COMMONWEALTH OF AUSTRALIA

Patents Act 1952

P/00/001
Form 1
Regulation 9

APPLICATION FOR A STANDARD PATENT OR A STANDARD PATENT OF ADDITION

617675

Insert full name(s) of applicant(s)

(71) I/We FOSTER WHEELER ENERGY CORPORATION

Insert address(es) of applicant(s)

of Perryville Corporate Park, Clinton, New Jersey 08809-4000, United States of America

Insert title of invention

(54) hereby apply for the grant of a ☒ standard patent ☐ patent of addition for an invention entitled

CYCLONE SEPARATOR HAVING WATER-STEAM COOLED WALLS

(tick appropriate box)

which is described in the accompanying ☐ provisional ☒ complete specification.

Insert name of actual inventor

(72) The actual inventor(s) of the said invention is/are BYRAM J. MAGOL, JOHN DAVID FAY, MICHAEL GARKAWE

Insert address for service of notices in Australia

(74) My/our address for service is SANDERCOCK, SMITH & BEADLE, 207 Riversdale Road, (P.O. Box 410) Hawthorn, Victoria, 3122 Attorney Code SA

**THESE SECTIONS ARE ONLY TO BE COMPLETED WHERE APPLICABLE:*

for Convention cases only

(ONLY TO BE USED IN THE CASE OF A CONVENTION APPLICATION)

Details of basic application(s) –

(31) Number of basic application 069,930
161,632
179,818

(33) Name of Convention country in which basic application was filed UNITED STATES OF AMERICA ISO Code US

(32) Date of basic application 6th July 1987
29th February 1988
11th April 1988

for Divisional applications only

(ONLY TO BE USED IN THE CASE OF A FURTHER APPLICATION MADE BY VIRTUE OF SECTION 51)

(62) Number of original application

Person by whom made

for Patents of addition only

(ONLY TO BE USED IN THE CASE OF AN APPLICATION FOR A PATENT OF ADDITION)

I request that the patent may be granted as a patent of addition to the patent applied for on

(61) Application No. Patent No.

in the name of

I request that the term of the patent of addition be the same as that for the main invention or so much of the term of the patent for the main invention as is unexpired.

1000897 05/07/88

Insert day, month and year form signed

Dated this 5TH day of JULY 19 88

Signature of applicant or Australian attorney

TO

(Signature)

SANDERCOCK, SMITH & BEADLE

THE COMMISSIONER OF PATENTS

This form must be accompanied by either a provisional specification (Form 9 and true copy) or by a complete specification (Form 10 and true copy).

FORM 7 & 8

AUSTRALIA
PATENTS ACT 1952

PATENT DECLARATION FORM
(CONVENTION OR NON-CONVENTION)

DECLARATION IN SUPPORT OF APPLICATION FOR A PATENT

Insert name of applicant.

In support of the application made by FOSTER WHEELER ENERGY CORPORATION

Insert title of invention.

for a patent for an invention entitled: CYCLONE SEPARATOR HAVING WATER-STEAM COOLED WALLS

Insert full name(s) and address(es) of person(s) making declaration. If applicant a company person must be authorised to make declaration.

I/~~We~~ JAMES T. SAMUEL,
of Perryville Corporate Park, Clinton, New Jersey 08809-4000, United States of America

do solemnly and sincerely declare as follows:

* Delete alternatives which do not apply

* 1. ~~(a) I am/We are the applicant(s) for the patent.~~

* OR (b) I am authorized by the abovementioned applicant to make this declaration on its behalf.

* 2. ~~(a) I am/We are the actual inventor(s) of the invention.~~

Insert name(s) and address(es) of actual inventor(s).

* OR (b) BYRAM J. MAGOL, of 11 Herms Place, Convent Station, New Jersey 07961, United States of America; JOHN DAVID FAY, of 9 Rose Way, Randolph, New Jersey 07869, United States of America; and MICHAEL GARKAWE, of 266 Oxford Street, Madison, New Jersey 07940, United States of America.

Insert details of entitlement to apply, e.g., Applicant is assignee of inventor(s)

~~is/~~are the actual inventor(s) of the invention and the facts upon which the applicant(s) ~~is/~~are entitled to make the application are as follows:—

Applicant is assignee of inventors.

Delete 3 and 4 if application non-convention. Otherwise insert details of basic application(s).

3. The basic application(s) as defined by Section 141 of the Act ~~was/~~were made in the following country or countries on the following date(s) by the following applicant(s)

in United States of America on 6th July 19 87
by Byram J. MAGOL, John D. FAY and Michael GARKAWE
in United States of America on 29th February 19 88
by Byram J. MAGOL, John D. FAY and Michael GARKAWE
in United States of America on 11th April 19 88
by Byram J. MAGOL, John D. FAY and Michael GARKAWE
in _____ on _____ 19 _____
by _____

4. The basic application(s) referred to in paragraph 3 of this Declaration was/were the first application(s) made in a Convention country in respect of the invention the subject of the application.

Place and date of Signature.

Declared at Clinton, N.J. this 19th day of July 19 88

FOSTER WHEELER ENERGY CORPORATION

NO ATTESTATION OR SEAL

James T. Samuel
James T. Samuel Signature(s) of declarant(s).
Secretary

To: The Commissioner of Patents, Australia

SANDERCOCK, SMITH & BEADLE,

P.O. Box 410, Hawthorn, 3122, Australia
cables: Sandpat Melbourne
telex: 34491, Sandpat

(12) PATENT ABRIDGMENT (11) Document No. AU-B-18725/88
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 617675

(54) Title
CYCLONE SEPARATOR HAVING WATER-STEAM COOLED WALLS

International Patent Classification(s)
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(71) Applicant(s)
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(56) Prior Art Documents
US 4615715
US 3732920
GB 567460

(57) Claim

1. A cyclone separator comprising an inner cylinder; an outer cylinder extending around said inner cylinder in a coaxial relationship to define an annular chamber between the two cylinders, said outer cylinder comprising a plurality of tubes extending vertically (in use) in a parallel relationship for at least a portion of their lengths, said plurality of tubes being arranged in a side-by-side relationship to form said outer cylinder, a portion of said tubes being bent from the plane of said outer cylinder to form an inlet opening in a tangential relationship to said outer cylinder for receiving gases containing solid particles and directing same through said annular chamber for separating the solid particles from said gases by centrifugal forces, the separated gases exiting through said inner cylinder and the separated solids falling to the bottom of said outer cylinder for

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disposal, said tubes being bent radially inwardly towards said inner cylinder such that they are adapted to support said inner cylinder, means for passing water-steam through said tubes to cool said outer cylinder; and a plurality of support tubes connected to said outer cylinder for supporting said separator from a building or structure.

PATENTS ACT 1952

617675

COMPLETE SPECIFICATION

(ORIGINAL)

FOR OFFICE USE

Short Title:

Int. Cl:

Application Number:
Lodged:

Complete Specification—Lodged:
Accepted:
Lapsed:
Published:

Priority:

Related Art:

TO BE COMPLETED BY APPLICANT

Name of Applicant: FOSTER WHEELER ENERGY CORPORATION

Address of Applicant: PERRYVILLE CORPORATE PARK, CLINTON, NEW JERSEY 08809-4000, UNITED STATES OF AMERICA

Actual Inventor: BYRAM J. MAGOL, JOHN DAVID FAY, MICHAEL GARKAWE

Address for Service: SANDERCOCK, SMITH & BEADLE, 207 RIVERSDALE ROAD (P.O. BOX 410), HAWTHORN. VICTORIA, 3122, AUSTRALIA.

Complete Specification for the invention entitled:

CYCLONE SEPARATOR HAVING WATER-STEAM COOLED WALLS

The following statement is a full description of this invention, including the best method of performing it known to me:—*

* Note: The description is to be typed in double spacing, pica type face, in an area not exceeding 250 mm in depth and 160 mm in width, on tough white paper of good quality and it is to be inserted inside this form.

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This invention relates to a cyclone separator and, more particularly, to such a separator for separating solid fuel particles from gases discharged from a combustion system or the like.

Conventional cyclone separators are normally provided with monlithic external refractory wall which is abrasion resistant and insulative so that the outer casing runs relatively cool. Typically, these walls are formed by an insulative refractory material sandwiched between an inner hard refractory material and an outer metal casing. In order to achieve proper insulation, these layers must be relatively thick which adds to the bulk, and cost of the separator. Also, the outside metal casing of these designs cannot be further insulated from the outside since to do so could raise its temperature as high as 1500°F which is far in excess of the maximum temperature it can tolerate.

Further, most conventional cyclone separators require relatively expensive, high temperature, refractory-lined ductwork and expansion joints between the reactor and the cyclone, and between the cyclone and the heat recovery section, which are fairly sophisticated and expensive. Still further, conventional separators formed in the above manner require a relatively long time to heat up before going online to eliminate premature cracking of the refractory walls, which is inconvenient and adds to the cost of the process. Also these type of conventional cyclone separators require a separate roof tube circuit which further adds to the cost of the system.

It is therefore an objective of the present invention

The invention provides a cyclone separator comprising an inner cylinder; an outer cylinder extending around said inner cylinder in a coaxial relationship to define an annular chamber between the two cylinders, said outer cylinder comprising a plurality of tubes extending vertically (in use) in a parallel relationship for at least a portion of their lengths, said plurality of tubes being arranged in a side-by-side relationship to form said outer cylinder, a portion of said tubes being bent from the plane of said outer cylinder to form an inlet opening in a tangential relationship to said outer cylinder for receiving gases containing solid particles and directing same through said annular chamber for separating the solid particles from said gases by centrifugal forces, the separated gases exiting through said inner cylinder and the separated solids falling to the bottom of said outer cylinder for disposal, said tubes being bent radially inwardly towards said inner cylinder such that they are adapted to support said inner cylinder, means for passing water-steam through said tubes to cool said outer cylinder; and a plurality of support tubes connected to said outer cylinder for supporting said separator from a building or structure.

Brief Description of the Drawings

The above brief description as well as further objects, features and advantages of the present invention will be more fully appreciated by reference to the

following detailed description of presently preferred but nonetheless illustrative embodiments in accordance with the present invention when taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a perspective schematic view of the cyclone separator of the present invention showing only the tubes forming the outer cylinder;

Fig. 2 is a cross-section view taken along the portion

of the wall of the outer cylinder of Fig. 1 designated by the line 2-2, and showing the insulative materials surrounding the tubes;

Fig. 3 is a perspective schematic view of a cyclone separator according to a further embodiment of the invention, showing only the tubes forming the outer cylinder;

Fig. 4 is an enlarged cross-sectional view taken along the portion of the outer cylinder designated by the line 2'-2' in Fig. 3 and showing the insulative materials surrounding the tubes;

Fig. 5 is a schematic view of a cyclone separator according to a still further embodiment of the present invention and an adjacent heat recovery area of a boiler system;

Fig. 6 is an enlarged perspective view of the tubes forming the outer cylinder of the separator of Fig. 5, and

Fig. 7 is an enlarged, cross-sectional view taken along the portion of the wall of the outer cylinder of Fig. 2 designated by the line 3-3, and showing the insulative materials surrounding the tubes.

Description of the Preferred Embodiments

Referring to Fig. 1 of the drawings, the reference numeral 10 refers in general to the cyclone separator of the present invention which includes a front header 12 and a rear header 14 forming the lower end portion of a side wall 16 of the separator. A front header 18 and a rear header 20 form the lower end portion of the other side wall 22 of the separator. The headers 12, 14, 18 and 20 extend to either

side of a hopper 21 disposed at the lower portion of the separator for reasons to be described.

A group of vertically extending spaced parallel tubes 24 are connected at their lower ends to the header 12 and form the front portion of the wall 16, and another group of vertically extending spaced parallel tubes 26 are connected to the header 14 and form the rear portion of the wall 16. In a similar manner, a group of vertically extending spaced parallel tubes 28 are connected to the header 18 and form the front portion of the wall 22, and another group of vertically extending spaced parallel tubes 30 extend from the header 20 and form the rear portion of the wall 22.

The groups of tubes 24, 26, 28 and 30 extend vertically upwardly for a relatively small length and then are bent inwardly and angularly so that they together form a closed right cylinder shown in general by the reference numeral 32, with the tubes 24 and 28 together forming the front half of the cylinder 32 and the tubes 26 and 30 together forming the rear half of the cylinder 32.

A portion of the tubes 24 and 28 are bent out of the plane of the cylinder 32 as shown by the reference numeral 24a and 28a to form an inlet passage to the interior of the cylinder for reasons that will be described.

At the upper end of the cylinder 32, the tubes 24, 26, 28, and 30 are bent radially inwardly, as shown by the reference numeral 36, and then upwardly, as shown by the reference numeral 38, to define a circular opening which, of course, is of a diameter less than that of the diameter of the cylinder 32. The tubes 24, 26, 28 and 30 are then bent

radially outwardly as shown by the reference numeral 44 and then vertically upwardly as shown by the reference numeral 46. The upper end portions of the tube group 26 thus form a sidewall which is connected to an upper header 48 and the upper end portions of the tube group 30 form a sidewall which is connected to an upper header 50. The upper end portions of the tubes 24 and 28 are bent horizontally to extend across the upper end portion of the cylinder 32 to form a roof 52 and are connected at their free ends to upper headers 54 and 56, respectively. A portion of the upper portions of the tubes 24 and 26 have been deleted for the convenience of presentation.

It is understood that a portion of the tubes 24, 26, 28 and 30 do not bend in the manner discussed above but rather extend vertically for the entire length of the cylinder 32 for the purpose of enabling the separator to be supported from the roof of a building or structure in which the separator 10 is located. These latter tubes are shown by the reference numeral 60 and extend from the header 18 in the manner discussed above, then straight up for the length of the cylinder 32 before bending horizontally to form a portion of the roof 52. Although not shown in the drawings, it is understood that a plurality of lugs, or the like, are connected to the tubes 60 and are adapted to be connected to hangers, or the like (not shown), which extend from the roof of the building to support the separator 10 without the need for steel supports at the bottom of the cylinders. It is also understood that the tubes 60 can be spaced out over the entire diameter of the cylinder 32 as needed.

An inner pipe, or barrel 61 is disposed within the cylinder 32 and is formed from a solid, metallic material such as stainless steel, and has an upper end portion extending approximately flush with the opening formed by the vertical bent tube portions 28. The pipe 61 extends from the latter opening to an area coincidental with the inlet formed by the bent tube groups 24a and 28a. Thus an annular passage is formed between the outer surface of the pipe 61 and the inner surface of the cylinder 32, for reasons that will be described.

The tubes 24, 26, 28 and 30 are disposed between an insulative material and an erosion preventing structure which are omitted from Fig. 1 for the convenience of presentation but which are shown in Fig. 2. More particularly, the details of a wall portion of the cylinder 32 formed by the group of tubes 24 are shown in Fig. 2. More particularly, each tube 24 has a pair of fins 62 and 64 extending from diametrically opposed portions of its wall, with a slight spacing being provided between the fin 62 of one tube and the fin 64 of an adjacent tube. A seal plate 66 is provided in a slightly spaced relationship to the plane of the tubes 24 and a heat insulative refractory material 68 is disposed between the outer surface of the tubes and the inner wall of the seal plate. A plurality of tiles 70 extend adjacent the inner wall of the tubes 24 and are interlocked to protect the tubes from erosion.

In operation, and assuming the separator 10 of the present invention is part of a boiler system including a fluidized bed reactor, or the like, disposed adjacent the

separator, the inlet formed by the bent tubes 24a and 28a receives hot gases from the reactor which gases contain entrained fine solid particulate fuel material from the fluidized bed. The gases contained the particulate material thus swirl around the annular chamber defined between the cylinder 32 and the inner pipe 61 and the solid particles are propelled by centrifugal forces against the inner wall of the cylinder 32 where they collect and fall downwardly by gravity into the hopper in a conventional manner.

The relatively clean gases in the annular chamber are prevented from flowing upwardly by the roof 52 and thus pass into and through the inner pipe 61 before exiting in a direction shown by the arrows in Fig. 1 through an outlet defined by the sidewalls connected to the headers 48 and 50. It is understood that a plurality of screen tubes (not shown) can be provided in the path of the gases exiting in this manner and the gases can then pass to a heat recovery area disposed adjacent the separator 10.

Water from an external source is passed into the headers 12, 14, 18 and 20 and thus passes upwardly through the groups of tubes 24, 26, 28 and 30 before exiting, via the headers 48, 50, 54 and 56, to external circuitry which may form a portion of the boiler system including the separator 10.

Description of the Preferred Embodiment

Referring to Fig. 3 of the drawings, the reference numeral 10a refers in general to the cyclone separator of the present invention which includes a lower ring header 12a and an upper ring header 14a. The header 12a extends

immediately above, and is connected to, a hopper 16a disposed at the lower portion of the separator 10a.

A group of vertically-extending, spaced, parallel tubes 20a are connected at their lower end to the header 12a and extend vertically for the greater parts of their lengths to form a right circular cylinder 22a.

A portion of the tubes 20a are bent out of the plane of the cylinder 22a, as shown by the reference numerals 20a, to form an inlet passage 24a to the interior of the cylinder for reasons that will be described.

At the the upper end of the cylinder 22a the tubes 20a are bent radially inwardly as shown by the reference numeral 20ba, and then upwardly as shown by the reference numeral 20ca to define a circular opening which, of course, is of a diameter less than that of the diameter of the cylinder 22a. The tubes 20a are then bent radially outwardly as shown by the reference numeral 20da, with their respective ends being connected to the upper header 14a. The tube portions 20ba thus form a roof for the cyclone.

A plurality of vertical pipes 28a extend upwardly from the upper header 14a, it being understood that the lower header 12a can be connected to a source of cooling fluid, such as water, or steam, which passes from the header 12a, through the tubes 20a, and into the upper header 14a before being discharged, via the pipes 28a, to external equipment. The direction of flow for the cooling fluid could also be reversed.

An inner pipe, or barrel, 30a is disposed within the cylinder 22a, is formed from a solid, metallic material,

such as stainless steel, and has an upper end portion extending slightly above the plane formed by the header 14a and the upper tube portions 20da. The pipe 30a extends immediately adjacent the tube portions 20ca, and its length approximately coincides with the inlet passage formed by the bent tube portions 20a. Thus, an annular passage is formed between the outer surface of the pipe 30a and the inner surface of the cylinder 22a, for reasons that will be described, and the tube portions 22ba form a roof for the chamber.

The tubes 20a are disposed between an insulative material and an erosion preventing structure which are omitted from Fig. 1 for the convenience of presentation but which are shown in Fig. 2. More particularly, a fin 32a is welded to, and extends from, the adjacent walls of each pair of adjacent tubes 20a. A lagging, or panel 34a of a lightweight material, such as aluminum, is provided in a slightly spaced relationship to the plane of the tubes 20a, and a heat insulative material 36a is disposed between the outer surface of the tubes 20a and the inner wall of the lagging 34a. A plurality of tiles 38a extend adjacent the inner wall of the cylinder 22a and are connected by anchors 40a extending from the fins 32a. A layer of refractory 42a is designed between the tiles 38a and the tubes 20a.

It is understood that an upper hood, or the like (not shown), preferably rectangular in cross section, can be provided above the plane formed by the upper header 14a and the tube portions 20da and can be connected to the pipe 30a by a plurality of conical plates or the like (not shown).

The hood can be top supported from the roof of the structure in which the separator 10a is placed and the remaining portion of the separator can be supported from hangers connected to header 14a, or pipes 28a.

In operation, and assuming the separator 10a of the present invention is part of a boiler system including a fluidized bed reaction, or the like, disposed adjacent the separator, the inlet passage 24a formed by the bent tube portions 20a receives hot gases from the reactor which gases contain entrained fine solid particulate fuel material from the fluidized bed. The gases containing the particulate material thus enter and swirl around in the annular chamber defined between the cylinder 22a and the inner pipe 30a, and the entrained solid particles are propelled by centrifugal forces against the inner wall of the cylinder 22a where they collect and fall downwardly by gravity into the hopper 16a. The relatively clean gases remaining in the annular chamber are prevented from flowing upwardly by the roof formed by the tube portions 20ba and their corresponding fins 32a, and thus enter the pipe 30a through its lower end. The gases thus pass through the length of the pipe before exiting from the upper end of the pipe to the aforementioned hood, or the like, for directing the hot gases to external equipment for further use.

Water, or steam from an external source is passed into the lower header 12a and passes upwardly through the tubes 20a before exiting, via the upper header 14a and the pipes 28a, to external circuitry which may form a portion of the boiler system including the separator 10a. The water thus

maintains the wall of cylinder 22a at a relatively low temperature.

Referring to Figs. 5 and 6 of the drawings, the reference numeral 10b refers in general to the cyclone separator of the present invention which includes a lower ring header 12b and an upper header 14b. The header 12b extends immediately above, and is connected to, a hopper 16b disposed at the lower portion of the separator 10b.

A group of vertically-extending, spaced, parallel tubes 20b are connected at their lower ends to the header 12b and extend vertically for the greater parts of their lengths to form a right circular cylinder 22b.

A portion of the tubes 20b are bent out of the plane of the cylinder 22b, as shown by the reference numerals 20ab, and, as shown in Fig. 2, approximately half of these bent tube portions are bent away from the other half to form an inlet passage 24b to the interior of the cylinder for reasons that will be described.

At the upper end of the cylinder 22b and tubes 20b are bent radially inwardly, as shown by the reference numeral 20bb, and then upwardly as shown by the reference numeral 20cb, to define a circular opening which, of course, is of a diameter less than that of the diameter of the cylinder 22b. The tubes 20b are then bent radially outwardly as shown by the reference numeral 20db, and a portion of these bent tube portions 20db are bent upwardly as shown by the reference numeral 20eb. As better shown in Fig. 2 the best tube portions 20eb form approximately one-half of a right circular cylinder 26b. The remaining portions of the bent

tube portions 20db extend horizontally are bent at right angles in a horizontal plane, and then vertically, as shown by the reference numeral 20fb, to form two vertically extending, spaced walls one of which is shown by the reference numeral 28b. The tube portions 20eb and the vertically extending tube portions 20fb are bent to form horizontal tube portions 20gb which form a roof 30b for an enclosure 32b defined by the tube portions 20db the partial cylinder 26b and the walls 28b.

The enclosure 32b has an outlet opening 32ab which discharges to a heat recovery area, shown in general by the reference numeral 36b.

The lower header 12b can be connected to a source of cooling fluid, such as water which passes from the header 12b, through the tubes 20b, and into the upper header 14b which is converted to a header 37b forming a portion of the water flow circuitry of the heat recovery area 36b.

An inner pipe, or barrel, 38b is disposed within the cylinder 22b, is formed from a solid, metallic material, such as stainless steel, and has an upper end portion extending slightly above the plane of the tube portions 20db. The pipe 38b extends immediately adjacent the tube portions 20cb, and its length substantially coincides with the inlet passage formed by the bent tube portions 20ab. Thus, an annular Chamber 34b is formed between the outer surface of the pipe 38b and the inner surface of the cylinder 22b, and the tube portions 20bb form a roof for said chamber.

The tubes 20b are disposed between an insulative

material and an erosion preventing structure which are omitted from Fig. 2 for the convenience of presentation but which are shown in Fig. 3. More particularly, a fin 40b is welded to, and extends from, the corresponding walls of each pair of adjacent tubes 20b. A lagging, or panel 42b of a lightweight material, such as aluminum, is provided in a slightly spaced relationship to the plane of tubes 20b, and a heat insulative material 44b is disposed between the outer surface of the tubes 20b and the inner wall of the lagging 34b. A plurality of tiles 46b extend adjacent the inner wall of the cylinder 22b and are connected by anchors 48b extending from the inner walls of tubes 20b. A layer of refractory material 50b is disposed between the tiles 46b and the tubes 20b.

In operation, and assuming the separator 10b of the present invention is part of a boiler system including a fluidized bed reactor, or the like, disposed adjacent to the separator, the inlet passage 24b formed by the bent tube portions 20ab receives hot gases from the reactor which gases contain entrained fine solid particulate fuel, ash, limestone, etc. from the fluidized bed. The gases containing the particulate material thus enter and swirl around in the annular chamber 34b defined between the cylinder 22b and the inner pipe 38b, and the entrained solid particles are propelled by centrifugal forces against the inner wall of the cylinder 22b where they collect and fall downwardly by gravity into the hopper 16b. The relatively clean gases remaining in the annular chamber 34b are prevented from flowing upwardly by the roof formed by the tube portions

20bb and their corresponding fins 40b, and thus enter the pipe 38b through its lower end. The gases thus pass through the length of the pipe 38b before exiting from the upper end of the pipe to the enclosure 32b which directs the hot gases radially outwardly to the heat recovery area 36b.

Water or steam from an external source is passed into the lower header 12b and passes upwardly through the tubes 20b before exiting, via the upper header 14b to the header 37b of the heat recovery area 36b. The water thus maintains the cylinder 22b and the enclosure 32b at a relatively low temperature.

Several advantages result from the foregoing arrangement. For example, the cyclone separator of the present invention reduces heat losses and minimizes the requirement for internal refractory insulation. Also, the bulk, weight, and cost of the separator of the present invention is much less than that of conventional separators. The separator of the present invention also eliminates the need for expensive high temperature refractory-lined ductwork and expansion joints between the reactor and cyclone separator, and between the latter and the heat recovery section.

Further, the cyclone separator can be put into use relatively quickly without any warm-up period, and the temperature of the outer walls of the separator can be maintained the same as the temperature of the walls of the adjoining reactor.

Still further, by utilizing the upper end portions of the tube groups to form a roof, the requirement for

additional roof circuitry is eliminated.

It is understood that several variations may be made in the foregoing without departing from the scope of the invention. For example, the fins 62 and 64 extending from each tube can be welded together to form a gas tight structure or, alternatively, can be eliminated and the tubes welded directly together.

The entire contents of the provisional specifications lodged with Australian Patent Applications of which this is the complete specification are hereby imported into this specification and form part of the disclosure of this specification. The claims form part of the disclosure of this specification.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A cyclone separator comprising an inner cylinder; an outer cylinder extending around said inner cylinder in a coaxial relationship to define an annular chamber between the two cylinders, said outer cylinder comprising a plurality of tubes extending vertically (in use) in a parallel relationship for at least a portion of their lengths, said plurality of tubes being arranged in a side-by-side relationship to form said outer cylinder, a portion of said tubes being bent from the plane of said outer cylinder to form an inlet opening in a tangential relationship to said outer cylinder for receiving gases containing solid particles and directing same through said annular chamber for separating the solid particles from said gases by centrifugal forces, the separated gases exiting through said inner cylinder and the separated solids falling to the bottom of said outer cylinder for disposal, said tubes being bent radially inwardly towards said inner cylinder such that they are adapted to support said inner cylinder, means for passing water-steam through said tubes to cool said outer cylinder; and a plurality of support tubes connected to said outer cylinder for supporting said separator from a building or structure.

2. A cyclone separator according to claim 1, wherein upper portions of said plurality of tubes are bent across the upper end of said outer cylinder to form a roof.

3. A cyclone separator according to claim 1 or claim 2,

wherein upper and lower end portions of said plurality of tubes are configured to form two opposite side walls of an enclosure and the intermediate portion of said tubes are bent into said cylindrical configuration.

4. A cyclone separator according to any preceding claim, wherein the tubes of said plurality of tubes are disposed in a spaced relationship.

5. A cyclone separator according to any preceding claim, wherein each tube has a continuous fin extending from diametrically opposite portions thereof for the length of said tube.

6. A cyclone separator according to any preceding claim, further comprising refractory means extending around the inner and outer surfaces of said outer cylinder.

7. A cyclone separator according to any preceding claim, wherein said support tubes are adapted to support said separator from a roof of said building or structure.

DATED this 23 September 1991

CARTER SMITH & BEADLE

Fellows Institute of Patent Attorneys of Australia

Patent Attorneys for the Applicant:

FOSTER WHEELER ENERGY CORPORATION

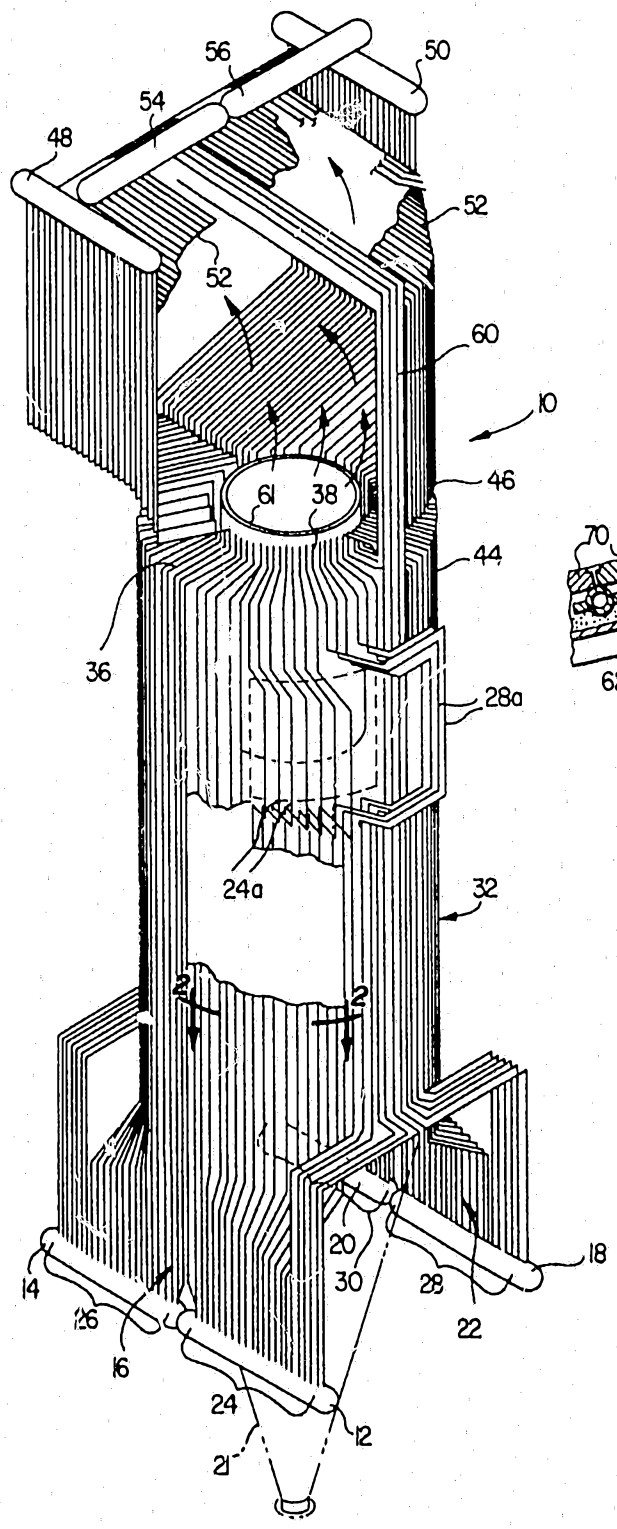
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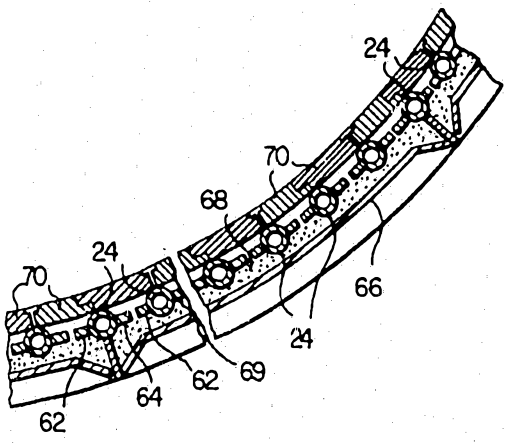
FIG. 1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62

FIG. 2

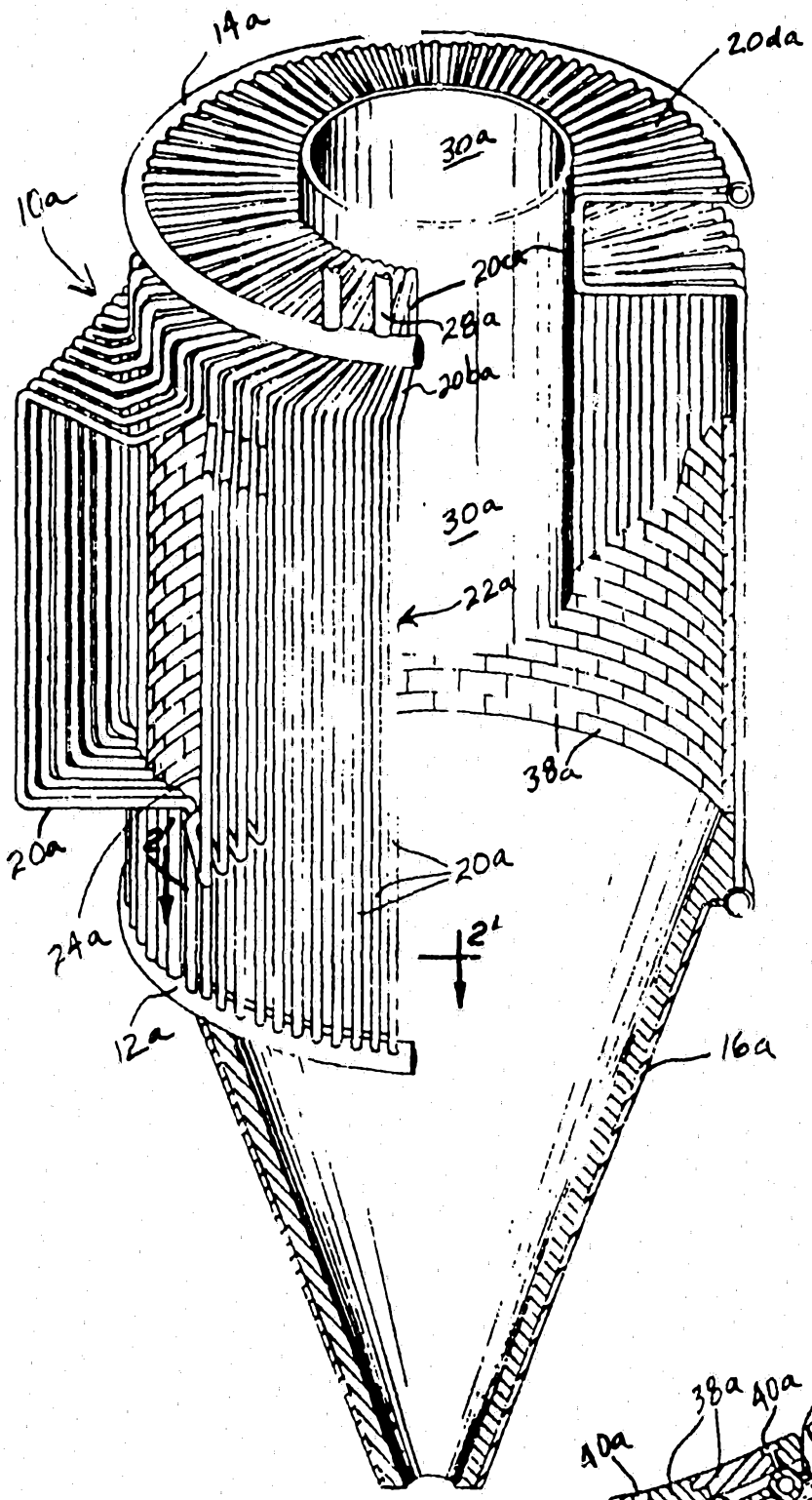
14a
20da
10a
30a
20ca
28a
20ba
30a
22a
38a
20a
20a
24a
2'
2'
12a
16a

FIG. 3

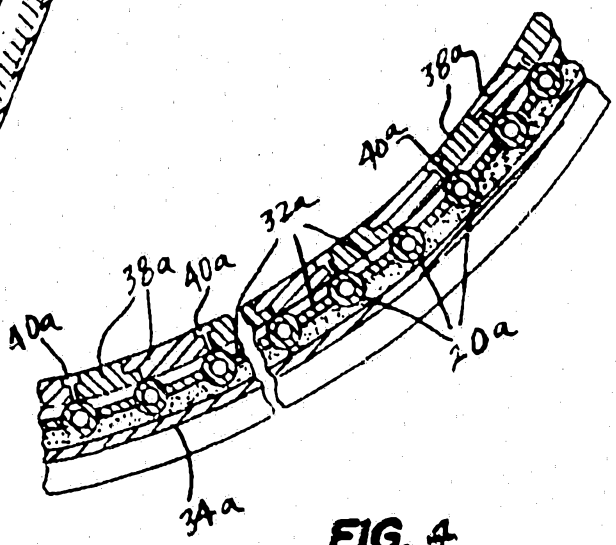
38a
40a
32a
38a
40a
40a
20a
34a

FIG. 4

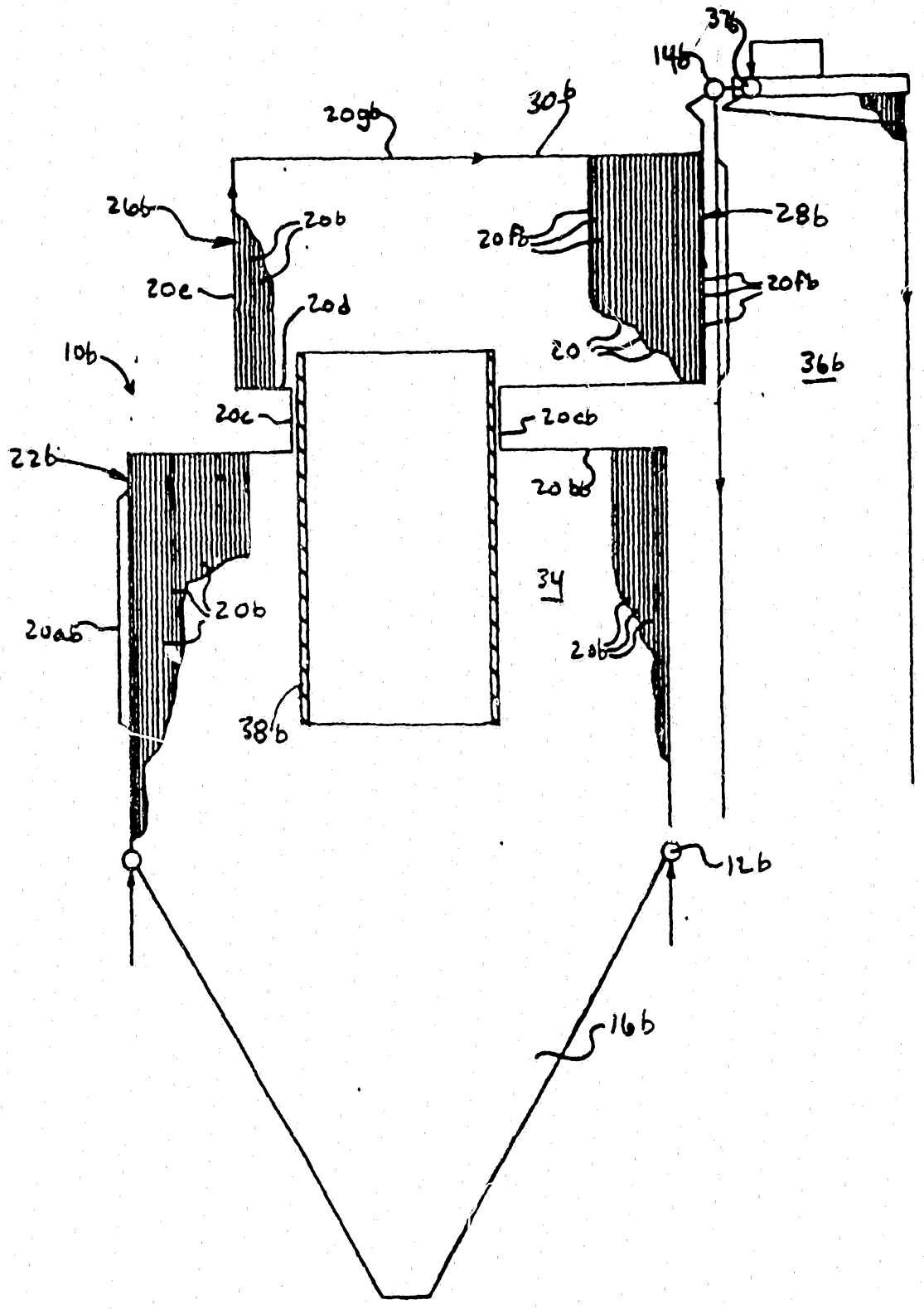
37b
14b
30b
20gb
26b
20b
20fb
28b
20e
20d
20fb
10b
20
36b
20c
20cb
22b
20bb
34
20ab
20b
20b
38b
12b
16b

FIG. 5

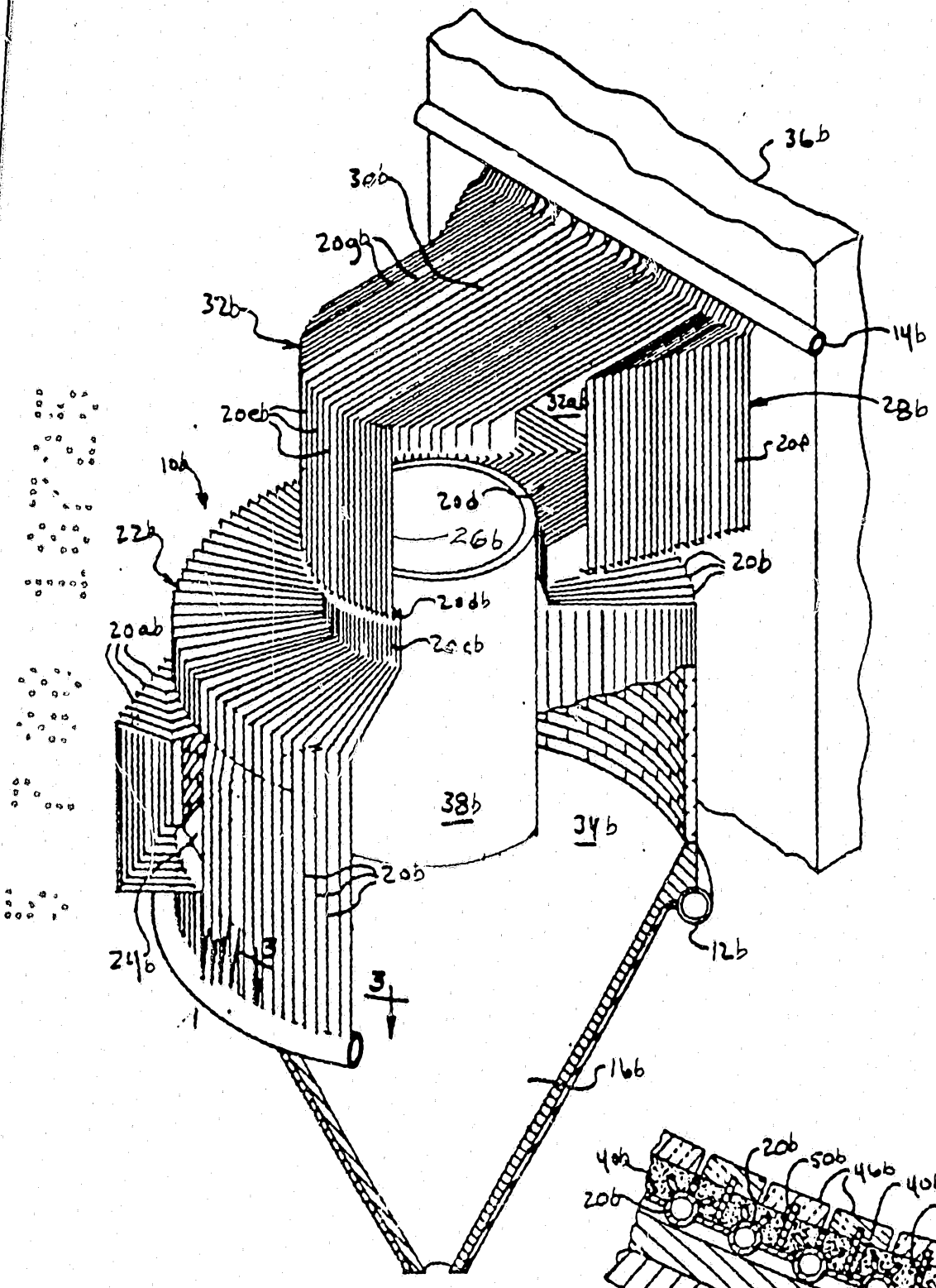
36b
30b
20gb
32b
14b
28b
20eb
32ab
20f
10b
20d
22b
26b
20b
20db
20ab
20cb
38b
34b
20b
12b
24b
3
3
16b

FIG. 6

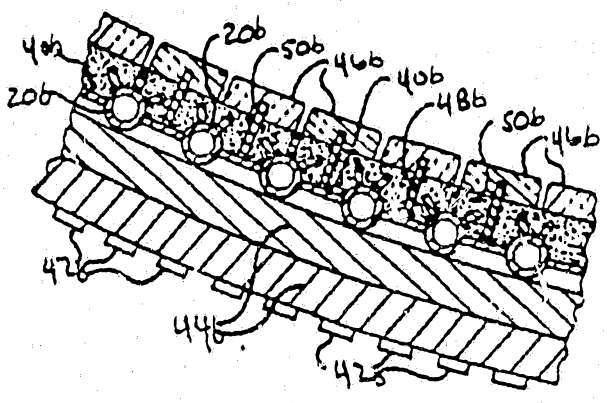
40b
20b
50b
46b
40b
20b
48b
50b
46b
42b
44b
42b

FIG. 7