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(54) **SOLID FUEL COMPOSITIONS, PROCESSES
FOR PREPARING SOLID FUEL, AND
COMBUSTION PROCESSES**

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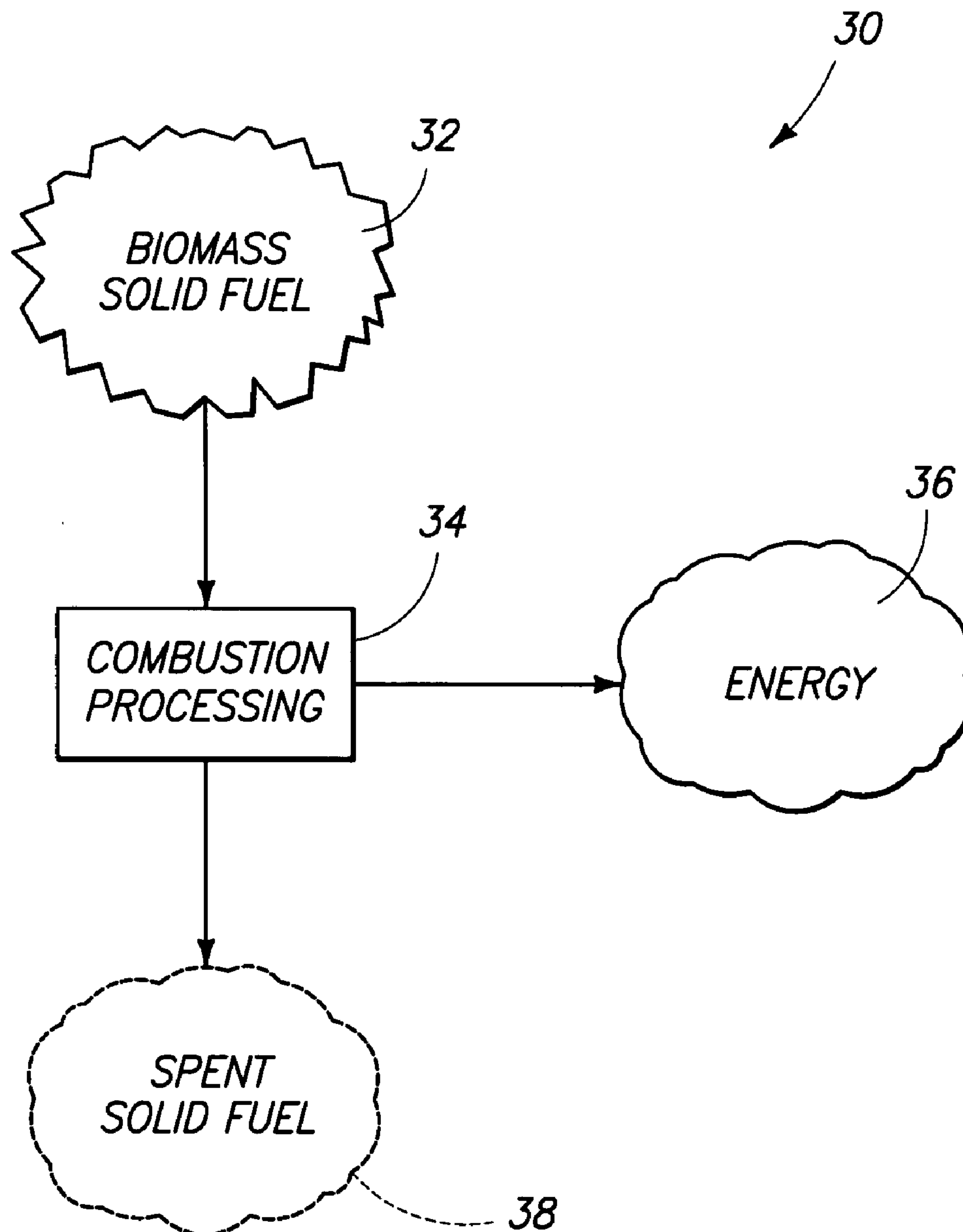
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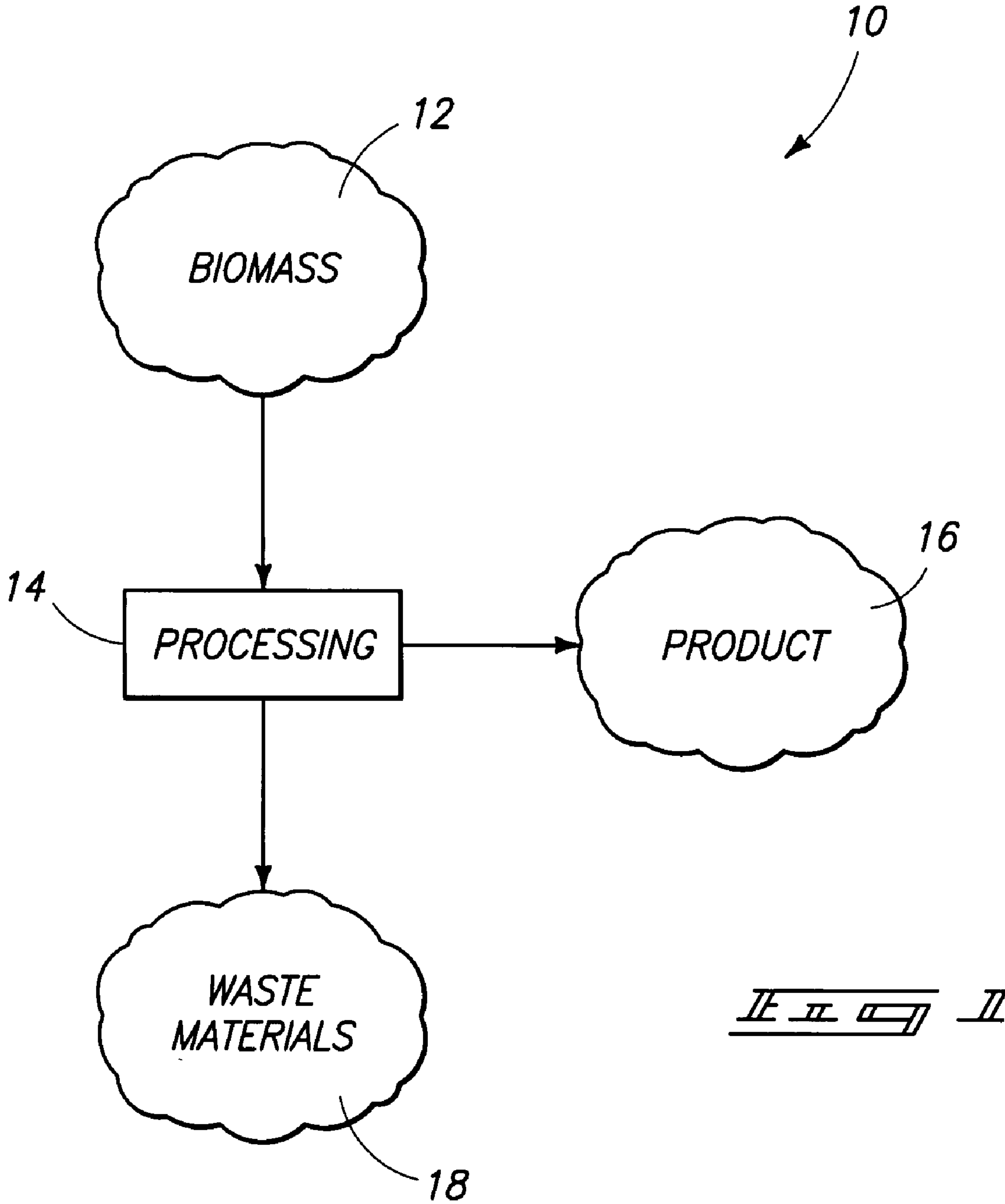
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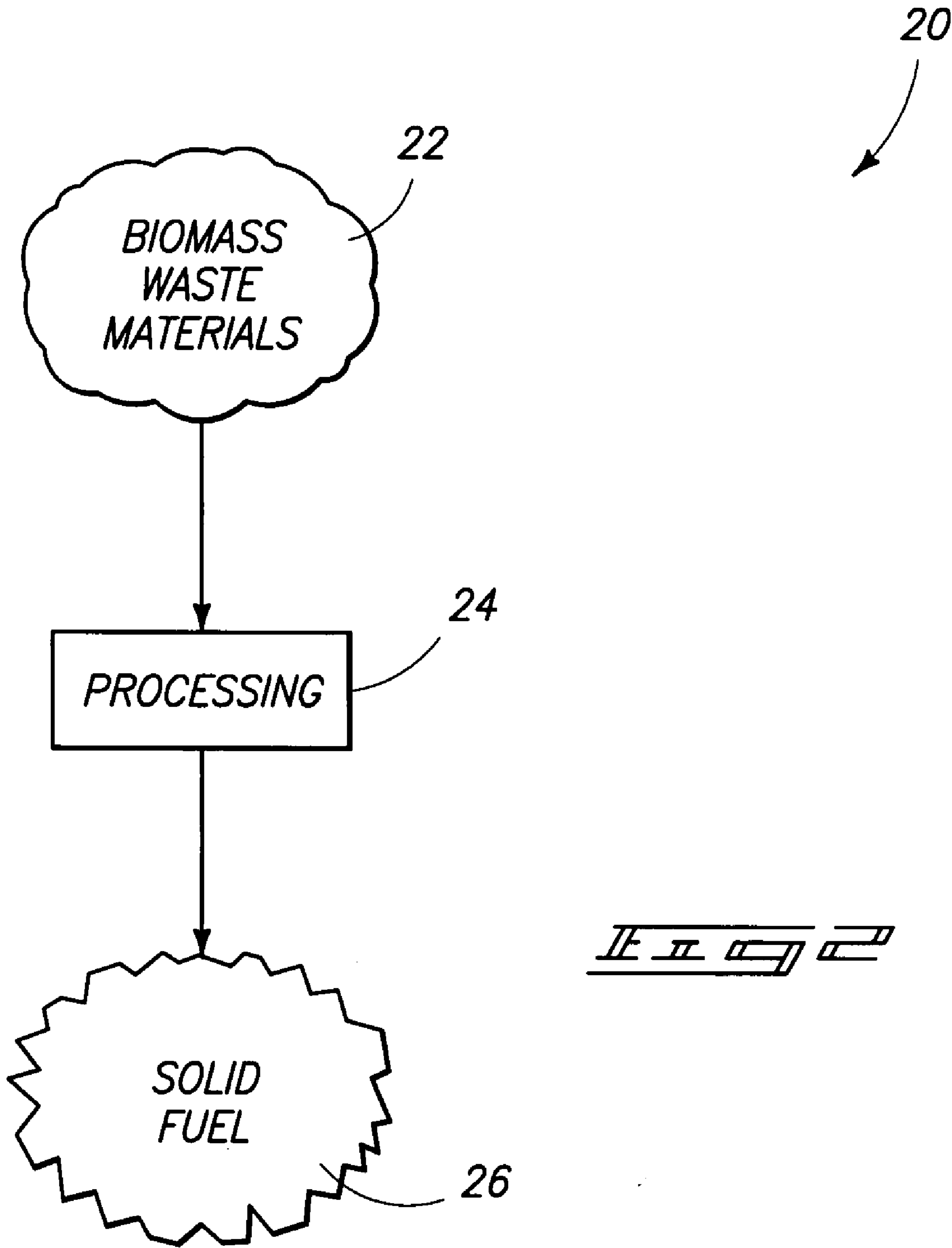
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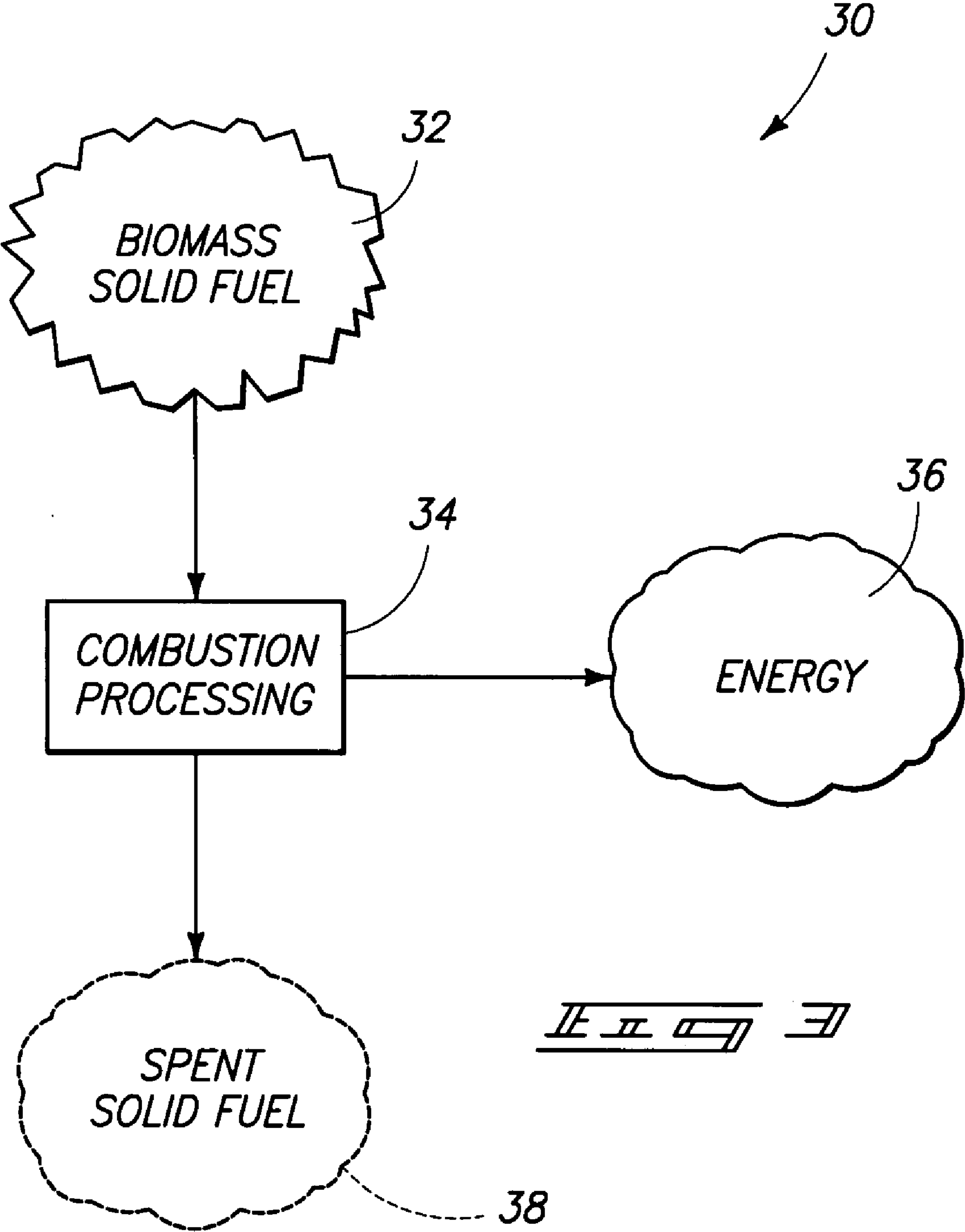
(57) **ABSTRACT**

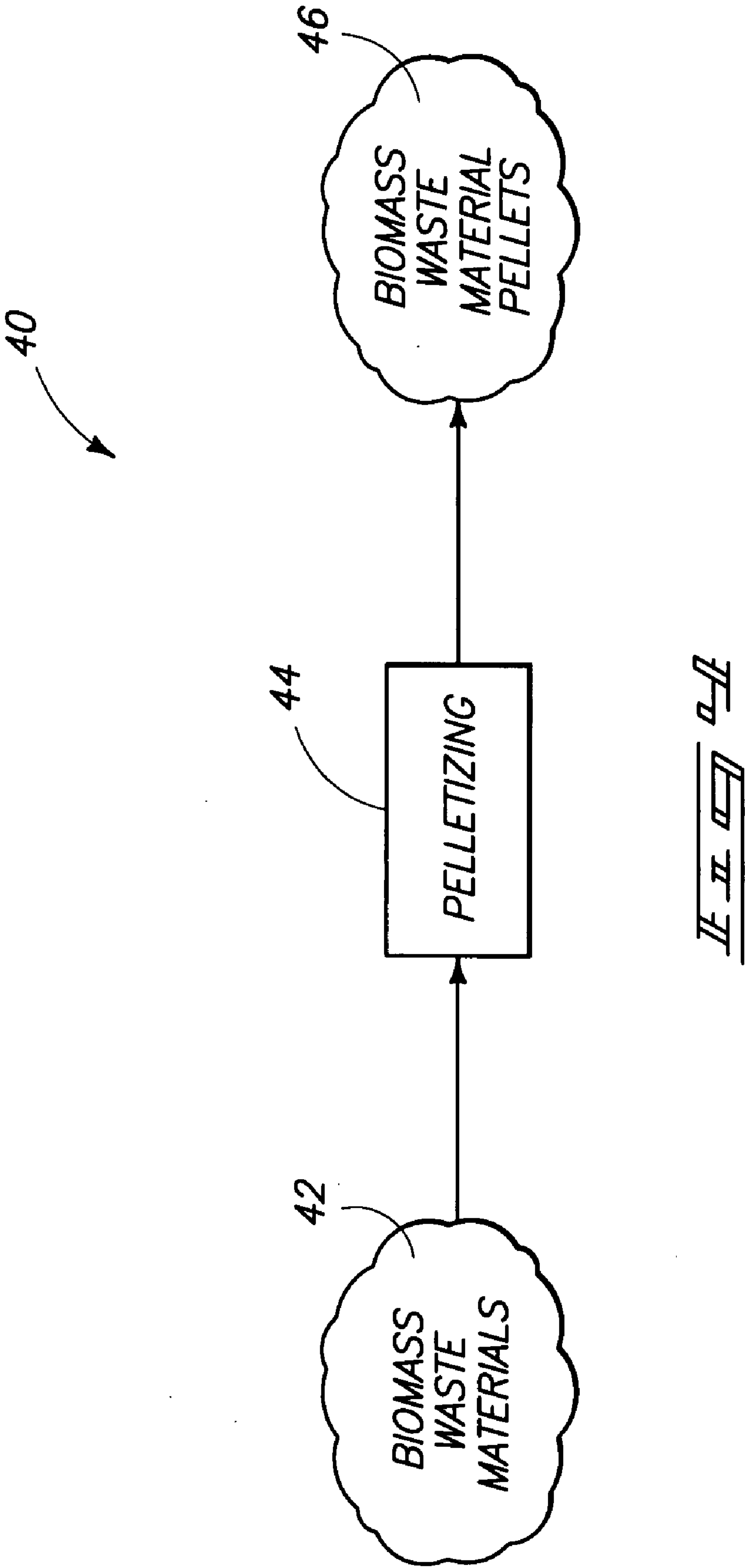
Solid fuel compositions consisting essentially of wet processed biomass are provided. Processes for preparing solid fuel are provided that can include pelletizing wet-processed biomass material. Combustion processes are provided that can include initiating combustion of a pelletized wet processed biomass material. Energy generation processes are included that can include gasifying a biomass pellet.

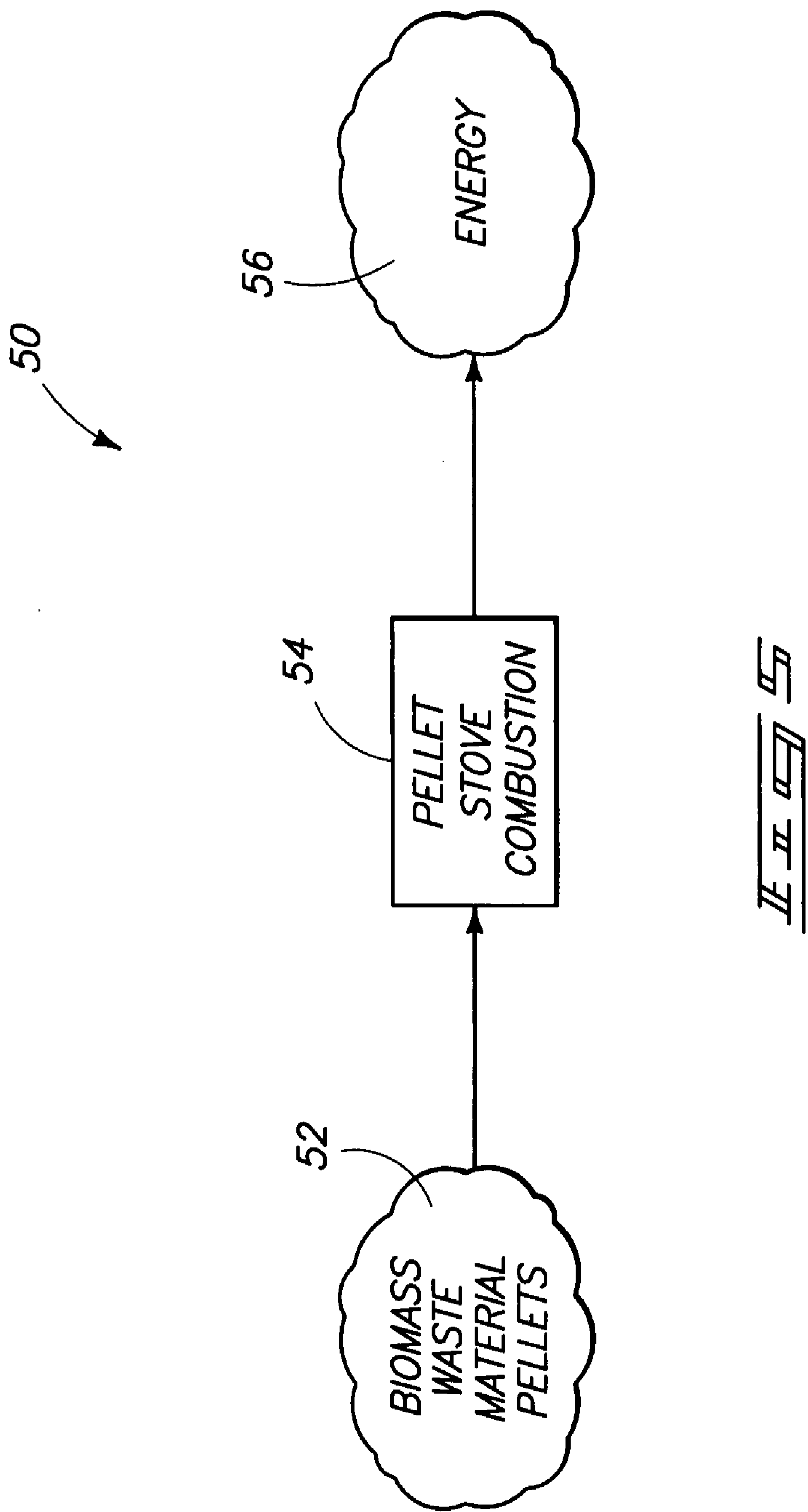


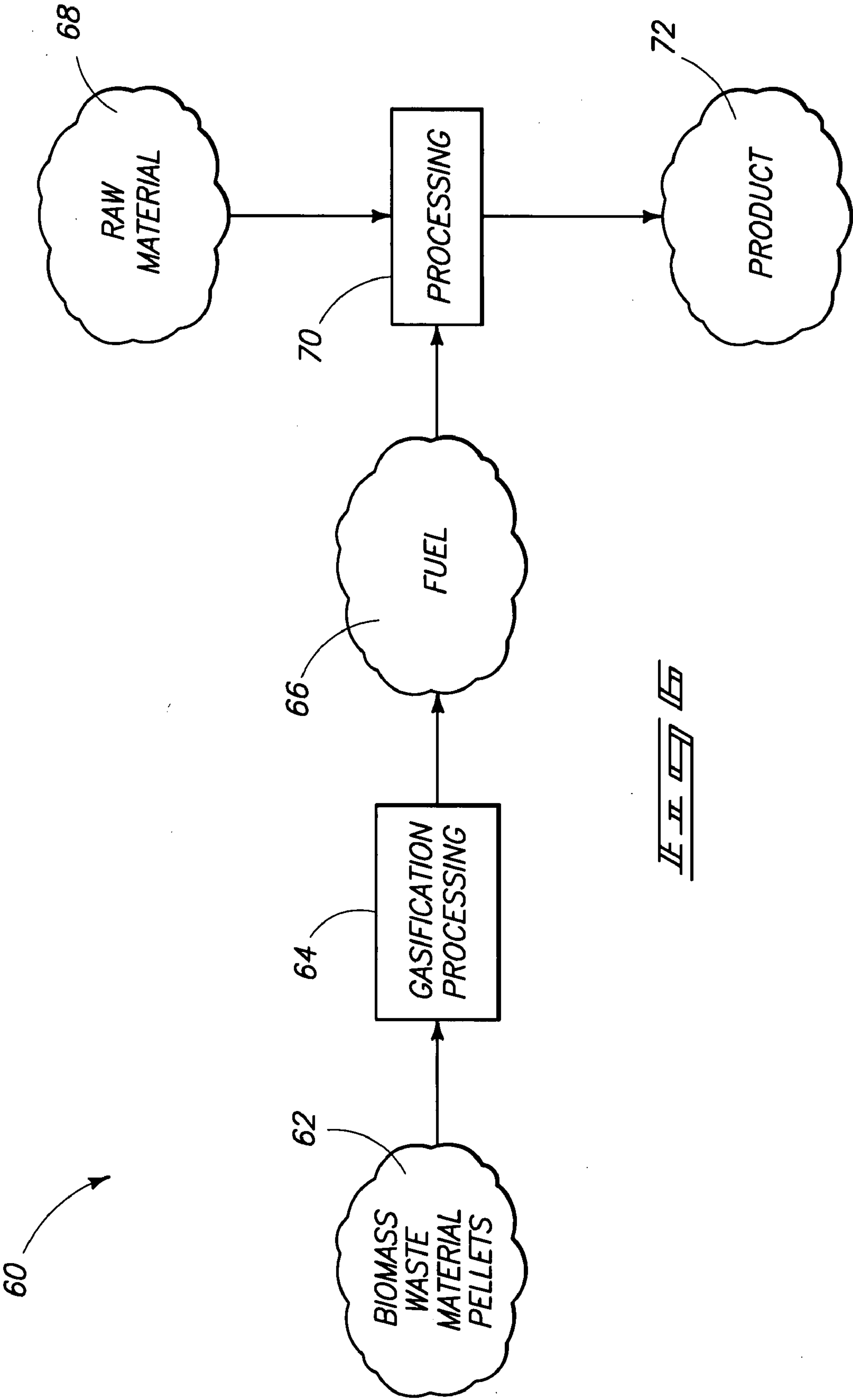












SOLID FUEL COMPOSITIONS, PROCESSES FOR PREPARING SOLID FUEL, AND COMBUSTION PROCESSES

TECHNICAL FIELD

[0001] The present disclosure provides compositions and processes, and more particularly solid fuel compositions as well as solid fuel composition combustion processes.

BACKGROUND

[0002] Waste materials are generated everyday, if not every second, throughout the world. These waste materials stress our environment by overtaxing landfills, polluting the oceans, and can even contribute to air quality problems when combusted inefficiently. As just one example, over two million tons of agricultural waste is generated within a five county area of the Tri-Cities within the State of Washington, USA. Heretofore, this waste has been traditionally landfilled or used as fertilizer or low value cattle feed, but in any case, it has not been utilized as fuel.

SUMMARY OF THE DISCLOSURE

[0003] Solid fuel compositions consisting essentially of wet-processed biomass are provided.

[0004] Processes for preparing solid fuel are provided that can include pelletizing wet-processed biomass material.

[0005] Combustion processes are provided that can include initiating combustion of a pelletized wet-processed biomass material.

[0006] Energy generation processes are included that can include gasifying a biomass pellet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

[0008] FIG. 1 is a process for preparing products from biomass.

[0009] FIG. 2 is a biomass waste material process according to an embodiment.

[0010] FIG. 3 is a combustion process according to an embodiment.

[0011] FIG. 4 is a pelletizing process according to an embodiment.

[0012] FIG. 5 is a pellet stove combustion process according to an embodiment.

[0013] FIG. 6 is a gasification process and gasification fuel utilization process according to an embodiment.

DESCRIPTION OF THE DISCLOSURE

[0014] This disclosure of the invention is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote" the progress of science and useful arts" (Article 1, Section 8).

[0015] The present disclosure is described with reference to FIGS. 1-6. Solid fuel compositions are provided that include processed biomass. The processed biomass can include wet-processed biomass, and/or the processed biomass can be at least partially spent biomass. Wet-processed biomass is a type of processed biomass and is to be distinguished from unprocessed biomass. Generally, biomass is harvested from the field or orchard, for example. Harvesting can include processing,

for example, as wheat is harvested, kernels are removed from stalks. Further processing can include pulverizing the kernels to flour. The production of flour from wheat can be considered dry biomass processing which is to be distinguished from wet biomass processing.

[0016] Wet biomass processing is applied during the processing of biomass such as mint, barley, hops, corn, soy beans, beets, grapes, and oranges, for example. Referring to FIG. 1, a general depiction of a biomass processing scheme 10. In this general scheme, biomass 12 is processed according to process parameters 14 to produce a product 16 and waste materials 18. Biomass 12 can be processed or unprocessed biomass. Process parameters 14 can include wet biomass processing parameters. Waste materials 18 can generally be spent wet-processed biomass, and product 16 can be considered wet-processed biomass product.

[0017] As an example of a process 10, biomass 12 can include mint which is processed according to wet process parameters after being cultivated to produce a wet-processed mint oil product and a spent wet-processed mint slug. The processing of mint includes the mowing of the mint and then the blowing of the mint, after drying, into a tube. Pressurized steam is used to shoot through the tubes to vaporize the mint oil from the mint leaves. The oil vapors and steam pass through a line at the top of the tubes to water cooled condensers where they return to a liquid state in a separator. The mint oil rises to the top and is drawn into drums.

[0018] As another example of process 10, biomass 12 can be barley which is wet processed by fermentation to produce the wet-processed product silage. Barley is also malted by soaking barley kernels, allowing them to germinate, and then drying. The malted barley is then used to make an extract for beer production, leaving behind the spent wet-processed barley wash.

[0019] As still another example, hops are typically utilized in the process of manufacturing beer. In this biomass process, the hops are boiled in water to coagulate unstable proteins and extract tannins in order to create a stable medium for fermentation of the beer. Upon boiling, the liquid is removed to leave a spent wet-processed biomass comprising spent hops.

[0020] Further wet processing of biomass can include the production of vegetable oil. In accordance with these wet processes, the vegetables can be husked, cleaned, crushed, and conditioned, according to dry processes and then oil extracted according to wet processes generally through the use of a solvent such as hexane. After the extraction and boiling, the liquid oil from the vegetables is skimmed, and the remaining spent wet-processed biomass is considered waste material. Two particularly important examples that are responsible for the majority of vegetable oil production is the processing of corn and/or soybeans. During this process, the corn and/or soy oils that are produced can be used in the production of compositions such as biodiesel.

[0021] In accordance with another wet process, fruit is relieved of its juice in a process to produce a fruit juice wet-processed product and leave behind a fruit pomace spent wet-processed waste material. The processing of grapes during wine or even juice production is an example of these wet processes.

[0022] The wet-processed biomass material may be saturated or at least partially saturated with some kind of liquid solution, either organic or an aqueous solution. These materials have been considered high in moisture content, making them undesirable as a fuel source.

[0023] Referring to FIG. 2, a process for preparing the solid fuel is referred to with respect to process 20 of FIG. 2. In accordance with an example embodiment, biomass materials 22 such as those described above can be processed utilizing processing apparatus 24 to produce solid fuel 26. As an example, biomass materials 22 can be compacted to a density of at least 20 lbs/ft³; 20-30 lbs/ft³; 40-45 lbs/ft³; or 20-50 lbs/ft³. Biomass materials 22 can, prior to being compacted, be combined and/or mixed with other biomass materials. As an example, wet-processed biomass materials may be combined with either dry-processed or even unprocessed biomass materials, and this combination of materials can then be compacted to form a solid fuel.

[0024] Referring to FIG. 3, a combustion process 30 is depicted utilizing biomass solid fuel 32. The combustion process can utilize a general pellet stove and/or a gasifier, for example, to produce energy 36, leaving behind spent solid fuel 38. According to exemplary embodiments, combustion processing apparatus 34 can be utilized to initiate combustion of a biomass solid fuel having a density of at least 20 lbs/ft³; 20-30 lbs/ft³; 40-45 lbs/ft³; or 20-50 lbs/ft³ comprising waste biomass material. The biomass solid fuel can be wet-processed biomass. In accordance with an example embodiment, combustion processing apparatus 34 can be configured to periodically provide additional quantities of solid fuel to continue the combustion. The energy provided from the combustion can be in the form of heat and the heat can be utilized in numerous ways. For example, the heat can be utilized to dry materials, warm the interior of a dwelling, and/or produce steam to drive turbines.

[0025] Referring to FIG. 4 a pelletizing process 40 is shown that includes biomass waste materials 42 being pelletized to form biomass waste material pellets. The biomass waste material can be at least about 50% (wt/wt) wet-processed biomass, for example, spent wet-processed biomass. The balance of the biomass waste material can be unprocessed biomass such as straw or even dry-process biomass, such as spent dry-processed biomass. Dry-processed biomass can also include the skins of the vegetables. For example, in the processing of soybeans, the actual skin of the soybean is removed to reveal the soy seed itself. The biomass materials can include extracted mint leaves, pomace, and mixtures of mint leaves and straw materials, including corn stover, for example. The processed biomass can also include animal waste such as cattle, chicken, or even hog manure. The processed biomass can also include digested waste such as sludge including water treatment sludge, for example. As additional ingredients to be utilized during process 40, glycerin and/or paper mill sludge may be added to the wet-processed biomass prior to pelletizing. Glycerin, a by product of biodiesel manufacturing, can be incorporated into the pellet in an amount of less than 10%.

[0026] According to exemplary embodiments, the processed biomass can include or be mixed with barley, straw, wheat, rice, flax straw, and even corn stover. As an example, mint slug may be mixed with straw, wood cuttings, and/or switch grass to form the biomass waste material to be processed. Wood cuttings and mint slug may be combined up to a 50:50 ratio of wood cuttings to mint slug.

[0027] Processing apparatus 24 can include a pellet mill. Example pellet mills include but are not limited to California Pellet Mill Model 7726 (available from California Pellet Mill Co., 1114 E. Wabash Avenue, Crawfordsville, Ind. 47933); Sprout Waldron Pellet Mill Model 501 (available from

Andritz, Inc., 10745 Westside Parkway, Alpharetta, Ga. 30004); and Bliss Pioneer Pellet Mill Model B120A-141 (available from Bliss Industries, Inc., P.O. Box 910, Ponca City, Okla. 74602).

[0028] According to exemplary embodiments, biomass waste material 42 can be provided to the pellet mill, and the pellet mill can compact the biomass waste material to a density of at least 20 lbs/ft³; 20-30 lbs/ft³; 40-45 lbs/ft³; or 20-50 lbs/ft³. The pellet can have a length longer than its diameter. As an example, the pellet can define the perimeter of a circle in one cross section and this circle can have a diameter of less than 1/2 inch. As another example, any cross section of the pellet can be less than 1 inch in length. The pellets may be configured for use in residential pellet stoves. According to an example embodiment, processing apparatus 44 can be configured to prepare pellets for use in domestic pellet stoves.

[0029] Referring to FIG. 5, a pellet stove combustion process 50 is shown that includes the combustion of biomass waste materials pellets 52 utilizing pellet stove combustion apparatus 54 to produce energy 56. Biomass waste material pellets 52 can include solid fuel and/or biomass pellets, such as the wet-processed biomass material fuel/pellets described herein. Apparatus 54 can be a domestic pellet stove, including but not limited to that manufactured by Alladin, or Quadra-Fire manufactured by Hearth & Home Technologies. Energy 56 can be in the form of heat, for example.

[0030] Referring to FIG. 6, a gasification process 60 is shown that includes biomass waste material pellets 62 being gasified using gasification apparatus 64 to produce fuel 66 which is utilized to facilitate the processing of raw materials 68 according to process 70 to produce product 72. Pellets 62 can be those pellets described herein or any commercial solid fuel pellet; however, embodiments of the process utilizing the Wet-processed biomass pellets described herein can be advantageous. Examples of gasification apparatus 64 can include Center for Strategic Alliance—Model GX36-01 (available from Center for Strategic Alliance, 629 East Moulton Street, Hickman, Ky. 42050); Community Power Corp—Model BioMax 100 (available from Community Power Corp., 8110 Shaffer Parkway, Suite 120, Littleton, Colo. 80127); and Integrated Environmental Technologies Biomass Gasifier (available from Integrated Environmental Technologies, LLC, 1935 Butler Loop, Richland, Wash. 99354).

[0031] Fuel 66 produced upon gasification of pellets 62 is typically smaller molecular weight hydrogen compositions including carbon hydrogen compositions, such as diatomic hydrogen and or methane, for example. In certain parlances, this can be referred to as partially gasified fuel or gasification processing fuel. This fuel can be provided for further combustion and utilized as the energy source for processing, according to processing apparatus 70, raw material 68 to produce product 72. In accordance with an example process, raw material 68 can be any raw materials that need to be processed, including agricultural or nonagricultural materials. Processing 70 can utilize the fuel provided 66 in the processing of raw materials 68. For example, processing 70 may simply utilize a heat source in the processing of raw material 68, and fuel 66 can provide the fuel for that heat source. In any event, processing 70 produces a product 72. As another example fuel 66 may be utilized to charge fuel cells.

[0032] Spent pellets of the gasification process include particles that can be further utilized. The process of gasifying the pellets can produce a carbon waste product and this carbon waste product can be utilized as a filtration media, thereby

resulting in a process that produces no waste material and is the efficient utilization of previously unutilized at least partially spent or processed biomass.

[0033] Tying these processes together, a processed biomass such as materials **18** described in FIG. **1** can be utilized to produce energy as disclosed in FIG. **3** as well as FIG. **5** and FIG. **6**, and then this energy or fuel may be utilized to process other raw materials to produce a product **72**.

[0034] In compliance with the statute, the invention has been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the invention is not limited to the specific features shown and described, since the means herein disclosed comprise preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted in accordance with the doctrine of equivalents.

What is claimed is:

1. A solid fuel consisting essentially of wet-processed biomass, the solid fuel having a density of at least 20 lbs/ft³.
2. The solid fuel of claim **1** wherein the solid fuel is in the form of pellets.
3. The solid fuel of claim **1** wherein the wet-processed biomass comprises extracted mint leaves.
4. The solid fuel of claim **3** wherein the wet-processed biomass comprises mint slug.
5. The solid fuel of claim **1** wherein the wet-processed biomass comprises fruit pomace.
6. The solid fuel of claim **5** wherein the wet-processed biomass comprises grape pomace.
7. The solid fuel of claim **1** wherein the wet-processed biomass comprises spent hops.
8. The solid fuel of claim **1** wherein the wet-processed biomass comprises barley waste.
9. The solid fuel of claim **1** wherein the wet-processed biomass comprises beet tailings.
10. The solid fuel of claim **1** further comprising less than or equal to about 50% (wt./wt.) unprocessed biomass.
11. The solid fuel of claim **10** wherein:
 - the wet-processed biomass comprises mint slug; and
 - the unprocessed biomass comprises wood cuttings.
12. The solid fuel of claim **10** wherein the unprocessed biomass is one or more of straw, stover, and vegetable husks.
13. The solid fuel of claim **12** wherein the unprocessed biomass is straw and the straw is one or more of wheat, rice, and flax straw.
14. The solid fuel of claim **10** wherein the unprocessed biomass is switch grass.
15. The solid fuel of claim **1** further comprising glycerin.
16. The solid fuel of claim **1** wherein the solid fuel is in the form of a pellet.
17. The solid fuel of claim **16** wherein the pellet has a length longer than its diameter.
18. The solid fuel of claim **16** wherein the pellet has a circular cross section less than about 1/2 inch in diameter.

19. The solid fuel of claim **16** wherein any cross section of the pellet is less than about 1 inch in length.

20. The solid fuel of claim **16** wherein the pellets are configured for use in residential pellet stoves.

21. The solid fuel of claim **1** further comprising less than or equal to about 50% (wt./wt.) digestion waste.

22. The solid fuel of claim **21** wherein the digestion waste comprises sludge.

23. The solid fuel of claim **22** wherein the sludge is sewage sludge.

24. The solid fuel of claim **1** further comprising less than or equal to about 50% (wt./wt.) animal waste.

25. The solid fuel of claim **24** wherein the animal waste comprises cow manure.

26. A process for preparing solid fuel comprising pelletizing material to produce a solid fuel pellet, the material comprising at least 50% (wt./wt.) wet-processed biomass material.

27. The process of claim **26** wherein the wet-processed biomass material is extracted soy beans.

28. The process of claim **26** wherein the material further comprises unprocessed biomass material.

29. The process of claim **28** wherein the wet-processed biomass material comprises mint slug and the unprocessed biomass material comprises straw.

30. The process of claim **28** wherein a weight of the wet-processed biomass material is at least equal to or greater than a weight of the unprocessed biomass material.

31. The process of claim **26** further comprising storing the solid fuel pellet in a container.

32. The process of claim **31** wherein the container is configured for distribution of the solid fuel pellet for residential use.

33. A combustion process comprising:

- initiating combustion of a pelletized fuel, the pelletized fuel comprising a wet-processed biomass material; and
- periodically providing additional quantities of the fuel to continue the combustion.

34. The process of claim **33** wherein the providing further comprises metering in an amount of solid fuel at predetermined rates.

35. The process of claim **33** further comprising utilizing the heat from the combustion as an energy source.

36. The process of claim **33** wherein the combustion is initiated and continued within a residential pellet stove.

37. An energy generation process comprising gasifying a biomass pellet.

38. The process of claim **37** wherein the biomass pellet comprises biomass slug.

39. The process of claim **37** wherein the gasifying creates a carbon waste product.

40. The process of claim **39** wherein the carbon waste product is utilized as filtration media.

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