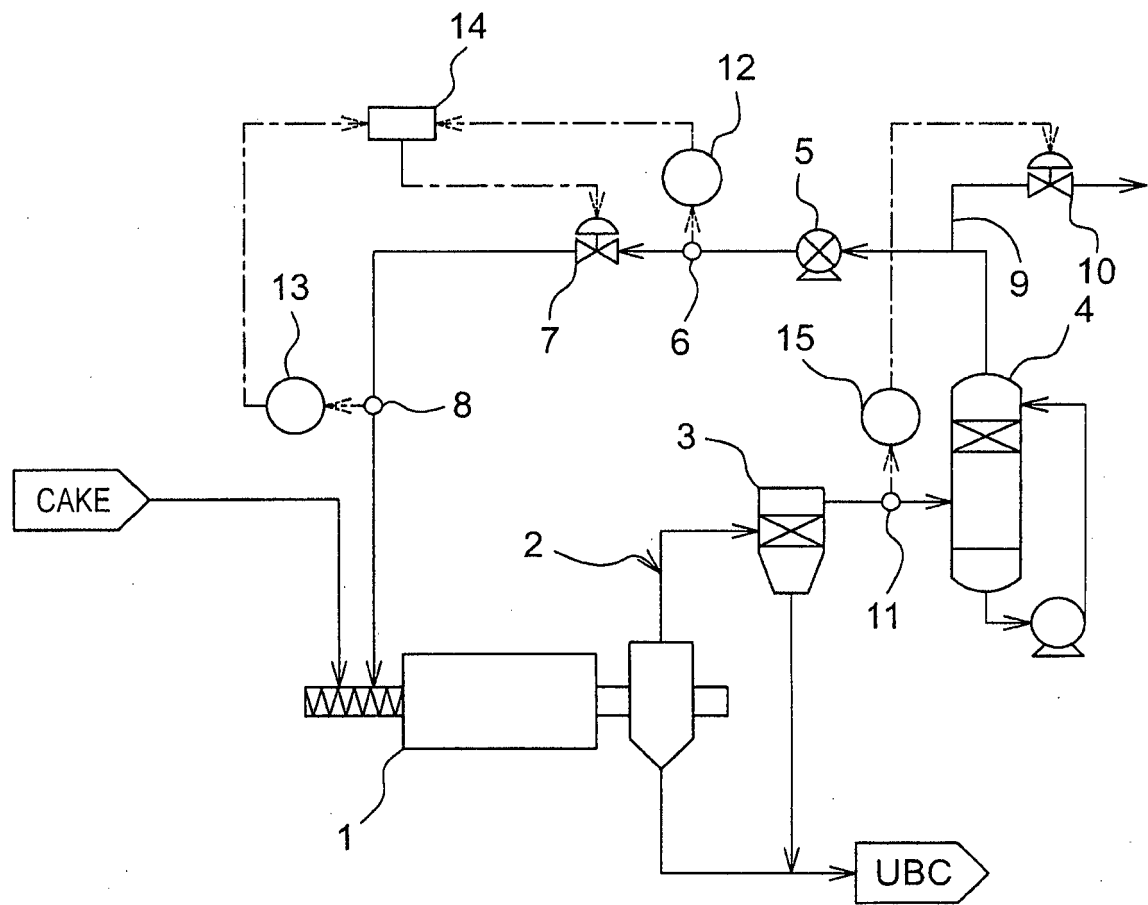
4. A device for manufacturing solid fuel comprising:

- 40 a mixing vessel that mixes porous coal with a mixture oil containing solvent oil and heavy oil, to obtain material
 slurry;
 an evaporator that heats the material slurry to promote dehydration of porous coal and that impregnates the
 mixture oil into pores of porous coal, to obtain dehydrated slurry;
 a centrifuge that separates upgraded porous coal and the mixture oil from the dehydrated slurry;
 45 a dryer that dries the upgraded porous coal by heating and conveying it while supplying carrier gas; and
 a control unit that sets a target value of the circulation amount of carrier gas and a target value of the pressure
 of carrier gas in the dryer, that calculates control outputs, based on deviations between the target values and
 measured values corresponding respectively thereto, and that adjusts the supply amount of carrier gas, based
 on a smaller value between the control outputs obtained.

- 50 5. The device for manufacturing solid fuel according to claim 4, wherein
 the control unit decides the target values, each based on the supply amount of upgraded porous coal to be dried in
 the dryer and on the amount of oil contained in upgraded porous coal leaving the dryer.

- 55 6. The device for manufacturing solid fuel according to claim 5, wherein
 the control unit decides each of the target values such that the pressure of carrier gas at a drying step lies within a
 preset range.

Fig. 1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/059767

A. CLASSIFICATION OF SUBJECT MATTER

C10L5/00(2006.01)i, F26B21/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C10L5/00, F26B21/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014

Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-97783 A (Kobe Steel, Ltd.), 07 May 2009 (07.05.2009), & US 2011/0041393 A1 & WO 2009/050939 A1 & CN 101828089 A	1-6
A	JP 2011-214808 A (Mitsubishi Heavy Industries, Ltd.), 27 October 2011 (27.10.2011), (Family: none)	1-6
A	JP 2008-144114 A (Kobe Steel, Ltd.), 26 June 2008 (26.06.2008), & US 2010/0077658 A1 & WO 2008/072522 A1 & CN 101535452 A	1-6

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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Date of the actual completion of the international search
27 May, 2014 (27.05.14)Date of mailing of the international search report
10 June, 2014 (10.06.14)Name and mailing address of the ISA/
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Patent documents cited in the description

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