APPARATUS FOR DIVERTING, REVECTORING AND ACCELERATING A FLOWING GAS MASS

(54) Title: APPARATUS FOR DIVERTING, REVECTORING AND ACCELERATING A FLOWING GAS MASS

(57) Abstract: An apparatus for diverting, revectoring and accelerating a mass of gas, for example, a rapidly moving air mass traversing the landscape, wherein the apparatus comprises first and second spaced-apart upstanding walls, the first wall being disposed relative to the second wall such that the lower terminus of the first wall is disposed above the lower terminus of the second wall, thereby forming an entry inlet for high velocity air mass to pass between the walls and exit at the other end; the walls are disposed in a convergent rotation in the direction of the exit outlet of the apparatus and further, the upper terminus of the second wall being positioned relative to the upper terminus of the first wall such that an air mass flowing through the space between the first and second walls will exit the apparatus at an accelerated flow rate relative to the entry flow rate and with a vector divergent form the flow vector at the entry inlet and the walls being disposed.
APPARATUS FOR DIVERTING, REVECTORING AND ACCELERATING A FLOWING GAS MASS

Background of the Invention

1. Field of the Invention

The present invention relates to an apparatus for diverting, revectoring and accelerating a moving gas, for example, a rapidly moving air mass.

2. Description of the Prior Art

An apparatus having a multiple wall configuration for deflecting jet exhausts is described in U.S. Patent No. 5,429,334. Another apparatus for deflecting jet exhausts and deadening the sounds generated by the jet exhaust is described in U.S. Patent No. 3,080,937.

Systems and apparatus for utilizing the power generated by passing high velocity gases against a working surface, such as a turbine blade, are described in U.S. Patents Nos. 5,464,320; 5,350,273; 5,053,899; 5,009,569 and 4,624,104.

The use of apparatus to divert a moving air mass (wind) to enhance the performance of sailing vessels is described in U.S. Patents Nos. 4,803,939 and 4,437,426.

Summary of the Invention

Briefly, and in its broadest aspect, the apparatus of this invention comprises first and second spaced-apart upstanding walls, the first wall being disposed relative to the second wall such that the lower terminus of the first wall is disposed above the lower terminus of the second wall,
thereby forming an entry inlet for high velocity gas to pass between the walls and exit at the other end; further, the walls are disposed in a convergent relation in the direction of the exit outlet of the apparatus and the upper terminus of the second wall is positioned relative to the upper terminus of the first wall so that a gas mass flowing through the space between the first and second walls will exit the apparatus at an accelerated flow rate relative to the entry flow rate and with a vector divergent from the flow vector at the entry inlet. The broadest aspect of the apparatus is described above and hereafter as if the second wall has its base resting on a horizontal surface. It should be understood that the method and apparatus and the relative spatial relationship of the first and second walls are applicable to the situation where the second wall moves through an upstanding position with the base of the second wall on a horizontal surface to a position where the second wall is parallel and contiguous to the horizontal surface.

In a preferred form, the rear face of the first wall is convexly and curvilinearly shaped and the front surface of the second wall is concavely and curvilinearly shaped.

In a more preferred form, the front surface of the first wall is concavely and curvilinearly shaped, together with the above indicated shape of the rear surface of the first wall and the front surface of the second wall.
In a further preferred form, in addition to the shapes set forth in the preceding two paragraphs, the rear surface of the first wall is aileron shaped, thus aiding in accelerating the gas mass flowing through the space between the walls.

In the most preferred form of the apparatus of this invention, in addition to the shapes described in the preceding three paragraphs, the second wall has a lip on the upper terminus of the second wall that is sloped toward the front wall. The tapered lip functions to thrust the accelerated air passing through the space between the first and second walls toward the prevailing air passing over the apparatus. This thrust action vectors the prevailing air upwards to increase the calm zone on the leeward side of the apparatus.

When the apparatus is used to divert wind and create an area of calm, the apparatus is positioned such that the first wall is facing in the direction of the high velocity wind and the second wall is standing on its base. The wind enters the space between the first and second walls and is vectored upwardly through the space at an increased speed and to exit the apparatus. The accelerated gas mass exiting the apparatus acts to divert the prevailing air in an upward direction, leaving the leeward side of the second wall relatively calm.

Further applications of the method and apparatus of this invention include directing wind into the sail of a vessel and also directing a flowing gas onto the turbine blades of a generator.
In using the apparatus of this invention to drive a turbine, the air directed through the apparatus is accelerated and pressurized, these parameters being maximized at the point of exit from the apparatus, whereat the turbine blades, mounted on a rotation shift, encounter the exiting air. The air moving along the front surface of the apparatus assists the exit speed of the air traversing the funnel of the apparatus by directing the prevailing airflow passing over the apparatus upward, thus effecting a relatively lower pressure zone at the exit port of the apparatus and causing the air exiting from the apparatus of the invention to increase in velocity as it approaches impingement on the turbine blades and, consequently, a greater driving force to the turbine blades.

Similarly, when using the apparatus of the invention to direct air traversing through the apparatus to a sail, the apparatus of the invention is mounted on the boom of the sailing vessel. Air passing through the funnel of the apparatus is accelerated and pressurized, reaching a maximum of these parameters at the exit port of the apparatus. The prevailing air passing over the front surface of the apparatus acts to direct prevailing air passing over the top of the apparatus in an upward direction, thus forming a zone of lower pressure at the exit port of the apparatus and thereby enhancing the acceleration of the air exiting the apparatus of the invention.
Brief Description of the Drawings

Figure 1 is a perspective view of the apparatus of this invention.

Figure 2 is a cross-sectional view of the apparatus of Figure 1.

Figure 3 is a cross-sectional view of a further embodiment of the apparatus of Figure 2.

Figure 4 is a depiction of air flow over the top and leeward side of a normal standing wall.

Figure 5 is a depiction of air flow over the top and leeward side of the apparatus of the invention.

Figure 6 is a graph setting forth the spacing of the outlet as a percentage of the inlet spacing at various wind velocities.

Figures 7a-7b are a schematic side view and a 30° isometric view of the apparatus of this invention as applied to driving a turbine.

Figures 8a-8b are a schematic side view and an isometric view of the apparatus of this invention as applied to directing air to the sail of a sailing vessel.

Figure 9 is a schematic of the wind diverting apparatus of this invention using simple curvilinear shapes.

Figure 10 is a schematic of the wind diverting apparatus of this invention using a more complex shape in the windward wall.

Figure 11 is a schematic of the wind diverting apparatus of this invention showing a variant of Sheet 2 of Figure 10.
Figure 12 is a schematic of the apparatus of Figure 11 having an inwardly directed upper exit edge on Sheet 1.

Figure 13 is a variant of the schematic of Sheet 3 of Figure 11.

Detailed Description of the Invention

In Figure 2, the apparatus of this invention, generally designated as (10), has an upstanding second wall (12), the front or windward face (14) of the second wall (12) being concave and curvilinear in shape. Disposed forwardly of the second wall (12) is a first wall (16) having a convex and curvilinearly-shaped rear surface (18) and a concave and curvilinearly-shaped front surface (20). The second wall (12) and the first wall (16) are disposed relative to each other to create a space (22), which space (22) converges from the inlet zone (24) to the exit zone (26). The first wall (16) and the second wall (12) may be joined to each other by any standard support (not shown).

As shown in Figures 1 and 2, the first wall has an airfoil shape such that the air traversing across the rear surface of the first wall is accelerated by having the air entering the space between the first and second walls travel a greater distance over the rear surface (18) of the first wall (16).

Figure 3 shows a preferred embodiment of the apparatus of this invention, where the apparatus is utilized to create a zone of air calmness on the leeward side of the second wall. In Figure 3, the top portion of the second wall has a lip (28)
sloped toward the first wall (16). The lip (28) acts to direct the accelerated air passing between the first and second walls of the apparatus of the invention towards the prevailing air movement. This action directs the vectoring of the prevailing air in a further upward direction and creates a larger zone of calm air on the leeward side of the second wall. This aspect will be further discussed hereafter.

With the aforesaid surface shapes of the first and second walls, the prevailing air is moved more efficiently between the walls of the apparatus and allows for the air to be directed in a new vector from the entry vector, while simultaneously minimizing air drag as it flows over the surfaces defining the space between the first and second walls, a curved surface is used on the rearward surface of the first wall and the front surface of the second wall; the rear surface of the first wall being convex and the front surface of the second wall being concave.

The use of the apparatus of this invention as a barrier to divert wind will create a zone on the leeward side of the barrier that will have a substantially increased zone of calmness as compared to the wind traversing into and over a regular upstanding wall. This improvement, namely, the creation of a zone of calm air on the leeward side of the barrier is illustrated in the depiction of wind vectors in Figures 4 and 5. It will be noted that with a standard upright wall, the wind velocity on the leeward side of the wall very rapidly intensifies a short distance after passing over the top of the barrier. While, as shown in Figure 5,
there is a substantial area of calm on the leeward side of the barrier of this invention. The wind velocity vectors are computer generated.

In utilizing the apparatus of this invention as a barrier, the terminus of the first and second walls at the exit port should be essentially coplanar for maximum efficiency.

In the instance where the apparatus is used to direct air into and onto a sail, the first or front wall is significantly lower than the second or rear wall for, in effect, the sail becomes an extension of the rear wall.

In the instance of utilizing the apparatus to drive a turbine, the upper terminus of the first or front wall may be slightly lower than the upper terminus of the second or rear wall for reason that the action of the turbine itself will redirect the air exiting between the walls of the apparatus away from the prevailing air through the rotational action of the turbine. Additionally, the venturi effect created by the increase in velocity of the air passing between the walls of the apparatus will draw air flowing over the front wall toward the higher velocity air passing between the walls of the apparatus and, thus, be drawn toward the turbine. The overall effect is beneficial to the desired rotation of the turbine.

Figure 6 discloses an approximation of the size of the outlet opening compared to the inlet opening for various wind velocities. It should be understood that the data set forth in Figure 6 is a calculation based on a series of bench tests using a prototype barrier apparatus of this invention and wind
velocities up to 45 m.p.h. by a controlled variable fan. Wind speed was determined by particulate movement over a set distance. Extrapolation was then made from the data generated to produce the curve of Figure 6. The criteria for the curve of Figure 6 was to note the greatest increase in exit velocity gained from modifying the exit gap relative to a set inlet gap. Of course, varying parameters such as the curve of either the first (front) or second (rear) wall or the type of foil used in the first wall modify the curve of Figure 6. However, in all applications of the apparatus of this invention where the intent is to accelerate the air to maximum velocity at the exit port of the apparatus, the optimum values of the inlet/exit ports or gaps set forth in Figure 6 will serve as a guide.

In the apparatus of this invention, the first and second wall may be mounted such that an adjustment in the spacing between the walls or elevationally one wall to the other wall may be made by means well-known to those skilled in the art.

The afore-described shape of the apparatus acts to funnel the prevailing air between the first and second walls, thereby accelerating the air through the exit port; the accelerated air exiting the apparatus providing an upward thrust to the prevailing air flowing over the top of the apparatus at the windward side and, thereby, increasing the area of calmness on the leeward side of the second wall. Additionally, the concave, curvilinear outer or windward face of the first wall deflects the prevailing air upward and protects the air passing between the first and second walls of
the apparatus of this invention from interference and
turbulence with the prevailing air.

While the apparatus is shown as standing with its base at
ground level, it should be understood that the apparatus of
the invention, in its use in creating an area of calm on the
leeward side of the apparatus could be mounted atop an
upstanding wall.

In the preferred form of the apparatus of this invention,
the surfaces of the first wall are in the form of a half-
parabola.

Figure 9 is a schematic diagram of the apparatus of this
invention employing simple curves for the first and second
walls and Figure 10 is a schematic of the device of the
invention employing more complex parabolic curves for the
first and second walls.

With the walls in the configuration of Figure 9 and the
air flow as indicated, the air enters at (A) between Sheet 1
and Sheet 2 and exits at (B); the curved Sheet 1 acting to
funnel the air in a direction 90° from the horizontal, while
Sheet 1 and Sheet 2 act to effect a pressurization and,
consequently, an acceleration of the air flowing between the
sheets.

Additionally, due to the concave, curvilinear outer
surface of Sheet 2 facing in the path of the prevailing air,
the air is moved in an upward direction. This upward or
vertical movement of the prevailing air across the outer wall
assists in having the upward vectored pressurized air moving
between the sheets move to a greater vertical distance as it exits at (B) from the funnel.

To obtain a further improvement over the effects described in conjunction with the simple curves of Figure 9, resort may be made to using semi-parabolic shapes for Sheets 1 and 2 as shown schematically in Figure 10. The effect of using the shapes of Figure 10 is to cause the entry angle for the air to be shallower and, thus, less drag and turbulence. Furthermore, because the nature of the parabolic curve is to tighten in radius as the curve moves toward its apex, the air passing between the sheets is more efficiently pressurized.

To further improve the acceleration and throughput of the apparatus of this invention, Sheet 2 of Figure 10 may be converted to the airfoil surface of Sheet 3 as shown in Figure 11, thereby accelerating the air passing between Sheets 1 and 3.

As shown in Figure 12, the upper edge of Sheet 1 may be sloped toward the prevailing air, with the consequence that the accelerated air is directed towards the prevailing air passing over and above the front surface of Sheet 3. This action increases the vectoring of the prevailing air passing upward over the front surface of Sheet 3 in an upward direction to a greater height to give a further improvement in the calmness of the zone beyond the apparatus.

While Figure 12 shows Sheet 1 having an upper trailing edge deviating toward the prevailing wind, a similar deviation to leeward could be provided allowing the air in the space between the Sheets defining the funnel to escape sooner from
the funnel. This structure would be useful when using the apparatus of this invention to direct prevailing air to a sail.

While the windward or front surface of Sheet 2 or Sheet 3 in Figures 9-12 is shown as curvilinear, the said surface could be flat and smooth as shown in Figure 13.

It is believed that the maximum efficiency of the apparatus is attained when the trailing edge of the first and second walls are coplaner, i.e., when the apparatus has the trailing edges of each of the first and second walls extending in a vertical direction to the same extent. It is further believed that a significant degree of calmness on the leeward side of the apparatus is attained where the coplanarity of the trailing edges of the first and second walls does not exceed ten (10) percent. Expectedly, where the coplanarity of the trailing edges of the first and second walls exceeds thirty (30) percent, there would be no improvement in the calmness on the leeward side of the apparatus. Further, it is expected that the afore-described planarity relationship would also apply where the apparatus of this invention is used to rotate turbine blades or as an assist in directing air to a sail.

Although specific examples of the invention have been shown for purposes of disclosure, it is to be understood that various modifications can be made therefrom without departing from the spirit and scope of the invention.
We claim:

1. An apparatus for diverting, revectoring and accelerating a flowing gas mass comprising a dual-wall assembly having a front and rear faced first wall with an upper portion and a base portion and a front and rear faced second wall with an upper portion and a base portion, said first and second walls being spaced from each other to provide an entry inlet between their respective base portions for a flowing gas mass and an exit outlet between their respective upper portions for the flowing gas mass, the space between the first wall and the second wall converging in the direction of the exit outlet and the terminus of the upper portion of the second wall being positioned relative to the terminus of the upper portion of the first wall such that a gas mass flowing through the space between the first and second walls will exit the apparatus at an accelerated flow rate relative the entry flow rate and with a vector substantially divergent to the flow vector at the entry inlet.

2. The apparatus of claim 1, and further wherein the terminus of the upper position of the first wall being positioned relative to the terminus of the upper position of the first wall such that a gas mass flowing through the space between the first and second walls will exit the apparatus at an accelerated flow rate relative the entry flow rate and with a vector substantially normal to the flow vector at the entry inlet.
3. The apparatus of claim 1, and further wherein the rear face of the first wall is convex and curvilinearly shaped and the front face of the second wall is concave and curvilinearly shaped.

4. The apparatus of claim 2, and further wherein the rear face of the first wall is convex and curvilinearly shaped and the front face of the second wall is concave and curvilinearly shaped.

5. The apparatus of claim 3, and further wherein the front face of the first wall is concave and curvilinearly shaped.

6. The apparatus of claim 4, and further wherein, the front face of the first wall is concave and curvilinearly shaped.

7. The apparatus as in any of the preceding claims, and further wherein the exit outlet is defined, in part, by the upper portion of the second wall being substantially in a common plane with the upper portion of the first wall.

8. The apparatus as in any of the preceding claims, and further wherein the upper portion of the second wall has a lip that is tapered toward the first wall.
9. An apparatus for diverting, revectoring and accelerating high velocity air flow to create a zone of calmness on the leeward side of the apparatus comprising a dual-wall assembly having a front and rear faced first wall with an upper portion and a lease portion and a front and rear faced second wall with an upper portion and a base portion, said second wall having its rear face vertically upstanding, said first and second walls being spaced from each other to provide an entry inlet between their respective base portions for a flowing gas mass and an exit outlet between their respective upper portions for the flowing gas mass, the space between the first wall and the second wall converging in the direction of the exit outlet, the terminus of the upper position of the first wall being positioned relative to the terminus of the upper position of the first wall such that a gas mass flowing through the space between the first and second walls will exit the apparatus at an accelerated flow rate relative the entry flow rate and with a vector substantially normal to the flow vector at the entry inlet.

10. The apparatus of claim 9 and further wherein the rear face of the first wall is convex and curvilinearly shaped and the front face of the second wall is concave and curvilinearly shaped.

11. The apparatus of claim 9 and further wherein the front face of the first wall is concave and curvilinearly shaped.
12. The apparatus as in claims 9, 10 and 11 and further wherein the exit outlet is defined, in part, by the upper portion of the second wall being substantially in a common plane with the upper portion of the first wall.

13. The apparatus as in claim 12 and further wherein the upper portion of the second wall has a lip that is tapered toward the first wall.

14. An apparatus for diverting, revectoring and accelerating ambient air flow to a turbine for driving the turbine blades comprising directing the air flow to a dual-wall assembly having a front and rear faced first wall with an upper portion and a lease portion and a front and rear faced second wall with an upper portion and a base portion, said second wall having its rear face vertically upstanding, said first and second walls being spaced from each other to provide an entry inlet between their respective base portions for a flowing gas mass and an exit outlet between their respective upper portions for the flowing gas mass, the space between the first wall and the second wall converging in the direction of the exit outlet, the terminus of the upper position of the first wall such that a gas mass flowing through the space between the first and second walls will exit the apparatus at an accelerated flow rate relative the entry flow rate and with a vector substantially normal to the flow vector at the entry inlet.
15. The apparatus of claim 14 and further wherein the rear face of the first wall is convex and curvilinearly shaped and the front face of the second wall is concave and curvilinearly shaped.

16. The apparatus of claim 14 and further wherein the front face of the first wall is concave and curvilinearly shaped.

17. The apparatus as in claims 14, 15 and 16 and further wherein the exit outlet is defined, in part, by the upper portion of the second wall being substantially in a common plane with the upper portion of the first wall.

18. The apparatus of claim 17 and further wherein the upper portion of the second wall has a lip that is tapered toward the first wall.

19. An apparatus for diverting, revectoring and accelerating ambient air flow to the sail of a sailing vessel comprising directing the air flow to a dual-wall assembly having a front and rear faced first wall with an upper portion and a base portion and a front and rear faced second wall with an upper portion and a base portion, said second wall having its rear face vertically upstanding, said first and second walls being spaced from each other to provide an entry inlet between their respective base portions for a flowing gas mass and an exit outlet between their respective upper portions for
the flowing gas mass, the space between the first wall and the second wall converging in the direction of the exit outlet, the terminus of the upper position of the first wall being positioned relative to the terminus of the upper position of the first wall such that a gas mass flowing through the space between the first and second walls will exit the apparatus at an accelerated flow rate relative the entry flow rate and with a vector substantially normal to the flow vector at the entry inlet.

20. The apparatus of claim 19 and further wherein the rear face of the first wall is convex and curvilinearly shaped and the front face of the second wall is concave and curvilinearly shaped.

21. The apparatus of claim 19 and further wherein the front face of the first wall is concave and curvilinearly shaped.

22. The apparatus as in claims 19, 20 and 21 and further wherein the exit outlet is defined, in part, by the upper portion of the second wall being substantially in a common plane with the upper portion of the first wall.

23. The apparatus of claim 22 and further wherein the upper portion of the second wall has a lip that is tapered toward the first wall.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

<table>
<thead>
<tr>
<th>IPC(7)</th>
<th>F01D 9/02</th>
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<td>US CL.</td>
<td>415/202, 208.1</td>
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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)

| U.S. | 415/202, 208.1, 80, 81, 914 |

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>X</td>
<td>US 410,360 A (HAM) 03 September 1889 (03.09.1889), column 2, lines 4-16.</td>
<td>1, 2, 7</td>
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<tr>
<td>A</td>
<td>US 4,115,028 A (HINTZE) 19 September 1978 (19.09.1978), column 1, lines 41-54</td>
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<td>A</td>
<td>US 4,295,783 A (LEBOST) 20 October 1981 (20.10.1981), column 6, lines 33-48</td>
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<tr>
<td>A</td>
<td>US 5,402,636 A (MIZE et al.) 04 April, 1995 (04.04.1995), column 4, lines 47-69, column 5, lines 1-17</td>
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Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "A" member of the same patent family

Date of the actual completion of the international search:

15 May 2002 (15.05.2002)

Date of mailing of the international search report:

08 JUL 2002

Name and mailing address of the ISA/US

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Form PCT/ISA/210 (second sheet) (July 1998)
INTERNATIONAL SEARCH REPORT

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claim Nos.: 8, 12, 13, 17, 18, 22, 23
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.: 8, 12, 13, 17, 18, 22, 23.

4. ☑ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant’s protest.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet(1)) (July 1998)