

SPECIFICATION

Gearbox with air-oil separator

5 The invention relates to the provision of an air-oil separator in the gearbox of, for example, an aircraft to help keep oil within the gear box from leaking out into the atmosphere. During operation of the aircraft, pressures may build up within the gear box. If these
10 pressures are allowed to build up in excess, they may interfere with the normal operation of the various components of the gearbox. Accordingly, a vent usually is provided from the gearbox to relieve interior pressures.

15 The air-oil separator provided in a gearbox according to the invention is intended to separate oil from the air in the interior of the gearbox so that oil-free air may be vented into the atmosphere thereby to avoid the loss of oil from the gearbox and pollution
20 of the atmosphere. The centrifugal forces generated by rotation of one of the gears in the gearbox are utilized to separate the oil and air through a series of first, second and third stages of separating, each successive stage tending to separate smaller particles of oil from the air. The first and second stages of separating occur as mixed air and oil flow radially
25 inwardly towards the rotational axis of the gear.

The invention provides a gearbox for an aircraft, having a multi-stage air-oil separator which comprises an impeller mounted on a gear in a housing of
30 the gearbox, at least one generally radially directed inlet passage that is formed in a shaft mounting the gear and leads to an axial bore in the shaft, an air discharge chamber communicating with the bore but otherwise sealed from communication with the
35 interior of the housing, means restricting the flow of oil along the wall of the bore into the discharge chamber and an outlet passage from the bore to direct oil collected within the bore back into the interior of the housing.
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The invention is hereinafter described by way of example only with reference to the drawings of which:

45 *Figure 1* is a fragmentary view of a portion of an aircraft gearbox within which is mounted an air-oil separator embodying the novel features of the present invention.

Figure 2 is an enlarged cross-sectional view taken substantially along line 2-2 of *Figure 1*.

50 *Figure 3* is an enlarged cross-sectional view substantially along line 3-3 of *Figure 2*.

Figure 4 is a view taken substantially along line 4-4 of *Figure 3*.

As shown in the drawings, the invention provides
55 an air-oil separator 10 in a gearbox of an aircraft so that oil-free air may be discharged from the gearbox and back into the atmosphere to avoid both losing oil from the gearbox and pollution of the atmosphere. The present invention is suited particularly for
60 use in a gearbox such as one which is powered by a turbine engine wherein an air buffered labyrinth seal (not shown) may be provided between the engine and the gearbox. Such seals are particularly designed to vent a considerable flow of air from the
65 engine into the interior of the gearbox both for seal-

ing and lubrication purposes. As a result, it is necessary to provide a vent 13 from the gearbox housing 11 to avoid a build up of back pressure within the housing. Such pressure, of course, would interfere
70 with the expected operation of the air-buffered labyrinth seal.

As the air flows through the gearbox housing 11, a certain amount of oil naturally becomes entrained with the air and it is desirable that this oil be separated from the air before the air is vented from the
75 housing. In order to separate the oil from the air, the separator 10 is of the type utilizing centrifugal forces to separate the heavier oil from the lighter air. Herein, the separator is mounted on one side of a gear 14 (see *Figure 2*) and the gear includes a central
80 hub 18 with an integrally formed shaft 15 extending axially from the opposite sides thereof. The shaft is suitably supported by bearings 16 and 17 within a chamber 23 defining a portion of the interior of the
85 housing. A clip ring 19 is seated within a groove in the housing 11 and abuts a retaining collar 20 which in turn engaged the outer race member of the bearing 16 so as to keep the gear 14 from moving in an axial direction to the left as shown in *Figure 2*. Power
90 to the gear is provided through the splined end 21 of the shaft 15 which may be drivingly connected to the aircraft engine (not shown).

When the aircraft engine is in operation driving the gear 14, pressure greater than atmospheric builds up
95 within the chamber 23 and because of the high speed rotating gears within the gearbox, oil becomes entrained with the air in chamber 23. As previously mentioned, to keep the back pressure from building up within the chamber 23 to an extent
100 that the efficiency of the air-buffered labyrinth seal is affected, the present invention contemplates the provision of the separator 10 to include first, second and third stages for separating the oil from the air. Of these three stages, the second and third stages will
105 be described in detail first. In venting the air from the chamber 23, passages are provided both laterally and axially through the shaft 15 for directing the air to a discharge chamber 24 communicating with the vent 13. In the second stage of the separator, lateral
110 or generally radial passages 25 are formed through the shaft 15 and intersect with a bore 26 which extends in an axial direction partially through the shaft 15. The bore 26 communicates with the chamber 24 and a member 27 is provided within the
115 bore 26 to keep the oil from flowing along the sides of the bore and into the discharge chamber 24. An additional passage 29 extends laterally, in a generally radial direction, through the shaft 15 and includes an inlet 30 particularly positioned to receive
120 the oil collected within the bore 26 so as to direct the separated oil away from the discharge chamber and back into the chamber 23. In this way, oil-free air may be vented from the gearbox housing thereby avoiding loss of oil from the housing and pollution of
125 the atmosphere.

In the present instance, this second stage of the separator is defined by the three angularly spaced inlet passages 25 which are formed laterally through the shaft 15. Herein, for ease in machining, the passages 25 are slanted away from the gear 14 upon
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progressing radially outward from the bore 26. As shown in Figure 4, two of the inlet passages 25 are located diametrically of each other while the other inlet passage is positioned diametrically of the outlet passage 29.

As shown in Figure 3, the radially inward ends of the passages 25 communicate with the bore 26 which herein extends axially relative to the shaft 15. As the shaft rotates and pressure builds up within the chamber 23, the air and oil mixture begins to flow toward the lower pressure air outside the vent 13. More particularly, the air-oil mixture flows through the passage 25, the axial bore 26 and into the discharge chamber 24 before exiting the vent 13. In this second stage of separation because of the greater mass weight of oil over that of air, the oil resists flowing rapidly inward to a greater degree than the air and some of the oil collected on the side walls of the passages 25 and is slung back into the chamber 23. In a third stage of separation, oil which is carried by the air into the bore 26 is slung radially outward toward the sides of the bore 26 by the rotating shaft 15 as the air flows in an axial direction toward the discharge chamber 24. In this way, oil collects along the side walls of the bore. Adjacent the outlet of the bore into the chamber 24 the member 27 provides a restriction in the diameter of the bore so that only the air flowing generally along the rotational axis the gear is allowed to enter the chamber 24, this air being virtually free of oil.

From the discharge chamber 24, a suitable passage (not shown) communicates with the vent 13 so that the air in the chamber 24 may flow out the vent into the atmosphere. To keep the air from flowing back into the interior chamber 23, a seal 31 is located between the shaft 15 and the housing 11 adjacent to the discharge passage 24. Thus virtually all of the air entering the discharge chamber is directed out of the housing.

To make sure that essentially only air enters the discharge chamber 24, one form of simplified restriction for blocking the flow of oil along the walls of the bore 26 and into the chamber 24 is shown in Figure 3 as the cup-shaped member 27. Herein, the cup-shaped member 27 includes a central aperture 33 concentric with the axis of the bore and having a diameter substantially smaller than the diameter of the bore. As a result of this construction, there is provided space within the bore radially outward of the aperture within which the centrifuged oil may accumulate before being discharged back into the interior chamber 23. To assure that the oil collected along the side walls of the bore 26 flows back into the interior chamber 23, the inlet 30 of the passage 29 advantageously is spaced radially outward of the aperture 33. By virtue of this arrangement, an excessive amount of oil is kept from accumulating within the bore to the point where it might flow through the aperture 33 and into the discharge chamber 24.

In summary of the operation of the separator as described thus far, it is seen that in the second stage of separation, oil and air mixture is forced into the inlet passage 25 where the heavier oil may be slung back into the interior chamber 23. Then, the resulting mixture of finer oil and air flows axially along the

bore while the third stage of separation occurs with the fine particles of oil being slung outwardly to collect along the walls of the bore 26 while the lighter air flows axially into the discharge chamber 24

through the aperture 33 in the cup-shaped member 27. The oil collects in the bore then enters the outlet passage 29 through the inlet 30 to that passage for eventual discharge back into the interior chamber 23.

As an aid to the third stage of air-oil separation, a sleeve 34 is telescoped into the inner end of bore 26 and includes three axially spaced holes 35 which gister with the inlet passages 25 to provide communication between these passages and the interior of the sleeve. Additionally, elongated flat 36 is formed on the outside of the sleeve diametrically of one of the holes 35 so that when the holes 35 are in registry with passages 25, the flat 36 is in registry with the inlet 30 of the passage 29. The flat extends in an axial direction to provide a passage between the sleeve and the space which is located radially outward of the aperture 33. In this way, the oil collected in the bore is free to flow along the passage defined by the flat and to the outlet passage 29.

More particularly, as shown in Figure 3, the bore 26 includes a reduced diameter inner end section 37 and the sleeve 34 is telescopically received in this reduced section. The central opening of the sleeve is substantially smaller in diameter than the diameter of the outer end section of the bore 26 and the sleeve extends from the inward end of the bore for approximately one half the length of the bore thereby providing a reduced diameter passage 39 extending for a substantial length of the bore 26. The oil and air mixture exiting the reduced diameter passage 39 is further centrifuged upon entering the larger diameter bore by the rotating shaft 15.

In accordance with another important aspect of the present invention, for very high operational speeds of the gearbox, a first stage of separation is provided by an impeller 40 attached to one face of the gear 14 adjacent the inlet passage 25 and outlet passage 29.

The impeller 40 provides early stage separation of oil and air and is particularly effective at high speeds when the oil in the gearbox has been churned into foam by the rotating gears.

One form of the impeller 40 is shown in Fig. 4 to include a plurality of radially extending blades 41 extending edgewise in a generally axial direction from a ring-shaped base 43. When installed on the gear 14 such as by means of rivets 44 (see Figure 3), a central opening 45 in the impeller is telescoped over the gear shaft 15. Herein, the central opening 45 is larger in diameter than the diameter of the shaft adjacent the impeller thereby providing a relatively confined space 46 surrounding the shaft inwardly of the inner ends of the impeller blades 41. When the shaft 15 is rotated in a counterclockwise direction as indicated by the arrow 42 in Figure 4, there is build up of high pressure along the leading side of each blade 41 and a reduction in pressure along the trailing side of each blade. As a result, oil and air is drawn inwardly along the leading side of each blade toward the space 46 between the radially inward

ends of the blades and the radially outward surface of the shaft 15. Being heavier, some of the oil separates from the air and flows radially outward along low pressure sides of the blades while another portion of the remaining mixture of oil and air is drawn into the inlet passages 25.

To avoid overloading of the two final stages of the separator 10, some oil is kept from entering the inlets to the passage 25 through the use of a slinger 47. The latter comprises a flanged collar sandwiched between the bearings 17 and the hub 18 of the gear 14. By virtue of this construction, a substantial amount of oil flowing along the impeller and toward the bearing 17 for lubrication purposes is kept from entering the space 46 and the passages 25 by utilizing the end face of the slinger to throw oil collecting thereon away from the passage 25. Moreover, with the radially outward edge of the slinger flange spaced slightly inwardly of the inner ends of the impeller blades 41, the resulting gap provides a way for some oil collected in the space 46 to flow out of the separator.

In view of the foregoing, it will be seen that the present invention brings to the art a new and improved multi-stage separator 10 particularly adapted for use in the high-speed gearbox of an aircraft to effectively separate oil from the air to be vented from the interior of the gearbox housing 11. For this purpose, the first stage of the separator includes the impeller 40 attached to one face of the gear 14 to provide for separation of larger particles of oil from the air. The second stage of the separator includes the three angularly spaced passages 25 opening into the central passage 39 of the sleeve 34 and, as the shaft 15 rotates, the lighter air moves toward the center of the shaft 15 while the heavier oil is slung outwardly in the passages 25 and back into the annular space 46. Upon reaching the outer end of the passage 39, oil is further separated from the air in a final stage with the oil collecting in the bore 26 radially outward of the aperture 33 of the cup-shaped member 27. From this space, the collected oil flows between the flat 36 and the reduced diameter inner end section 37 of the bore through the opening 30 of the discharge passage 29 and finally into the annular space 46. The oil-free air exhausted through the aperture 33 enters the discharge chamber 24 to eventually flow out of the discharge chamber to be vented into the atmosphere.

CLAIMS

1. A gearbox for an aircraft, having a multi-stage air-oil separator which comprises an impeller mounted on a gear in a housing of the gearbox, at least one generally radially directed inlet passage that is formed in a shaft mounting the gear and leads to an axial bore in the shaft, an air discharge chamber communicating with the bore but otherwise sealed from communication with the interior of the housing, means restricting the flow of oil along the wall of the bore into the discharge chamber and an outlet passage from the bore to direct oil collected within the bore back into the interior of the housing.

2. A gearbox according to claim 1, wherein the impeller is mounted on the shaft concentric with a rotational axis thereof, and there is a plurality of the inlet passages angularly spaced from each other and having inlet openings spaced radially inwardly of a central opening of the impeller.

3. A gearbox according to claim 2, wherein the bore comprises axially inner and outer end sections, the inner end section being of a lesser diameter than the outer end section, and a sleeve is telescopically received in the inner end section and has a plurality of angularly spaced ports in registry with the inlet passages, a central passage in the sleeve extending concentric with the axis of the gear and having a diameter of the outer section of the bore.

4. A gearbox according to claim 3, wherein the sleeve has a flat formed on the outside surface thereof so as to form a gap between the flat and the inside of the bore, in registry with the outlet passage.

5. A gearbox according to any preceding claim, wherein the means restricting the flow of oil along the wall of the bore into the discharge chamber comprises an inwardly directed flange extending from the wall of the bore to define a central aperture smaller in diameter than the diameter of the larger section of the bore.

6. A gearbox according to claim 5, wherein the outlet passage is located radially outwardly of the aperture.

7. A gearbox according to claim 5 or claim 6, wherein the flange is provided by a generally cup-shaped member axially inserted into the bore.

8. A gearbox according to any preceding claim, further comprising a slinger retained on the shaft adjacent the one or more inlet passages to prevent an excessive amount of oil from entering the one or more inlet passages.

9. A gearbox for an aircraft, having a multi-stage air-oil separator substantially as described herein and illustrated in the drawings.



ends of the blades and the radially outward surface of the shaft 15. Being heavier, some of the oil separates from the air and flows radially outward along low pressure sides of the blades while another portion of the remaining mixture of oil and air is drawn into the inlet passages 25.

To avoid overloading of the two final stages of the separator 10, some oil is kept from entering the inlets to the passage 25 through the use of a slinger 47. The latter comprises a flanged collar sandwiched between the bearings 17 and the hub 18 of the gear 14. By virtue of this construction, a substantial amount of oil flowing along the impeller and toward the bearing 17 for lubrication purposes is kept from entering the space 46 and the passages 25 by utilizing the end face of the slinger to throw oil collecting thereon away from the passage 25. Moreover, with the radially outward edge of the slinger flange spaced slightly inwardly of the inner ends of the impeller blades 41, the resulting gap provides a way for some oil collected in the space 46 to flow out of the separator.

In view of the foregoing, it will be seen that the present invention brings to the art a new and improved multi-stage separator 10 particularly adapted for use in the high-speed gearbox of an aircraft to effectively separate oil from the air to be vented from the interior of the gearbox housing 11. For this purpose, the first stage of the separator includes the impeller 40 attached to one face of the gear 14 to provide for separation of larger particles of oil from the air. The second stage of the separator includes the three angularly spaced passages 25 opening into the central passage 39 of the sleeve 34 and, as the shaft 15 rotates, the lighter air moves toward the center of the shaft 15 while the heavier oil is slung outwardly in the passages 25 and back into the annular space 46. Upon reaching the outer end of the passage 39, oil is further separated from the air in a final stage with the oil collecting in the bore 26 radially outward of the aperture 33 of the cup-shaped member 27. From this space, the collected oil flows between the flat 36 and the reduced diameter inner end section 37 of the bore through the opening 30 of the discharge passage 29 and finally into the annular space 46. The oil-free air exhausted through the aperture 33 enters the discharge chamber 24 to eventually flow out of the discharge chamber to be vented into the atmosphere.

CLAIMS

1. A gearbox for an aircraft, having a multi-stage air-oil separator which comprises an impeller mounted on a gear in a housing of the gearbox, at least one generally radially directed inlet passage that is formed in a shaft mounting the gear and leads to an axial bore in the shaft, an air discharge chamber communicating with the bore but otherwise sealed from communication with the interior of the housing, means restricting the flow of oil along the wall of the bore into the discharge chamber and an outlet passage from the bore to direct oil collected within the bore back into the interior of the housing.

2. A gearbox according to claim 1, wherein the impeller is mounted on the shaft concentric with a rotational axis thereof, and there is a plurality of the inlet passages angularly spaced from each other and having inlet openings spaced radially inwardly of a central opening of the impeller.

3. A gearbox according to claim 2, wherein the bore comprises axially inner and outer end sections, the inner end section being of a lesser diameter than the outer end section, and a sleeve is telescopically received in the inner end section and has a plurality of angularly spaced ports in registry with the inlet passages, a central passage in the sleeve extending concentric with the axis of the gear and having a diameter of the outer section of the bore.

4. A gearbox according to claim 3, wherein the sleeve has a flat formed on the outside surface thereof so as to form a gap between the flat and the inside of the bore, in registry with the outlet passage.

5. A gearbox according to any preceding claim, wherein the means restricting the flow of oil along the wall of the bore into the discharge chamber comprises an inwardly directed flange extending from the wall of the bore to define a central aperture smaller in diameter than the diameter of the larger section of the bore.

6. A gearbox according to claim 5, wherein the outlet passage is located radially outwardly of the aperture.

7. A gearbox according to claim 5 or claim 6, wherein the flange is provided by a generally cup-shaped member axially inserted into the bore.

8. A gearbox according to any preceding claim, further comprising a slinger retained on the shaft adjacent the one or more inlet passages to prevent an excessive amount of oil from entering the one or more inlet passages.

9. A gearbox for an aircraft, having a multi-stage air-oil separator substantially as described herein and illustrated in the drawings.