Claims

1. A method of production of ammonia comprising the steps of:-

gasification of combustible material to produce syngas, wherein saidthe gasification ~~process~~ includesing extracting oxygen from air for use in ~~the~~ said gasification ~~process~~ thereby producing nitrogen enriched air;

~~substantially~~ removing oxygen from said nitrogen enriched air to produce substantially oxygen free air;

separating hydrogen from said syngas; ~~and~~

reacting said hydrogen with said substantially oxygen free air to produce ammonia;

wherein said step of extracting oxygen from said air comprises extracting said oxygen from said air using an oxygen selective membrane;

wherein said gasification takes place at substantially atmospheric pressure.

~~2. A method according to claim 1, wherein said oxygen is extracted from the air using an oxygen selective membrane.~~

~~3~~2. A method according to claim 1 ~~or 2~~, wherein said step of removing oxygen from said nitrogen enriched air comprises removing said oxygen ~~is removed~~ by combustion with syngas from which hydrogen has been removed.

~~4~~3. A method according to ~~any one of claims 1 to 3~~claim 1 or claim 2, wherein said step of separating said hydrogen from said syngas comprises extracting said hydrogen ~~is extracted~~ from the syngas using at least one hydrogen selective membrane.

~~5~~4. A method according to any one of claims 1 to ~~4~~3, wherein said reaction to produce ammonia takes place in a plasma reactor.

~~6~~5. An apparatus for the production of ammonia, the apparatus comprising:-

at least one gasifier for gasification of combustible material to produce syngas, the gasifier including at least one first oxygen removal device for extracting oxygen from air for use in ~~the~~ said gasification ~~process~~ thereby producing nitrogen enriched air;

at least one second oxygen removal device for ~~substantially~~ removing oxygen from said nitrogen enriched air to produce substantially oxygen free air;

at least one hydrogen separating device for separating hydrogen from said syngas to produce hydrogen-depleted syngas; and

at least one reaction device for reacting said hydrogen with said substantially oxygen free air to produce ammonia;

wherein at least one said first oxygen removal device comprises an oxygen selective membrane;

wherein said gasification takes place at substantially atmospheric pressure.

~~7. An apparatus according to claim 6, wherein at least one first oxygen removal device comprises an oxygen selective membrane.~~

8. An apparatus according to claim ~~6 or 7~~5, wherein at least one said second oxygen removal device comprises at least one combustion device for removing said oxygen by combustion with said hydrogen-depleted syngas ~~from which hydrogen has been removed~~.

9. An apparatus according to ~~any one of~~ claims ~~6 to 8~~5 or 6, wherein said hydrogen separating device comprises at least one hydrogen selective membrane.

~~10~~8. An apparatus according to any one of claims ~~6 to 9~~5 to 7, wherein said reaction device comprises a plasma reactor.

~~11. A method of production of ammonia substantially as hereinbefore described with reference to the accompanying drawings.~~

~~12. An apparatus for the production of ammonia substantially as hereinbefore described with reference to the accompanying drawings.~~

~~13. An air input system for a gasifier, the input system comprising:~~

~~at least one input for receiving air;~~

~~at least one oxygen selective membrane adapted to be located adjacent a combustion zone of a gasifier, the membrane allowing oxygen from said received air to pass through said membrane and into said gasifier.~~

~~14. A system according to claim 13, further comprising air extraction means for directing air from which oxygen has been extracted.~~

~~15. A system according to claim 13 or 14, further comprising at least one support layer bonded to the membrane.~~

16. A system according to any one of claim 13 to 15, wherein said membrane further comprises at least one first catalyst layer.

17. A system according to claim 16, wherein said membrane further comprises at least one second catalyst layer located further away from said membrane than said first catalyst layer.

18. A system according to any one of claim 13 to 17, wherein said membrane is metal-ceramic oxygen selective membrane.

19. An air input system for a gasifier substantially as hereinbefore described with reference to the accompanying drawings.

20. A catalyst comprising:-

a least one catalyst body comprising at least one catalyst material; and

at least one coating extending substantially around said catalyst material and including at least one porous material allowing reactants to diffuse through said porous material and engage with said catalyst material.

21. A catalyst according to claim 20, wherein said coating is substantially electrically insulating.

22. A catalyst according to claim 20, wherein said coating has a high permittivity.

23. A catalyst according to claim 20 to 22, wherein said coating comprises Barium oxide (BaO).

24. A catalyst according to claim 20 to 22, wherein said coating comprises Barium titanate ($BaTiO_3$).

25. A method of producing a catalyst comprising the steps of coating a catalyst body with a porous material adapted to allow reactants to diffuse through said material and engage with said catalyst.

26. A catalyst substantially as hereinbefore described with reference to the accompanying drawings.

27. A method of producing a catalyst substantially as hereinbefore described with reference to the accompanying drawings.

28. A method of catalysing a reaction comprising the steps of mixing reactants with a catalyst according to any one of claims 1 to 5.

29. A plasma reactor comprising:-

at least one vessel adapted to receive reactants;

a plurality of electrodes contained within an outermost volume of said vessel; and

at least one granular catalyst material coated with a porous and substantially electrically insulating material.

30. A plasma reactor according to claim 29, wherein said vessel comprises at least one electrode.

31. A plasma reactor according to claim 29 or 28, wherein said vessel is tubular

32. A plasma reactor according to claim 30, wherein at least one electrode extends substantially along the centre of said tubular vessel.

33. A plasma reactor substantially as hereinbefore described with reference to the accompanying drawings.

34. A method of extracting ammonia from a stream of ammonia production gases including ammonia, hydrogen and nitrogen comprising the steps of:-

passing a stream of gases including ammonia through a bed of a strong acid ion exchange resin, wherein at least some ammonia is adsorbed onto said bed;

recycling said stream of gases once at least some ammonia is removed for further reaction.

35. A method according to claim 34, wherein said strong acid ion exchange resin comprises sulphonated PolyHIPE polymer.

35. A method according to claim 34, wherein said strong acid ion exchange resin comprises hyper cross-linked sulphonated ion exchange resins.

36. A product produced by the processes according to claim 33.