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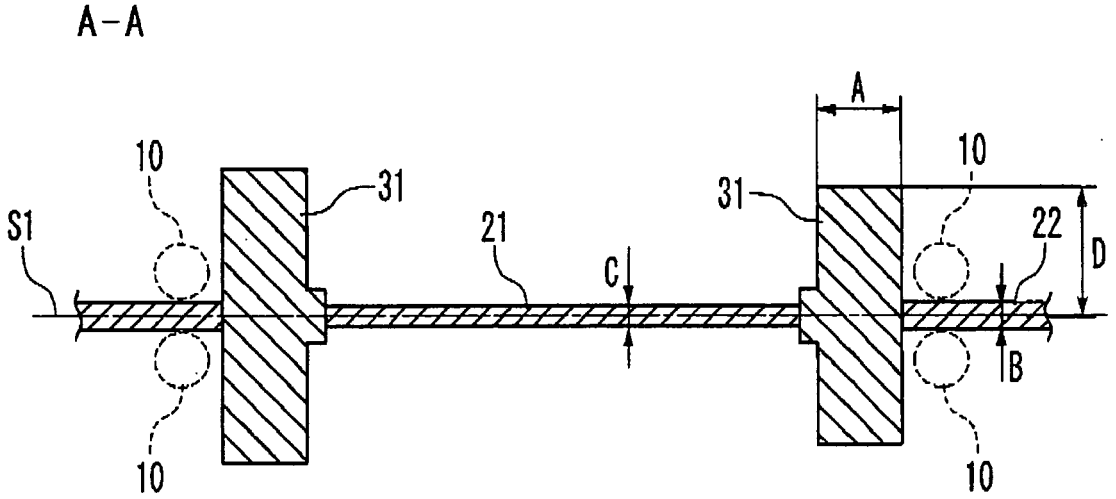
(54) Engine frame

(57) An engine frame (6) includes: a first plate (21) forming a center portion of a bulkhead (20) ; a second plate (22) forming a camshaft-side portion or exhaust-side portion of the bulkhead (20); and a slide plate (31) arranged between the first plate (21) and the second plate (22). The slide plate (31) guides a crosshead (5). The first plate (21) and the second plate (22) are arranged on a plane (S1). The first plate (21) and the slide plate (31) are arranged in a T-shape.. The second plate (22) and the slide plate (31) are arranged in a T-shape. A ratio A/B of a thickness A of the slide plate (31) to a thickness B of the second plate (22) is equal to or larger than 1.5.

Fig. 4



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Description

Technical Field

[0001] The present invention relates to a crosshead engine and particularly relates to a frame of a crosshead engine.

Background Art

[0002] Japanese Examined Utility Model Application Publication (JU-Y-Heisei 06-48137) discloses a frame of a crosshead internal combustion engine. The frame includes a bulkhead 104 shown in Fig. 1. The bulkhead 104 is integrally formed of cast steel by casting. The bulkhead 104 includes a center plate 101, guide bars (slide plates) 102, interposing plates 103, sidewalls 110, and horizontal ribs 112. Bosses 111 are formed in the respective interposing plates 103. Each boss 111 includes a hole through which a tie-bolt (not shown) penetrates,

[0003] Japanese Laid Open Patent Application (JP-P2001-289-114A), Japanese Laid Open Patent Application (JP-P2007-211786A), Japanese Patent No. 2977901, Japanese Patent No. 3226458, Japanese Patent No. 3538280, and Japanese Patent No. 4005550 disclose crosshead engines, respectively.

Summary of Invention

[0004] An object of the present invention is to provide an engine frame easy to manufacture and inspect.

[0005] In a first aspect of the present invention, an engine frame includes: a first plate forming a center portion of a bulkhead; a second plate forming a camshaft-side portion or exhaust-side portion of the bulkhead; and a slide plate arranged between the first plate and the second plate. The slide plate guides a crosshead. The first plate and the second plate are arranged on a plane. The first plate and the slide plate are arranged in aT-shape. The second plate and the slide plate are arranged in a T-shape: A ratio A/B of a thickness A of the slide plate to a thickness B of the second plate is equal to or larger than 1.5.

[0006] Since the slide plate is thick such that the ratio A/B is equal to or larger than 1.5, rigidity of the engine frame is ensured without reinforcements such as horizontal ribs. When no reinforcement is provided, the engine frame has a simple shape and it is easy to manufacture and inspect the engine frame.

[0007] In a second aspect of the present invention, an engine frame includes: a first plate forming a center portion of a bulkhead; a second plate forming a camshaft-side portion or exhaust-side portion of the bulkhead; and a slide plate arranged between the first plate and the second plate. The slide plate guides a crosshead. The first plate and the second plate are arranged on a plane. The first plate and the slide plate are arranged in a T-shape. The second plate and the slide plate are arranged in a T-shape. A ratio A/C of a thickness A of the slide plate to a thickness C of the first plate is equal to or larger than 1.5.

[0008] Since the slide plate is thick such that the ratio A/C is equal to or larger than 1.5, rigidity of the engine frame is ensured without reinforcements such as horizontal ribs. When no reinforcement is provided, the engine frame has a simple shape and it is easy to manufacture and inspect the engine frame.

[0009] In a third aspect of the present invention, an engine frame includes: a first plate forming a center portion of a bulkhead; a second plate forming a camshaft-side portion or exhaust-side portion of the bulkhead; and a slide plate arranged between the first plate and the second plate. The slide plate guides a crosshead. The first plate and the second plate are arranged on a plane. The first plate and the slide plate are arranged in a T-shape. The second plate and the slide plate are arranged in a T-shape. The slide plate is symmetrically formed with respect to the plane. A ratio D/A of a distance D from the plane to an end of the slide plate measured along a normal of the plane to a thickness A of the slide plate is equal to or smaller than 4.0.

[0010] Since the distance D is small such that the ratio D/A is equal to or smaller than 4.0, a ratio of a distance between an action point of a side force acted from the crosshead on the slide plate and the plane to the thickness A of the slide plate is small. Therefore, rigidity of the engine frame is ensured without reinforcements such as horizontal ribs. When no reinforcement is provided, the engine frame has a simple shape and it is easy to manufacture and inspect the engine frame.

[0011] In a fourth aspect of the present invention, an engine frame includes: a first plate forming a center portion of a bulkhead; a second plate forming a camshaft-side portion or exhaust-side portion of the bulkhead; and a slide plate arranged between the first plate and the second plate. The slide plate guides a crosshead. The first plate and the second plate are arranged on a plane. The first plate and the slide plate are arranged in a T-shape. The second plate and the slide plate are arranged in a T-shape. A ratio B/C of a thickness B of the second plate to a thickness C of the first plate is equal to or larger than 1.5.

[0012] Since the second plate is thick such that the ratio B/C is equal to or larger than 1.5, the second plate reinforces the slide plate against a side force acted from the crosshead on the slide plate. Therefore, rigidity of the engine frame is ensured without reinforcements such as horizontal ribs. When no reinforcement is provided, the engine frame has a simple shape and it is easy to manufacture and inspect the engine frame.

[0013] The slide plate guides the crosshead along a vertical direction. Preferably, a top plate is welded to an upper side of the slide plate, a bottom plate is welded to a lower side of the slide plate, and a side plate is welded to a side of the second plate. The side of the second plate is opposite to the first plate. Preferably, any reinforce-

ment reinforcing the slide plate from the second plate or the side plate is not provided.

[0014] Since there is no reinforcement reinforcing the slide plate from the second plate or the side plate, the engine frame has a simple shape and it is easy to manufacture and inspect the engine frame.

[0015] Since the engine frame has a simple shape, man-hour of welding and man-hour of inspection are reduced in a case that the first plate and the second plate are respectively welded to the slide plate.

[0016] Since the engine frame has a simple shape, in a case that the first plate and the slide plate are integrally formed as a cast and the second plate is welded to the slide plate, a wooden model for the cast is easily prepared, castability of the cast is improved, the cast is easily inspected, and man-hour of welding and man-hour of inspection for a welding between the side plate and the second plate are reduced.

[0017] Since the engine frame has a simple shape, in a case that the second plate and the slide plate are integrally formed as a cast and the first plate is welded to the slide plate, a wooden model for the cast is easily prepared, castability of the cast is improved, the cast is easily inspected, and man-hour of welding and man-hour of inspection for a welding between the slide plate and the first plate are reduced.

[0018] Since the engine frame has a simple shape, in a case that the first plate, the second plate and the slide plate are integrally formed as a cast, a wooden model for the cast is easily prepared, castability of the cast is improved, and the cast is easily inspected.

[0019] The slide plate guides the crosshead along a vertical direction. Preferably, the engine frame further includes: a top plate welded to an upper side of the slide plate; a bottom plate welded to a lower side of the slide plate; and a side plate welded to a side of the second plate. The side of the second plate is opposite to the first plate. Since the engine frame has a simple shape, in a case that the first plate, the second plate, the slide plate, the top plate, the bottom plate and the side plate are integrally formed as a cast, a wooden model for the cast is easily prepared, castability of the cast is improved, and the cast is easily inspected.

[0020] The slide plate guides the crosshead along a vertical direction. Preferably, the engine frame further includes: a top plate welded to an upper side of the slide plate; a bottom plate welded to a lower side of the slide plate; and a side plate welded to a side of the second plate. The side of the second plate is opposite to the first plate. Since the engine frame has a simple shape, in a case that a portion of the first plate, the second plate, the slide plate, the top plate, the bottom plate and the side plate are formed as a cast, a wooden model for the cast is easily prepared, castability of the cast is improved, and the cast is easily inspected. Since the shape of the engine frame is simple, in a case that the engine frame is formed by welding the plates that are not formed as the cast to the cast, man-hour of welding and man-hour of inspection are reduced.

[0021] In a fifth aspect of the present invention, an engine includes: the above engine frame; a cylinder; a piston configured to move in the cylinder; a piston rod connected to the piston; the crosshead connected to the piston rod; a crankshaft; a connecting rod connecting the crosshead to the crankshaft; a jacket in which the cylinder is arranged; a bed in which the crankshaft is arranged; and a tie-bolt fastening the jacket, the engine frame and the bed.

[0022] According to the present invention, an engine frame easy to manufacture and inspect is provided.

Brief Description of Drawings

[0023] The above and other objects, advantages and features of the present invention will be more apparent from the following description of certain embodiments taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a horizontal sectional view of a conventional frame;
Fig. 2 is a longitudinal sectional view of an engine according to a first embodiment of the present invention;
Fig. 3 is a front view of a frame according to the first embodiment;
Fig. 4 is a horizontal sectional view of the frame according to the first embodiment;
Fig. 5 is a front view of a frame according to a fourth embodiment of the present invention;
Fig. 6 is a horizontal sectional view of the frame according to the fourth embodiment; and
Fig. 7 is a graph showing relationship between a position of a crosshead and a magnitude of a side force.

Description of Embodiments

[0024] Hereinafter, an engine frame according to embodiments of the present invention will be described with reference to the attached drawings.

(First Embodiment)

[0025] Referring to Fig. 2, an engine according to a first embodiment of the present invention will be described. The engine includes a cylinder 2, a piston 3 moving in the cylinder 2, a piston rod 4 connected to the piston 3, a crosshead 5 connected to the piston rod 4, a crankshaft 8, a connecting rod 7 connecting the crosshead 5 to the crankshaft 8, a jacket 1 in which the cylinder 2 is arranged, a bed 9 in which the crankshaft 8 is arranged, and a frame (engine frame) 6 arranged between the jacket 1 and the bed 9. In a combustion space that is a space surrounded by the cylinder 2 and the piston 3, a fuel is combusted. A translational motion of the piston 3 caused by the combustion is converted into a rotational motion

of the crankshaft 8 via the connecting rod 7. The jacket 1, the frame 6, and the bed 9 are fastened to one another by tie-bolts 10.

[0026] As shown in Fig. 3, the frame 6 according to the present embodiment incudes a bulkhead 20, a top plate 23 arranged on a side adjacent to the jacket 1, a bottom plate 24 arranged on a side adjacent to the bed 9, and side plates 25. The bulkhead 20 includes a center plate 21 that forms a center portion of the bulkhead 20, interposing plates 22 that respectively form a camshaft-side portion and an exhaust-side portion of the bulkhead 20, and slide plates 31 arranged between the center plate 21 and the respective interposing plate 22. Positions of the camshaft-side portion and the exhaust-side portion of the bulkhead 20 correspond to positions of a camshaft-side and an exhaust-side of the engine, respectively. The slide plates 31 are located on both sides of the center plate 21 along a crosswise direction in Fig. 3, respectively. The interposing plates 22 are located outside of both the slide plates 31, and side plates 25 are located outside of both the interposing plates 22, respectively. It is to be noted that a longitudinal direction in Fig. 3 agrees with a moving direction (vertical direction) of the crosshead 5, a depth direction in Fig. 3 agrees with a rotation axis direction of the crankshaft 8, and that the crosswise direction in Fig. 3 is perpendicular to the moving direction of the crosshead 5 and the rotation axis direction of the crankshaft 8. Inner side surfaces of the slide plates 31 are welded to the center plate 21. Inner edges of the interposing plates 22 are welded to outer side surfaces of the slide plates 31. Inner side surfaces of the side plates 25 are welded to outer edges of the interposing plates 22. The outer edges of the interposing plates 22 are sides opposite to the slide plates 31. The top plate 23 is welded to upper sides of the slide plates 31, the interposing plates 22, and the side plates 25. The bottom plate 24 is welded to lower sides of the slide plates 31, the interposing plates 22, and the side plates 25.

[0027] The slide plates 31 are provided along the vertical direction. The slide plates 31 guide the crosshead 5 to move along the vertical direction. Each slide plate 31 receives a side force from the crosshead 5. A direction of the side force is parallel to the crosswise direction in Fig. 3. Thickness directions of the slide plates 31 are parallel to the crosswise direction in Fig. 3. Thickness directions of the center plate 21 and the interposing plates 23 are parallel to the depth direction in Fig. 3.

[0028] Fig. 4 shows a horizontal sectional view of the bulkhead 20, taken along the line A-A in Fig. 3. The tie-bolts 10 are arranged on both sides of each interposing plate 22, respectively. The center plate 21 and the interposing plates 22 are arranged on a center plane 51 of the bulkhead 20. A normal of the center plane S1 is parallel to the rotation axis direction of the crankshaft 8. Each of the center plate 21 and the interposing plates 22 is welded to the slide plate 31 such that the center plate 21 and the slide plate 31 are arranged in a T-shape and the interposing plate 22 and the slide plate 31 are arranged in a T-shape. As shown in Fig. 4, A denotes a thickness of each slide plate 31, B denotes a thickness of each interposing plate 22, C denotes a thickness of the center plate 21, and D denotes a distance from the center plane S1 to an end of each slide plate 31 measured along the normal of the center plane S1. Each slide plate 31 is symmetrically formed with respect to the center plane S1.

[0029] In the present embodiment, since each slide plate 31 is thick such that a ratio A/B of the thickness A of the slide plate 31 to the thickness B of the interposing plate 22 is equal to or larger than 1.5, rigidity of the frame 6 is ensured without reinforcements such as horizontal ribs. For example, there is no need to provide a reinforcement reinforcing the slide plate 31 from the interposing plate 22 and a reinforcement reinforcing the slide plate 31 from the side plate 25. Since the rigidity of the frame 6 is ensured, a moving locus of the crosshead 5 is stabilized. When no reinforcement is provided, the frame 6 has a simple shave and it is easy to manufacture and inspect the frame 6.

[0030] Similar advantages can be attained when each slide plate 31 is thick such that a ratio A/C of the thickness A of the slide plate 31 to the thickness C of the center plate 21 is equal to or larger than 1.5.

[0031] While the thickness A of the slide plate 31 is affected by design constraints, in general, the thickness A is smaller than a width (for example, 2D) of the slide plate 31.

(Second Embodiment)

[0032] An engine according to a second embodiment of the present invention is configured similarly to the engine according to the first embodiment.

[0033] In the present embodiment, a ratio D/A of the distance D from the center plane S1 to the end of the slide plate 31 to the thickness A of the slide plate 31 is equal to or smaller than 4.0. The side force acts on the end of the slide plate 31 or on a position of the slide plate 31 closer to the center plane S1 than the end. Accordingly, by setting the distance D small such that the ratio D/A is equal to or smaller than 4.0, a ratio of a distance between an action point of the side force and the center plane S1 to the thickness A of the slide plate 31 is small. Therefore, rigidity of the frame 6 is ensured without reinforcements such as horizontal ribs. For example, there is no need to provide a reinforcement reinforcing the slide plate 31 from the interposing plate 22 and a reinforcement reinforcing the slide plate 31 from the side plate 25. When no reinforcement is provided, the frame 6 has a simple shape and it is easy to manufacture and inspect the frame 6.

[0034] While the distance D from the center plate S1 to the end of the slide plate 31 is affected by design constrains, in general, the distance D is larger than a larger one of half the thickness C of the center plate 21 and half the thickness B of the interposing plate 22.

(Third Embodiment)

[0035] An engine according to a third embodiment of the present invention is configured similarly to the engine according to the first embodiment.

[0036] In the present embodiment, since each interposing plate 22 is thick such that a ratio B/C of the thickness B of the interposing plate 22 to the thickness C of the center plate 21 is equal to or larger than 1.5, each interposing plate 22 reinforces the slide plate 31 against the side force. Consequently, rigidity of the frame 6 is ensured without reinforcements such as horizontal ribs. For example, there is no need to provide a reinforcement reinforcing the slide plate 31 from the interposing plate 22 and a reinforcement reinforcing the slide plate 31 from the side plate 25. When no reinforcement is provided, the frame 6 has a simple shape and it is easy to manufacture and inspect the frame 6.

[0037] While the thickness B of the interposing plate 22 is affected by design constrains, in general, the thickness B is smaller than the width (for example, 2D) of the slide plate 31.

[0038] Also in a case that the center plate 21 and the slide plates 31 are integrally formed as a cast in each of the above embodiments, in a case that the interposing plate 22 and the slide plate 31 are integrally formed as a cast in each of the above embodiments, in a case that the center plate 21, the slide plates 31 and interposing plates 22 are integrally formed as a cast in each of the above embodiments, in a case that all of the center plate 21, interposing plates 22, slide plates 31, the top plate 23, the bottom plate 24 and the side plates 25 are integrally formed as a cast in each of the above embodiments, and in a case that a portion of the center plate 21, interposing plates 22, slide plates 31, the top plate 23, the bottom plate 24 and the side plates 25 are formed as a cast in each of the above embodiments, a wooden model for the cast is easily prepared, castability of the cast is improved, and the cast is easily inspected. In a case that the frame 6 is formed by welding the plates that are not formed as the cast to the cast, man-hour of welding and man-hour of inspection are reduced.

(Fourth Embodiment)

[0039] An engine according to a fourth embodiment of the present invention is configured similarly to the engine according to any one of the first to third embodiments except for points described below.

[0040] Referring to Fig. 5, in the bulkhead 20 of the frame 6 according to the present embodiment, reinforcements 40 reinforce one of the slide plate 31 on the camshaft-side and the slide plate 31 on the exhaust-side. The reinforcements 40 are provided to upper and lower portions of the slide plate 31. The reinforcements 40 are plate-shaped and thickness directions of the reinforcements 40 are parallel to the vertical direction.

[0041] Fig. 6 shows a horizontal sectional view of the bulkhead 20, taken along the line B-B in Fig. 5. The reinforcements 40 provided to the lower portion of the slide plate 31 are arranged on both sides of the center plane S1 of the bulkhead 20, respectively, and welded to the slide plate 31 and the interposing plate 22. The reinforcements 40 provided to the lower portion of the slide plate 31 are welded to the lower portion of the slide plate 31. The tie-bolt 10 penetrates through a space surrounded by the reinforcement 40, the slide plate 31, and the interposing plate 22. The reinforcements 40 provided to the upper portion of the slide plate 31 are configured similarly to the reinforcements 40 provided to the lower portion of the slide plate 31.

[0042] Referring to Fig. 7, the upper and lower portions of the slide plate 31 to which the reinforcements 40 are provided will be described. As shown in Fig. 7, a magnitude F of the side force received by the slide plate 31 from the crosshead 5 changes according to a motion of the crosshead 5 along the vertical direction (Z-axis direction). The magnitude F of the side force has a first local maximum value when the crosshead 5 is at a first position (Z1) and has a second local maximum value when the crosshead 5 is at a second position (Z2). The second position (Z2) is lower than the first position (Z1). The upper portion of the slide plate 31 receives the side force when the crosshead 5 is at the first position (Z1), The lower portion of the slide plate 31 receives the side force when the crosshead 5 is at the second position (Z2).

[0043] According to the present embodiment, since no reinforcement is provided to one of the slide plate 31 on the camshaft-side and the slide plate 31 on the exhaust-side, the frame 6 has a simple shape. Furthermore, as for the slide plate 31 to which the reinforcements 40 are provided, the reinforcements 40 are provided only to the upper and lower portions of the slide plate 31, so that the frame 6 has a simple shape. Therefore, man-hour of welding and man-hour of inspection for the frame 6 are reduced, and it is easy to manufacture and inspect the frame 6.

[0044] It is to be noted that the thickness A of the slide plate 31 to which the reinforcements 40 are provided can be thinner than the thicknesses A according to the first to third embodiments. The reinforcements 40 may be provided only to one of the upper and lower portions of the slide plate 31.

[0045] Also in a case that the center plate 21 and the slide plates 31 are integrally formed as a cast in the present embodiment, in a case that the interposing plate 22 and the slide plate 31 are integrally formed as a cast in the present embodiment, in a case that the center plate 21, the slide plates 31 and interposing plates 22 are integrally formed as a cast in the present embodiment, in a case that the center plate 21, interposing plates 22, slide plates 31, the top plate 23, the bottom plate 24 and the side plates 25 are integrally formed as a cast in the present embodiment, in a case that all of the center plate 21, interposing plates 22, slide plates 31, the top plate 23, the bottom plate 24, the side plates 25 and the rein-

forcements 40 are formed as a cast in the present embodiment, and in a case that a portion of the center plate 21, interposing plates 22, slide plates 31, the top plate 23, the bottom plate 24, the side plates 25 and the reinforcements 40 are formed as a cast in the present embodiment, castability of the cast is improved and the cast is easily inspected. In a case that the frame 6 is formed by welding the plates that are not formed as the cast to the cast, man-hour of welding and man-hour of inspection are reduced.

[0046] Although the present invention has been described above in connection with several embodiments thereof, it would be apparent from those skilled in the art that those embodiments are provided solely for illustrating the present invention, and should not be relied upon to construe the appended claims in a limiting sense.

Claims

1. An engine frame (6) comprising:

a first plate (21) forming a center portion of a bulkhead (22);
a second plate (22) forming a camshaft-side portion or exhaust-side portion of said bulkhead (20); and
a slide plate (31) arranged between said first plate (21) and said second plate (22),
wherein said slide plate (31) guides a crosshead (5),
said first plate (21) and said second plate (22) are arranged on a plane (S1),
said first plate (21) and said slide plate (31) are arranged in a T-shape,
said second plate (22) and said slide plate (31) are arranged in a T-shape, and
a ratio A/B of a thickness A of said slide plate (31) to a thickness B of said second plate (22) is equal to or larger than 1.5.

2. The engine frame (6) according to claim 1, wherein said slide plate (31) guides said crosshead (5) along a vertical direction,
a top plate (23) is welded to an upper side of said slide plate (31),
a bottom plate (24) is welded to a lower side of said slide plate (31),
a side plate (25) is welded to a side of said second plate (22),
said side of said second plate (22) is opposite to said first plate (21), and
any reinforcement reinforcing said slide plate (31) from said second plate (22) or said side plate (25) is not provided.

3. The engine frame (6) according to claim 1 or 2, wherein said first plate (21) and said second plate (22) are respectively welded to said slide plate (31).

4. The engine frame (6) according to claim 1 or 2, wherein said first plate (21) and said slide plate (31) are integrally formed as a cast, and
said second plate (22) is welded to said slide plate (31).

5. The engine frame (6) according to claim 1 or 2, wherein said second plate (22) and said slide plate (31) are integrally formed as a cast, and
said first plate (21) is welded to said slide plate (31).

6. The engine frame (6) according to claim 1 or 2, wherein said first plate (21), said secondplate (22) and said slide plate (31) are integrally formed as a cast.

7. The engine frame (6) according to claim 1, further comprising:

a top plate (23) welded to an upper side of said slide plate (31);
a bottom plate (24) welded to a lower side of said slide plate (31); and
a side plate (25) welded to a side of said second plate (22),
wherein said slide plate (31) guides said crosshead (5) along a vertical direction,
said side of said second plate (22) is opposite to said first plate (21), and
said first plate (21), said second plate (22), said slide plate (31), said top plate (23), said bottom plate (24) and said side plate (25) are integrally formed as a cast.

8. The engine frame (6) according to claim 1, further comprising:

a top plate (23) welded to an upper side of said slide plate (31);
a bottom plate (24) welded to a lower side of said slide plate (31); and
a side plate (25) welded to a side of said second plate (22),
wherein said slide plate (31) guides said crosshead (5) along a vertical direction,
said side of said second plate (22) is opposite to said first plate (21), and
a portion of said first plate (21), said second plate (22), said slide plate (31), said top plate (23), said bottom plate (24) and said side plate (25) are formed as a cast.

9. The engine frame (6) according to any of claims 1 to 8, further comprising a reinforcement (40) provided to a portion of said slide plate (31),
wherein magnitude (F) of side force from said cross-

head (5) has a local maximum value when said crosshead (5) is at a position (Z1, Z2), and
said portion of said slide plate (31) receives said side force when said crosshead (5) is at said position (Z1, Z2).

10. The engine frame (6) according to claim 9, wherein said reinforcement (40) is welded to said portion of said slide plate (31) and said second plate (22).

11. An engine comprising:

the engine frame (6) according to any of claims 1 to 10;
a cylinder (2);
a piston (3) configured to move in said cylinder (2);
a piston rod (4) connected to said piston (3);
said crosshead (5) connected to said piston rod (4);
a crankshaft (8);
a connecting rod (7) connecting said crosshead (5) to said crankshaft (8);
a jacket (1) in which said cylinder (2) is arranged;
a bed (9) in which said crankshaft (8) is arranged; and
a tie-bolt (10) fastening said jacket (1), said engine frame (6) and said bed (9).

12. An engine frame (6) comprising:

a first plate (21) forming a center portion of a bulkhead (20);
a second plate (22) forming a camshaft-side portion or exhaust-side portion of said bulkhead (20); and
a slide plate (31) arranged between said first plate (21) and said second plate (22),
wherein said slide plate (31) guides a crosshead (5),
said first plate (21) and said second plate (22) are arranged on a plane (S1),
said first plate (21) and said slide plate (31) are arranged in a T-shape,
said second plate (22) and said slide plate (31) are arranged in a T-shape, and
a ratio A/C of a thickness A of said slide plate (31) to a thickness C of said first plate (21) is equal to or larger than 1.5.

13. An engine frame (6) comprising:

a first plate (21) forming a center portion of a bulkhead (20);
a second plate (22) forming a camshaft-side portion or exhaust-side portion of said bulkhead (20); and
a slide plate (31) arranged between said first plate (21) and said second plate (22),
wherein said slide plate (31) guides a crosshead (5),
said first plate (21) and said second plate (22) are arranged on a plane (S1),
said first plate (21) and said slide plate (31) are arranged in a T-shape,
said second plate (22) and said slide plate (31) are arranged in a T-shape,
said slide plate (31) is symmetrically formed with respect to said plane (S1), and
a ratio D/A of a distance D from said plane (S1) to an end of said slide plate measured along a normal of said plane (S1) to a thickness A of said slide plate (31) is equal to or smaller than 4.0.

14. An engine frame (6) comprising:

a first plate (21) forming a center portion of a bulkhead (20);
a second plate (22) forming a camshaft-side portion or exhaust-side portion of said bulkhead (20); and
a slide plate (31) arranged between said first plate (21) and said second plate (22),
wherein said slide plate (31) guides a crosshead (5),
said first plate (21) and said second plate (22) are arranged on a plane (S1),
said first plate (21) and said slide plate (31) are arranged in a T-shape,
said second plate (22) and said slide plate (31) are arranged in a T-shape, and
a ratio B/C of a thickness B of said second plate (22) to a thickness C of said first plate (21) is equal to or larger than 1.5.

Fig. 1

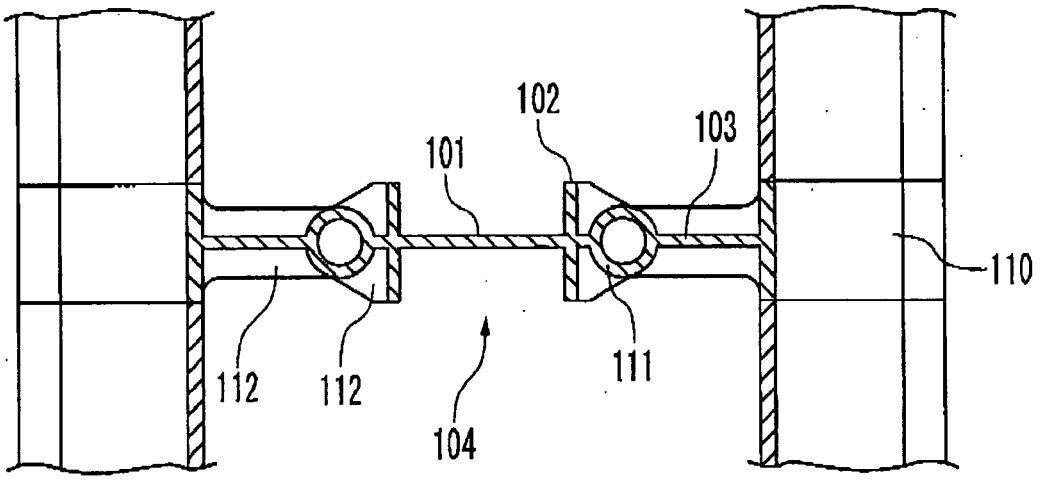


Fig. 2

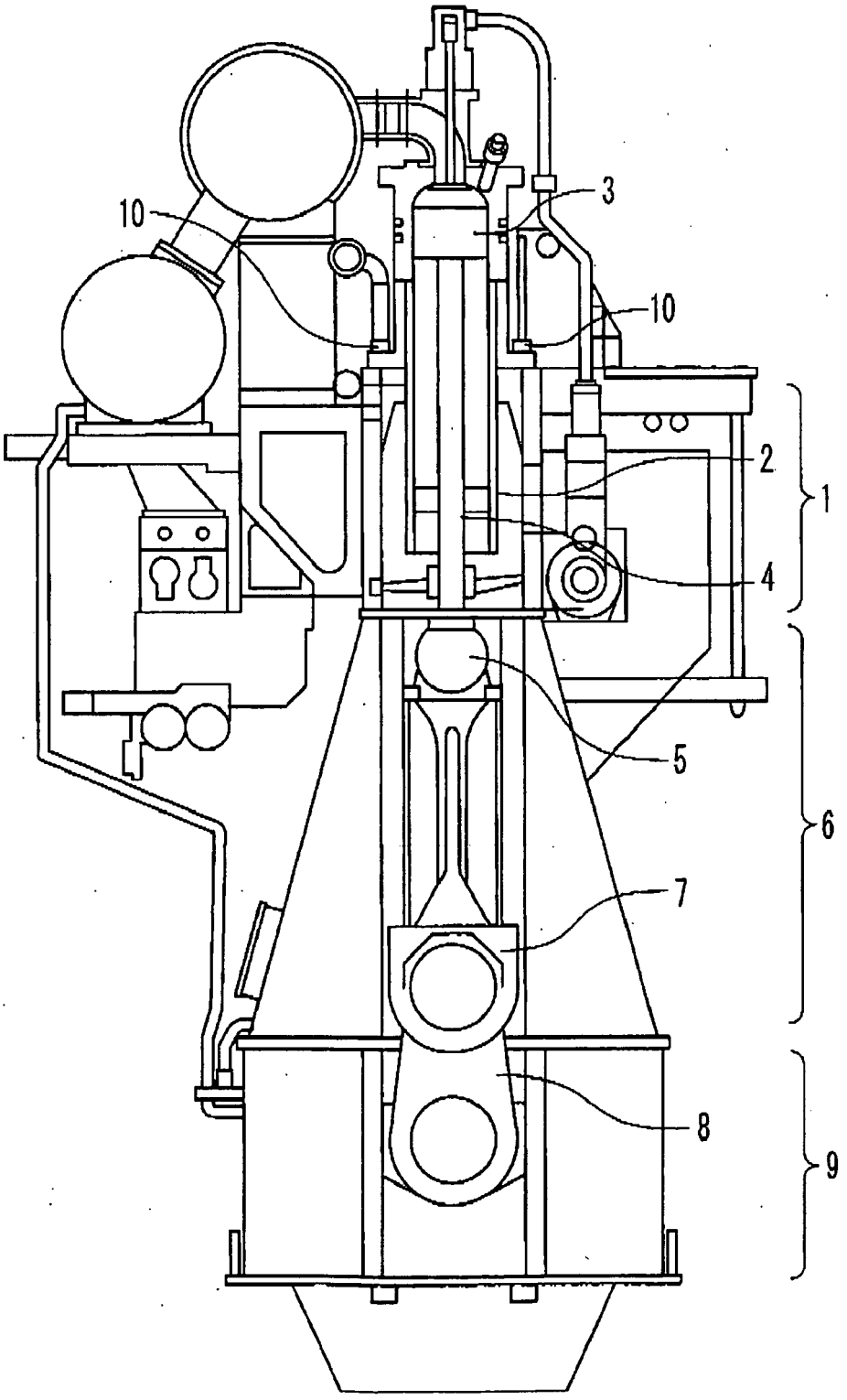


Fig. 3

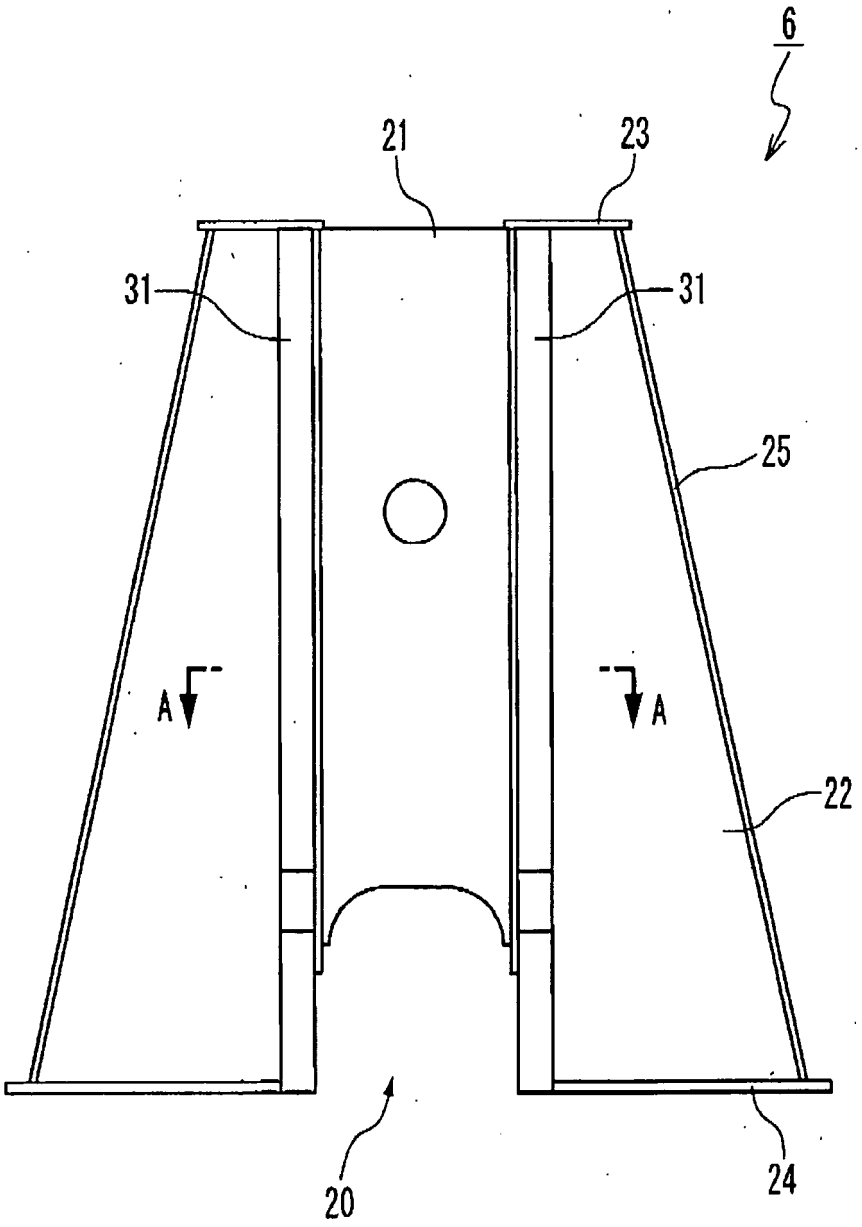


Fig. 4

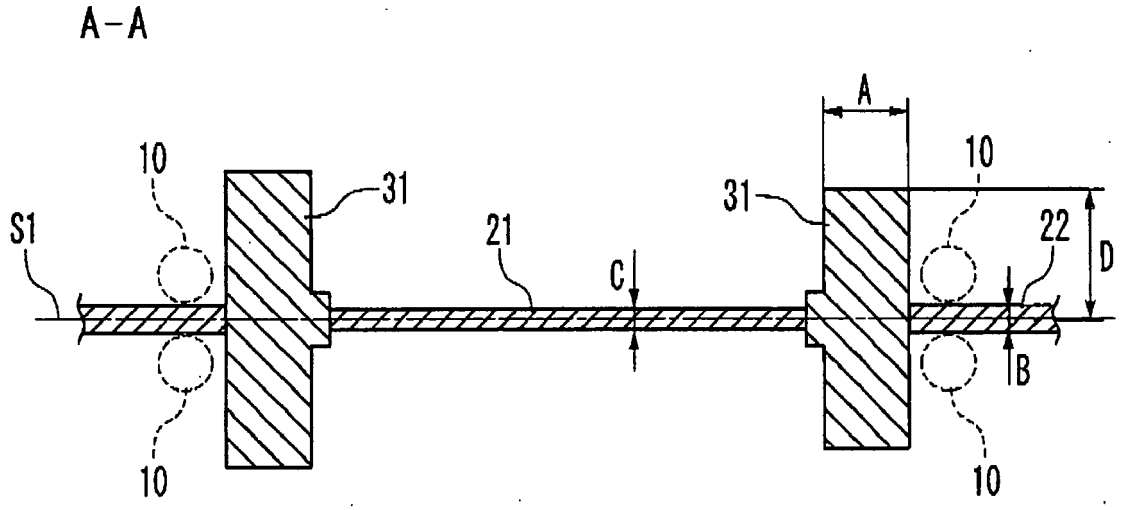


Fig. 5

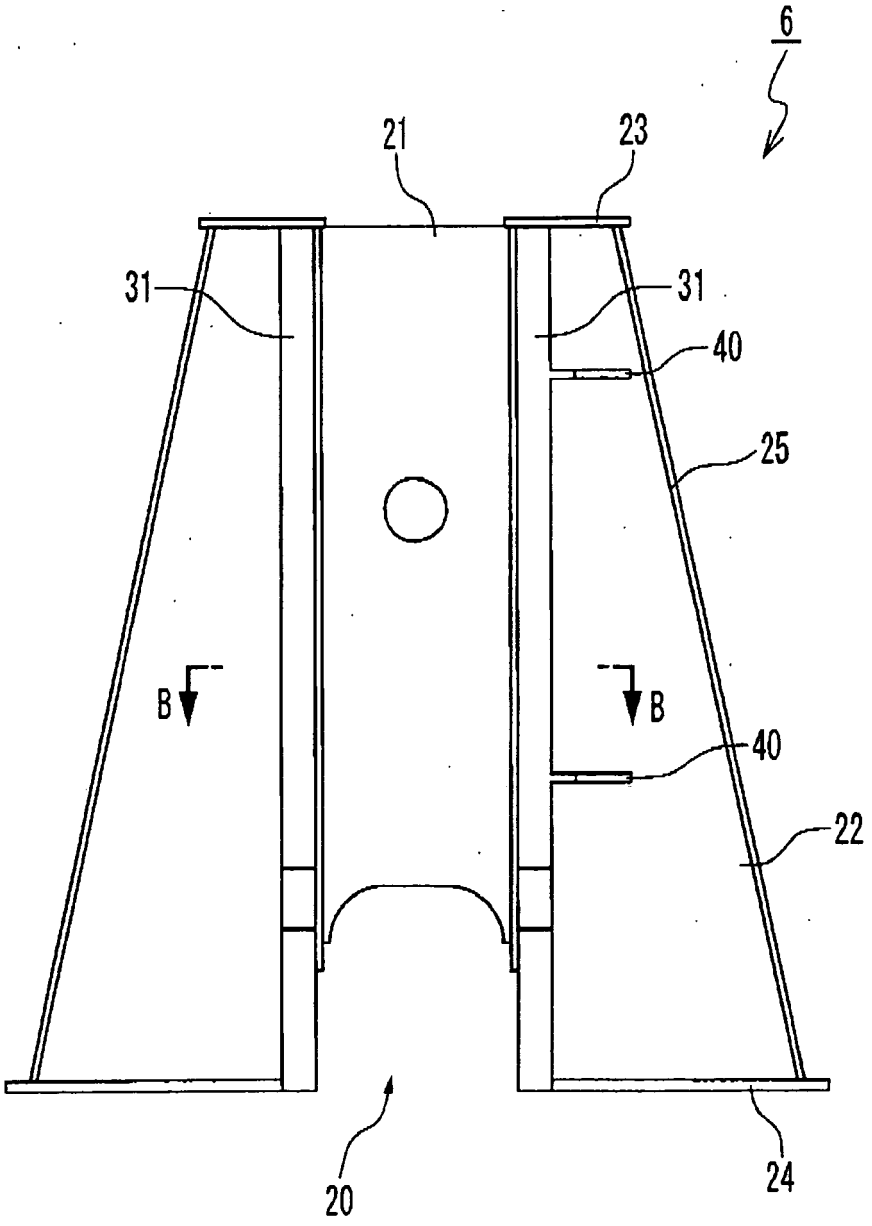


Fig. 6

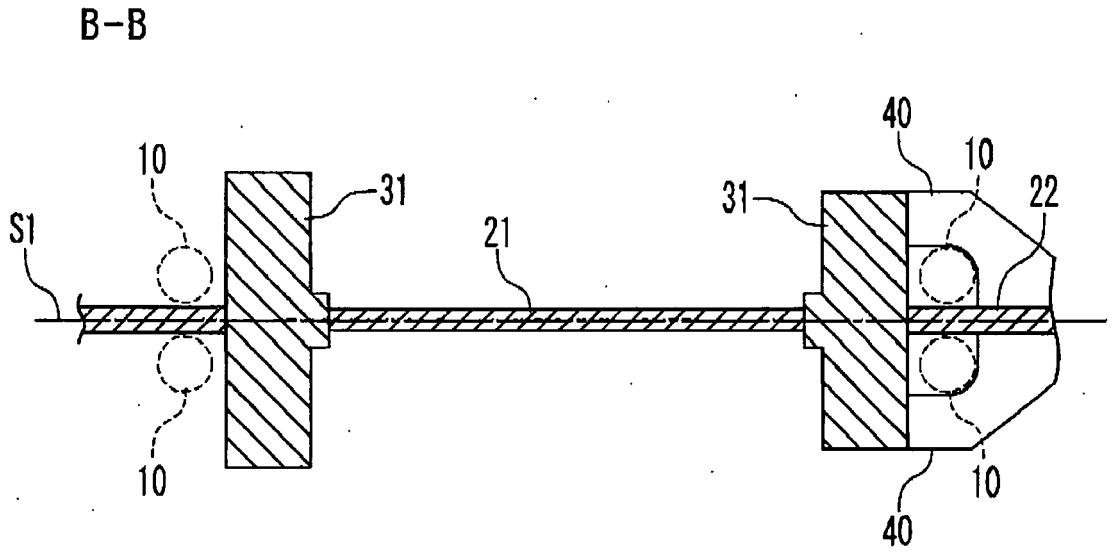
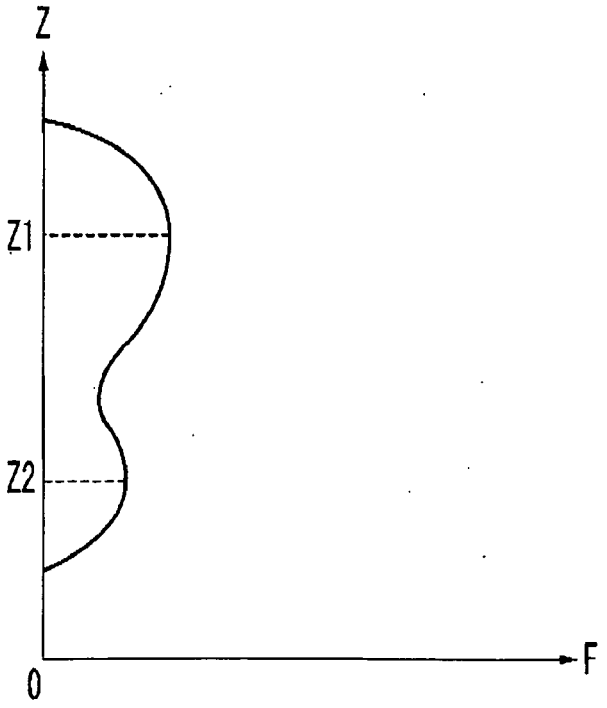


Fig. 7



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PARTIAL EUROPEAN SEARCH REPORT

under Rule 62a and/or 63 of the European Patent Convention. This report shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number
EP 10 00 1806

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 2 006 920 A (SULZER AG) 10 May 1979 (1979-05-10) * figure 2 * -----	1-11	INV. F02F7/00
X	GB 615 201 A (MARK FERDINAND MEINERTZ) 3 January 1949 (1949-01-03) * figure 4 * -----	1-11	
X	EP 2 006 523 A1 (WAERTSILAE SCHWEIZ AG [CH]) 24 December 2008 (2008-12-24) * figure 8 * -----	1-11	
X	JP 52 110312 A (MITSUBISHI HEAVY IND LTD) 16 September 1977 (1977-09-16) * figures 3,9 * -----	1-11	
X	US 1 999 350 A (EDOUARD ATTESLANDER) 30 April 1935 (1935-04-30) * figure 5 * -----	1-11	
E	EP 2 236 802 A1 (WAERTSILAE SCHWEIZ AG [CH]) 6 October 2010 (2010-10-06) * figures 7b, 7c, 7d * ----- -/--	1-11	TECHNICAL FIELDS SEARCHED (IPC) F02F

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

Place of search	Date of completion of the search	Examiner
Munich	11 February 2011	Yates, John

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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EPO FORM 1503 03.82 (P04E07)

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PARTIAL EUROPEAN SEARCH REPORT

Application Number
EP 10 00 1806

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (IPC)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	GB 579 846 A (OVE PETERSEN; MADS LINDBERG NIELSEN) 19 August 1946 (1946-08-19) * figure 1 * -----	1-11	
			TECHNICAL FIELDS SEARCHED (IPC)

1

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INCOMPLETE SEARCH
SHEET C

Application Number
EP 10 00 1806

Claim(s) completely searchable:
1-11

Claim(s) not searched:
12-14

Reason for the limitation of the search:

Multiple independent claims having different subject matter (1, 12,13,14) tend to disguise which features are important for the invention and thus make it difficult, if not impossible, to determine the matter for which protection is sought, and places an undue burden on others seeking to establish the extent of the protection. Further such claims do not meet the requirements of Rule 43 (2) EPC, are not concise and could lead to problems of unity of invention, once a search has disclosed the relevant prior art.
Clearly, however, until it can be established which features are important for the invention, no meaningful search or examination can be carried out. As the application currently stands, from the claims, and indeed from the application as a whole, it is not apparent where an invention should lie.

All independent claims relate to the usual form of frame for an engine, as indeed this is reflected in the prior art mentioned by the applicant in the description. The claims then go on to take seemingly random combinations of dimensions and relate them to each other. In detail, and looking at fig 4 of the application, claim 1 relates dimensions A and B, claim 12 - A and C, claim 13, D and A, and claim 14 B and C.

Especially bearing in mind the general principle that it is the daily work of the skilled man to choose suitable dimensions, it is not apparent where any common surprising effect could possibly lie, since the different measurements concern different parts of the overall structure.

In response to a request for clarification under Rule 63 EPC, the applicant has argued that all independent claims represent different solutions to the problem of ensuring adequate stiffness without requiring reinforcements. Quite apart from the fact that none of the independent claims mention a lack of reinforcement, the desire for sufficient stiffness with minimum complexity is the usual aim of the skilled man, so that the problem alone cannot provide a unifying concept. Further, setting the relative dimensions of different parts of the structure will inevitably have different effects on the local stiffness, so that the same result will not be achieved, i.e. even if overall stiffness is adequate in each case, the force distribution through the structure will be different. Since an inadequate (i.e. unconvincing) response to the clarification request was received, the search has simply concentrated on the subject matter of claim 1 i.e. the relationship A/B.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 00 1806

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11-02-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2006920 A	10-05-1979	CH 625603 A5	30-09-1981
		DE 2748900 A1	03-05-1979
		DK 459578 A	28-04-1979
		IT 1099956 B	28-09-1985
		JP 1136097 C	28-02-1983
		JP 54067153 A	30-05-1979
		JP 57025727 B	31-05-1982
		SU 743598 A3	25-06-1980
GB 615201 A	03-01-1949	NONE	
EP 2006523 A1	24-12-2008	BR PI0803014 A2	07-04-2009
		CN 101328835 A	24-12-2008
		JP 2008309149 A	25-12-2008
		KR 20080111381 A	23-12-2008
JP 52110312 A	16-09-1977	JP 1148222 C	26-05-1983
		JP 57040367 B	27-08-1982
US 1999350 A	30-04-1935	NONE	
EP 2236802 A1	06-10-2010	CN 101839172 A	22-09-2010
		JP 2010223220 A	07-10-2010
		KR 20100105357 A	29-09-2010
GB 579846 A	19-08-1946	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP JUYHEISEI0648137 B **[0002]**
- JP P2001289114 A **[0003]**
- JP P2007211786 A **[0003]**
- JP 2977901 B **[0003]**
- JP 3226458 B **[0003]**
- JP 3538280 B **[0003]**
- JP 4005550 B **[0003]**