(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 January 2007 (04.01.2007)

PCT

(10) International Publication Number
WO 2007/001366 A2

(51) International Patent Classification:
B64D 41/00 (2006.01)

(21) International Application Number:
PCT/US2005/032738

(22) International Filing Date:
14 September 2005 (14.09.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/951,185 27 September 2004 (27.09.2004) US

(71) Applicant *(for all designated States except US)*: **THE BOEING COMPANY** [US/US]; 100 N. Riverside Plaza, Chicago, IL 60606 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **NGUYEN, Phuong, H.** [US/US]; 12711 SE 227th Ct, Kent, WA 98031 (US). **SIKORA, Jospeh, A.** [US/US]; 6508 Woodlawn Ave N., Seattle, WA 98103-5428 (US). **CAMPBELL, Thomas, A.** [US/US]; 1026 NE 120th St, Seattle, WA 98125-5004 (US).

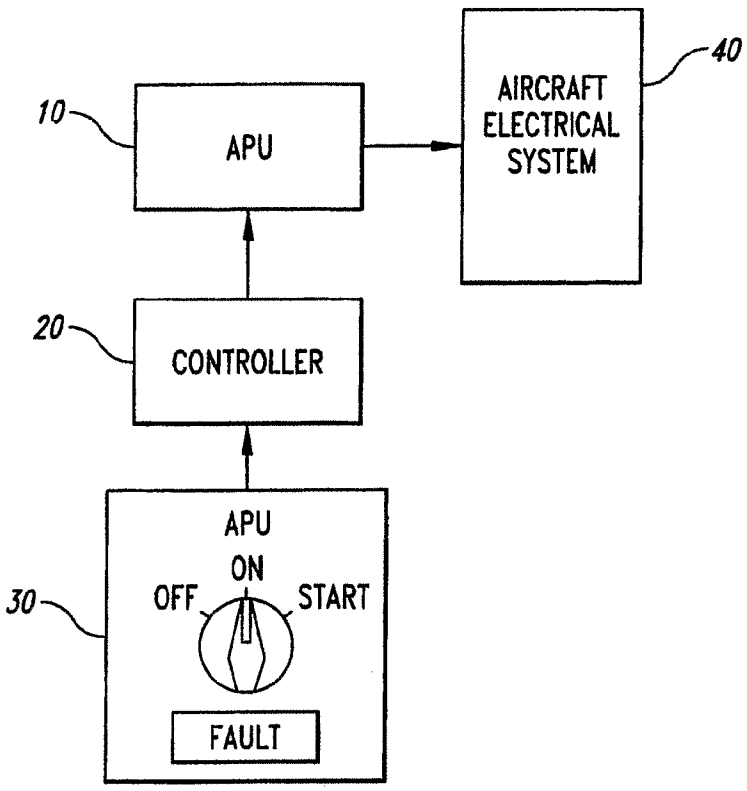
(74) Agents: **WOO, Euclid** et al.; The Boeing Company, 15460 Laguna Canyon Road, MC 1650-7006, Irvine, CA 92618 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,

[Continued on next page]

(54) Title: AUTOMATIC CONTROL SYSTEMS FOR AIRCRAFT AUXILLIARY POWER UNITS, AND ASSOCIATED METHODS



(57) Abstract: Systems and methods for operating aircraft power systems are disclosed. A power system in accordance with one embodiment of the invention includes an aircraft auxiliary power unit and a controller coupled to the aircraft auxiliary power unit, with the controller being configured to automatically stop the auxiliary power unit while the auxiliary power unit is functioning normally. The controller can also be configured to automatically start the auxiliary power unit in-flight when power supplied or expected to be supplied to a subsystem of the aircraft has a non-zero value at or below a threshold value. The controller may also be configured to start the auxiliary power unit when a load or expected load on the subsystem meets or exceeds a threshold value.

WO 2007/001366 A2

FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

AUTOMATIC CONTROL SYSTEMS FOR AIRCRAFT AUXILIARY POWER UNITS, AND ASSOCIATED METHODS

TECHNICAL FIELD

The present invention relates generally to automatic control systems for aircraft auxiliary power units, and associated methods.

BACKGROUND

Existing commercial transport jet aircraft typically include two or more primary turbine engines for propulsion. These aircraft also typically include at least one auxiliary power unit (APU) that provides electrical and/or pneumatic power in addition to or in lieu of the power provided by the primary engines. Accordingly, APUs can be used to provide power to the aircraft when the primary engines are not running, for example, when the aircraft is waiting in an airport gate. The APUs can also provide temporary power to start the primary engines during normal operations, and/or temporary emergency power during an engine-out condition or other emergency condition.

Figure 1 illustrates a system configured in accordance with the prior art, in which an APU 10 provides temporary electrical power to an aircraft electrical system 40. A controller 20 directs the operation of the APU 10, and a control input device 30 (typically housed at the flight deck of the aircraft) allows a pilot or other operator to manually direct the operation of the controller 20 and therefore the APU 10. Accordingly, the control input device 30 can include a rotary knob that is in an "off" position when the APU 10 is unstarted. The pilot or other operator rotates the knob to the "start" position to start the APU 10. Then, the operator releases the knob, which is spring loaded so as to rotate back to the "on" position. The APU 10 remains in a started state with the knob in the "on" position until the pilot manually moves the knob to the "off" position.

In certain aircraft, the controller 20 can automatically shut down the APU 10 in case of significant operating malfunctions. Such malfunctions include a fire in the compartment housing the APU 10, or failure of the APU 10 itself. In certain aircraft, the controller 20 will

start the APU 10 automatically only if all electrical power on the aircraft has failed. Accordingly, the APU 10 can provide automatic backup power in this emergency situation. Typically, a manual action is required to start the APU and, in other situations, the APU 10 can be configured to operate during an entire flight. In most situations, the APU 10 need not be operational for the aircraft to be dispatched. If the APU 10 is not operational and additional power is required during flight, the same signal that triggers in-flight emergency starting of the APU 10 can instead trigger deployment of a ram air turbine, which provides additional electrical power during flight.

While the APU system described above provides adequate ground and emergency power for existing aircraft, both airline operators and airline manufacturers have come under pressure to increase the efficiency of overall aircraft operations. Accordingly, it may be desirable to further increase the overall efficiency of aircraft power system and aircraft APUs to reduce aircraft operational costs.

SUMMARY

The present invention is directed generally to systems and methods for providing power to an aircraft. An aircraft power system in accordance with one aspect of the invention includes an aircraft auxiliary power unit and a controller coupled to the aircraft auxiliary power unit. The controller can be configured to automatically stop the auxiliary power unit while the auxiliary power unit is functioning normally. Accordingly, in further particular aspects of the invention, the controller can be configured to automatically stop the auxiliary power unit while the aircraft is in flight and after the auxiliary power unit was started while the aircraft was on the ground. The controller can also be configured to automatically start the auxiliary power unit while the aircraft is in flight.

In further aspects of the invention, the controller can be configured to automatically start the auxiliary power unit in flight when power supplied or expected to be supplied to an aircraft subsystem (e.g., an electrical circuit) to which the auxiliary power unit is coupleable has a non-zero value at or below a threshold value. In yet another aspect of the invention, the controller can be configured to automatically start the auxiliary power unit in flight when a load or expected load on the aircraft subsystem meets or exceeds a threshold value.

The invention is also directed toward methods for operating an aircraft power system. In one aspect of the invention, such a method includes starting an aircraft auxiliary power unit by operating an input device to direct a first control signal to the auxiliary power unit. The method can further include authorizing automatic operation of the auxiliary power unit by directing a second control signal. Operating an input device can include manually operating a rotary, multi-position switch at an aircraft flight deck.

A method for operating an aircraft power system in accordance with another aspect of the invention includes receiving a first signal corresponding to a load on an aircraft subsystem (e.g., an electrical power system) coupled to an aircraft auxiliary power unit, and receiving a second signal corresponding to power provided to the subsystem. If a difference between the power and the load is at or below a first threshold value and the auxiliary power unit is not started, the method can further include automatically starting the auxiliary power unit. If the difference between the power and the load is at or above a second threshold value and the auxiliary power unit is started, the method can further include automatically stopping the auxiliary power unit.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partially schematic illustration of a system for controlling an aircraft auxiliary power unit in accordance with the prior art.

Figure 2 is a partially schematic, isometric illustration of an aircraft having an auxiliary power unit controlled and configured in accordance with an embodiment of the invention.

Figure 3 is a partially schematic, isometric illustration of an auxiliary power unit, associated power system, controller, and input device configured in accordance with an embodiment of the invention.

[0001] Figure 4 is a flow diagram illustrating aspects of several methods for controlling an aircraft auxiliary power unit in accordance with multiple embodiments of the invention.

DETAILED DESCRIPTION

The present invention is directed generally toward systems and methods for controlling operation of aircraft auxiliary power units (APUs). Several embodiments of

systems and methods for controlling APUs are described below. A person skilled in the relevant art will understand, however, that the invention may have additional embodiments, and that the invention may be practiced without several of the details of the embodiments described below with reference to Figures 2-4.

Figure 2 is a partially schematic, isometric illustration of an aircraft 200 having a fuselage 201, wings 202, and an empennage 204 that includes a tail cone 207. Horizontal stabilizers 205 and a vertical stabilizer 206, along with associated control surfaces on the stabilizers and wings 202 provide stability and control for the aircraft 200. Primary power is provided by two primary engines 203 (e.g., turbofan engines) carried by the wings 202 (as shown in Figure 2) and/or other portions of the aircraft 200. An APU 210 can be positioned in the tail cone 207 (or elsewhere within the aircraft 200) to provide auxiliary electrical or pneumatic power for the aircraft 200. Further details of systems and methods for controlling the APU 210 are described below with reference to Figures 3 and 4.

Figure 3 illustrates the APU 210 positioned within the tail cone 207 of the aircraft 200. The APU 210 can include a compressor that receives air from an inlet 311. Exhaust products from the APU 210 can be vented from the aircraft 200 via an exhaust duct 312. The electrical power generated by the APU 210 can be provided to a power bus 342. The power bus 342 can also receive power from the primary engines 203, and can provide power to multiple electrically driven devices (including, but not limited to, lights, galleys, and ice protection systems), represented collectively as a load 341 in Figure 3. Accordingly, the load 341, the bus 342, the primary engines 203 and the APU 210 can form an electrical power system 340 of the aircraft 200. The power system 340 can include other components as well (e.g., a deployable ram air turbine for emergency power generation) that are not shown in Figure 3 for purposes of clarity.

The electrical load 341 and the circuit to which it is coupled provide an example of a subsystem that receives power from the APU 210. In other embodiments, the APU 210 can provide power to other subsystems, e.g., hydraulic subsystems and/or pneumatic subsystems. Accordingly, aspects of the invention described below in the context of electrical systems apply as well to other subsystems, including without limitation, pneumatic subsystems and hydraulic subsystems.

The APU 210 can be coupled to a controller 320 that (a) responds to manual instructions from the flight crew to start and/or stop the APU 210, and/or (b) autonomously and automatically provides instructions to start and/or stop the APU 210, without requiring inputs from the flight crew. As described below, the controller 320 can be coupled to an input device 330 that allows the flight crew to select between manual and automatic operation, and allows the flight crew to select which manual instruction will be provided to the controller 320.

The input device 330 can include a rotary switch 331 that can be rotated from an "off" position to a "start" position for manually starting the APU 210, and can then return to an "on" position after the operator (e.g., the pilot or other crew member) has released the switch 331. This aspect of the operation of the input device 330 is accordingly generally similar to that described above with reference to the input device 30 shown in Figure 1. The input device 330 shown in Figure 3 can also include an "auto" position in which the APU 210 starts and/or stops automatically, without direct inputs from the flight crew via the input device 330. When the input device 330 is in the "auto" position, the controller 320 can automatically start and/or stop the APU 210, for example, in response to signals received from a detection system 350 and/or other aircraft system controllers 360. In one aspect of this embodiment, the detection system 350 can be configured to detect the size of the electrical load or demand placed on the electrical power system 340 by the load 341. In another aspect of this embodiment, the detection system 350 can determine how much power is being supplied to electrical power system 340 by the APU 210, the primary power units 203, and/or any other power generators coupled to the power system 340. In still further aspects of this embodiment, the detection system 350 can detect the current state of the APU 210, including whether or not the APU 210 is operating, and/or whether the APU 210 or the compartment in which it is housed are experiencing a malfunction. Such malfunctions can include high APU temperature, low APU oil pressure, and/or a fire or other high temperature event in the APU compartment. The crew can be alerted to malfunction by an illuminated "FAULT" indicator 332. Other information pertaining to the status of the APU 210 can be presented to the crew via a central alerting system (not shown in Figure 3). Such information can include whether the APU 210 is running, shutting down, shut down, in a "failed off" mode, and/or "armed" (e.g., configured to operate in the

"auto" mode). Accordingly, the crew can readily assess the status of the APU 210, even if the APU 210 is being operated in the "auto" mode. Further details of the automatic operation of the APU 210 are described below with reference to Figure 4.

Figure 4 illustrates a process 400 for automatically controlling an aircraft APU, in accordance with an embodiment of the invention. In process portion 402, the process 400 includes determining whether it is desirable to have the APU provide power to the aircraft electrical system. APU power may be desirable if the load on the aircraft electrical system is at or above a threshold level, or if the power provided to the electrical system is at or below a threshold level. Accordingly, the process 400 can further include determining whether the load (or expected load) on the electrical system is at or above a threshold level (process portion 404) and/or determining if power (or expected power) provided to the electrical power system has a non-zero value at or below a threshold level (process portion 406). The information for making either determination can be based upon data received from an onboard aircraft system, for example, the detection system 350 or other aircraft system controllers 360 described above with reference to Figure 3.

If, in process portion 402, it is determined that APU power is desirable, the process 400 can further include determining whether or not the APU is currently operating (process portion 408). If the APU is not operating, the process 400 can include automatically starting the APU (process portion 410). The process 400 can optionally include waiting for a selected delay period before automatically starting the APU (process portion 412). During this delay period, the system can continually check to determine (a) if the load on the electrical system remains at or above a threshold level, and/or (b) if the power provided to the electrical power system remains at or below a threshold level. If either (or both) conditions are met for the duration of the selected delay period, the system can automatically start the APU, as indicated in process portion 410. By providing a delay period, this aspect of the method can reduce the likelihood that the APU will be repeatedly started and stopped when the load on the electrical system fluctuates close to the threshold level, and/or when the power provided to the electrical system fluctuates close to the threshold level.

If, in either process portion 404 or process portion 406, it is determined that APU power is not desirable, then the process 400 can include determining whether or not the

APU is operating (process portion 414). If the APU is not operating, the process 400 can include repeating process portions 404 and/or 406 to determine whether and when APU power becomes desirable. If it is determined that the APU is operating, but that APU power is not desirable, the process 400 can include automatically shutting the APU down while the APU is functioning normally (process portion 416). In a particular aspect of this embodiment, the process 400 can include waiting for a selected delay period (process portion 418) while continuing to monitor whether APU power is desirable. If APU power remains desirable for the duration of the selected delay period, then the APU shutdown process can be completed. This optional delay period can prevent the APU from being frequently shut down and restarted if the load on the electrical system and/or the power provided to the electrical power system fluctuate close to the respective threshold levels. In any of the foregoing embodiments, the APU can also be shut down automatically if it is not functioning normally (for example, if the APU itself is malfunctioning, or if a fire is detected in the compartment housing the APU).

In other embodiments, other techniques can be used to determine when to start and/or stop the APU. For example, the APU can be started when the difference between the power provided to the electrical system and the load on the electrical system falls below a threshold value. The APU can be stopped when this difference is above the same or a different threshold value. In still further embodiments, aspects of the automatic operation of the APU can be inhibited during certain phases of operation. For example, the APU controller can be inhibited from automatically starting (and/or stopping) the APU while the aircraft is on the ground.

One feature of at least some of the embodiments described above is that the APU can be stopped automatically, even if it is running normally. An advantage of this feature is that it can reduce pilot workload by eliminating the need for the pilot or other operator to monitor the condition of the APU and manually shut the APU down when it is no longer necessary or desirable for the APU to be running. For example, during a normal ground start sequence, the pilot starts the APU, and then uses the APU to start one main engine. The started main engine is then used to start the second main engine in a process that can be repeated for as many main engines as are present on the aircraft. In an embodiment of the invention, the controller can automatically stop the APU without pilot intervention, for

example, when the APU power is no longer needed, or when the aircraft leaves the ground.

Another feature of at least some embodiments of the invention is that the APU can also be started automatically. For example, if the load on the aircraft electrical system is at or above a threshold level, or the power supplied by non-APU power generators is at or below a threshold level, the APU controller can automatically start the APU. An advantage of this feature is that it eliminates the need for the pilot to monitor either the load on the electrical system or the power provided to the electrical system. Another advantage of this feature is that it can eliminate the need for the pilot to manually start the APU when the load on the electrical system or the power supplied to the electrical system fall outside selected limits.

Still another feature of at least some embodiments of the invention is that the pilot or operator can select between manual and automatic operation of the APU. An advantage of this feature is that the pilot can take over manual control of the APU at any point during the operation of the aircraft. The pilot can also authorize automatic operation of the APU, for example, by transmitting an appropriate signal via an input device.

Still another advantage of at least some of the foregoing embodiments is that they can support the increased use of electrical systems on the aircraft. For example, it may be desirable to replace some non-electrical systems (e.g., hot air anti-icing systems) with electrical counterparts (e.g., resistance heaters). It may also be desirable to add electrical power capacity (e.g., to support increased use of consumer electronics onboard the aircraft). The periodically high power demands placed by such loads on the aircraft electrical system can be more easily supported by an APU controller that starts and stops the APU on an "as needed" basis.

Yet another feature of at least some of the foregoing embodiments is that the controller can respond to actual loads and/or power levels when directing the APU to start or stop, and/or the controller can respond to anticipated loads and/or power levels. For example, if the crew or an automatic system requests power by activating a system (e.g., a galley system or ice protection system), the controller can determine if the present power level is high enough to support the new load without starting the APU. If not, the controller can automatically start the APU before supplying power to the new load. If one of the main

engines begins a shutdown sequence that will result in low power supplied to the electrical system, the controller can automatically start the APU before the power falls below a threshold level.

From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various modifications may be made without deviating from the spirit and scope of the invention. For example, aspects of the invention described in the context of particular embodiments can be combined or eliminated in other embodiments. Although advantages associated with certain embodiments of the invention have been described in the context of those embodiments, other embodiments may also achieve those advantages. None of the foregoing embodiments need necessarily exhibit such advantages to fall within the scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

CLAIMS

I/We claim:

1. An aircraft power system, comprising:
an aircraft auxiliary power unit; and
a controller coupled to the aircraft auxiliary power unit, the controller being configured to automatically stop the auxiliary power unit while the auxiliary power unit is functioning normally.

2. The system of claim 1 wherein the controller is configured to automatically start the auxiliary power unit while the aircraft is in flight.

3. The system of claim 1 wherein the controller is configured to automatically stop the auxiliary power unit while the aircraft is in flight and after the auxiliary power unit was started while the aircraft was on the ground.

4. The system of claim 1 wherein auxiliary power unit is part of an aircraft electrical power system, and wherein the controller is configured to automatically start the auxiliary power unit when the overall electrical power of the electrical power system has a non-zero value at or below a threshold value, and wherein the controller is configured to automatically stop the auxiliary power unit when the overall electrical power is at or above the threshold value.

5. The system of claim 1 wherein the controller has a first mode in which the controller directs the auxiliary power unit to start, stop or both start and stop based on inputs received from an operator, and wherein the controller has a second mode in which the controller directs the auxiliary power unit to start, stop or both start and stop automatically and during normal aircraft operations, without direct inputs from an operator.

6. The system of claim 5, further comprising an operator-selectable switch coupled to the controller, the switch having at least one first setting corresponding to the first mode and at least one second setting corresponding to the second mode.

7. The system of claim 1, further comprising an electrical power circuit electrically coupled to the aircraft auxiliary power unit.

8. The system of claim 1, further comprising:
an electrical power circuit electrically coupled to the aircraft auxiliary power unit; and
at least one primary power source coupled to the electrical power circuit.

9. The system of claim 1, further comprising:
an electrical power circuit electrically coupled to the aircraft auxiliary power unit;
at least one primary power source coupled to the electrical power circuit, the at least one primary power source including a turbofan engine; and
a detector operatively coupled to the at least one primary power source to determine a load on the at least one primary power source;

10. The system of claim 1 wherein the controller is configured to:
receive a signal corresponding to an aircraft electrical power demand; and
(a) if the aircraft electrical power demand exceeds a threshold level, and the auxiliary power unit is not started, automatically direct the auxiliary power unit to start after a delay; or
(b) if the aircraft electrical power demand is below a threshold level, and the auxiliary power unit is started, automatically direct the auxiliary power unit to stop after a delay; or both (a) and (b).

11. The system of claim 1 wherein the controller is configured to:
receive a signal corresponding to an aircraft electrical power output; and

(a) if the aircraft electrical power output is at or below a threshold level, and the auxiliary power unit is not started, automatically direct the auxiliary power unit to start after a delay; or

(b) if the aircraft electrical power output is at or above a threshold level, and the auxiliary power unit is started, automatically direct the auxiliary power unit to stop after a delay; or both (a) and (b).

12. An aircraft power system, comprising:

an aircraft auxiliary power unit; and

a controller coupled to the aircraft auxiliary power unit, the controller being configured to automatically start the auxiliary power unit in flight when power supplied or expected to be supplied to an aircraft subsystem to which the auxiliary power unit is coupleable has a non-zero value at or below a threshold value.

13. The system of claim 12 wherein the subsystem includes at least one of an electrical circuit, a hydraulic subsystem, and a pneumatic subsystem.

14. The system of claim 12, further comprising a detector operatively coupleable to the subsystem and being configured to detect power supplied to the subsystem.

15. The system of claim 12 wherein the subsystem to which the auxiliary power unit is coupleable includes an electrical circuit, and wherein the controller is configured to automatically stop the auxiliary power unit when the electrical power of the aircraft electrical circuit is at or above the threshold value.

16. An aircraft power system, comprising:

an aircraft auxiliary power unit; and

a controller coupled to the aircraft auxiliary power unit, the controller being configured to automatically start the auxiliary power unit in flight when a load placed on or expected to be placed on an aircraft subsystem to which the auxiliary power unit is coupleable meets or exceeds a threshold value.

17. The system of claim 16 wherein the subsystem to which the auxiliary power unit is coupleable includes an electrical circuit, and wherein the controller is configured to automatically stop the auxiliary power unit when the load on the aircraft electrical circuit is at or below the threshold value.

18. The system of claim 16, further comprising a detector operatively coupleable to the system and being configured to detect the load on the system.

19. The system of claim 16 wherein the subsystem includes at least one of an electrical circuit, a hydraulic subsystem and a pneumatic subsystem.

20. An aircraft power system, comprising:

at least one aircraft primary power source;

an aircraft auxiliary power unit;

an electrical power circuit coupled to the at least one aircraft primary power source and the aircraft auxiliary power unit;

a detection system operatively coupled to the electrical power circuit to provide a first signal corresponding to a load on the electrical power circuit, and a second signal corresponding to the power supplied to the electrical power circuit; and

a controller coupled to the detection system and the auxiliary power unit, the controller being configured to:

receive the first and second signals; and

(a) if the first signal corresponds to a load that exceeds a first threshold level, and the auxiliary power unit is not started, automatically direct the auxiliary power unit to start after a delay;

(b) if the first signal corresponds to a load that is below the first threshold level, and the auxiliary power unit is started, automatically direct the auxiliary power unit to stop after a delay;

(c) if the second signal corresponds to a power that is below a second threshold level, and the auxiliary power unit is not started, automatically direct the auxiliary power unit to start after a delay; and

(d) if the second signal corresponds to a power that is above the second threshold level, and the auxiliary power unit is started, automatically direct the auxiliary power unit to stop after a delay.

21. The system of claim 20 wherein the at least one aircraft primary power source includes a turbofan engine.

22. An aircraft power system, comprising:
an aircraft auxiliary power unit; and
control means for directing operation of the aircraft auxiliary power unit, the control means being configured to automatically stop the auxiliary power unit while the auxiliary power unit is functioning normally.

23. The system of claim 22 wherein the control means is configured to:
receive a signal corresponding to an aircraft electrical power demand; and
(a) if the aircraft electrical power demand exceeds a threshold level, and the auxiliary power unit is not started, automatically direct the auxiliary power unit to start after a delay; or
(b) if the aircraft electrical power demand is below a threshold level, and the auxiliary power unit is started, automatically direct the auxiliary power unit to stop after a delay; or both (a) and (b).

24. The system of claim 22 wherein the control means is configured to:
receive a signal corresponding to an aircraft electrical power output; and
(a) if the aircraft electrical power output is at or below a threshold level, and the auxiliary power unit is not started, automatically direct the auxiliary power unit to start after a delay; or
(b) if the aircraft electrical power output is at or above a threshold level, and the auxiliary power unit is started, automatically direct the auxiliary power unit to stop after a delay; or both (a) and (b).

25. A method for operating an aircraft power system, comprising:
receiving a signal corresponding to a state of an aircraft subsystem that includes and receives power from an auxiliary power unit; and
in response to receiving the signal, automatically stopping the auxiliary power unit while the auxiliary power unit is functioning normally.

26. The method of claim 25 wherein the subsystem includes an electric power circuit, and wherein receiving a signal includes receiving a signal corresponding to an aircraft electrical power output provided to the aircraft electrical power circuit while the aircraft is in flight and while the auxiliary power unit of the aircraft is in an unstarted state, and wherein the method further comprise automatically starting the auxiliary power unit while the aircraft is in flight if the electrical power output is at or below a threshold value.

27. The method of claim 25 wherein the subsystem includes an electric power circuit, and wherein receiving a signal includes receiving a signal corresponding to a load on the aircraft electrical power circuit while the aircraft is in flight and while the auxiliary power unit of the aircraft is in an unstarted state, and wherein the method further comprise automatically starting the auxiliary power unit while the aircraft is in flight if the load is at or above a threshold value.

28. A method for operating an aircraft power system, comprising:
receiving a signal corresponding to an aircraft power output provided to an aircraft subsystem while the aircraft is in flight and while an auxiliary power unit of the aircraft is in an unstarted state; and
if the power output is or is expected to be at or below a threshold value, automatically starting the auxiliary power unit while the aircraft is in flight.

29. The method of claim 28, further comprising automatically stopping the auxiliary power unit if the power output is at or above the threshold value.

30. The method of claim 28 wherein automatically starting the auxiliary power unit includes automatically starting the auxiliary power unit after a delay from the time the signal is received.

31. A method for operating an aircraft power system, comprising:
receiving a signal corresponding to a load on an aircraft subsystem while the aircraft is in flight and while an auxiliary power unit of the aircraft is in an unstarted state; and
if the load is at or above a threshold value, automatically starting the auxiliary power unit while the aircraft is in flight.

32. The method of claim 31 wherein automatically starting the auxiliary power unit includes automatically starting the auxiliary power unit after a delay from the time the signal is received.

33. The method of claim 31, further comprising detecting the load and transmitting the corresponding signal.

34. The method of claim 31, further comprising automatically stopping the auxiliary power unit if the load subsequently drops below the threshold value.

35. The method of claim 31, further comprising starting the auxiliary power unit in response to an input signal provided by an operator while the aircraft is on the ground.

36. The method of claim 31, further comprising stopping the auxiliary power unit in response to an input signal provided by an operator while the aircraft is on the ground.

37. A method for operating an aircraft power system, comprising:
receiving a first signal corresponding to a load on an aircraft electrical power system;
receiving a second signal corresponding to power provided to the aircraft electrical power system;

if the first signal exceeds a first threshold level, and the auxiliary power unit is not started, automatically directing the auxiliary power unit to start after a delay;
if the first signal is below the first threshold level, and the auxiliary power unit is started, automatically directing the auxiliary power unit to stop after a delay;
if the second signal is below a second threshold level, and the auxiliary power unit is not started, automatically directing the auxiliary power unit to start after a delay; and
if the second signal is above the second threshold level, and the auxiliary power unit is started, automatically directing the auxiliary power unit to stop after a delay.

38. A method for operating an aircraft power system, comprising:
starting an aircraft auxiliary power unit by operating an input device to direct a first control signal to the auxiliary power unit; and
authorizing automatic operation of the auxiliary power unit by directing a second control signal.

39. The method of claim 38 wherein directing a second control signal includes directing the second control signal from the input device to a controller for the auxiliary power unit.

40. The method of claim 38 wherein operating an input device includes manually operating a rotary, multi-position switch at an aircraft flight deck.

41. A method for operating an aircraft power system, comprising:
receiving a first signal corresponding to a load on an aircraft subsystem coupled to an aircraft auxiliary power unit;
receiving a second signal corresponding to power provided to the subsystem;
if a difference between the power and the load is at or below a first threshold value and the auxiliary power unit is not started, automatically starting the auxiliary power unit; and
if the difference between the power and the load is at or above a second threshold value and the auxiliary power unit is started, automatically stopping the auxiliary power unit.

42. The method of claim 41 wherein first threshold value is at least approximately the same as the second threshold value.

43. The method of claim 41 wherein automatically starting the auxiliary power unit includes automatically starting a gas turbine engine.

44. A computer-readable medium configured perform a method for operating an aircraft power system, comprising:
receiving a signal corresponding to a load on a normally functioning aircraft subsystem while the aircraft is in flight and while an auxiliary power unit of the aircraft is in an unstarted state; and
if the signal corresponds to a load or expected load that meets or exceeds a threshold value, automatically directing the auxiliary power unit to start while the aircraft is in flight.

45. The computer-readable medium of claim 44 wherein the method further comprises automatically directing the auxiliary power unit to stop while the aircraft is in flight and the auxiliary power unit is in a started state, if the signal corresponds to a load that is at or below the threshold value.

46. A computer-readable medium configured perform a method for operating an aircraft power system, comprising:
receiving a signal corresponding to power input to a load on a normally functioning aircraft subsystem while the aircraft is in flight and while an auxiliary power unit of the aircraft is in an unstarted state; and
if the signal corresponds to a power level or expected power level that is at or below a threshold value, automatically directing the auxiliary power unit to start while the aircraft is in flight.

47. The computer-readable medium of claim 44 wherein the method further comprises automatically directing the auxiliary power unit to stop while the aircraft is in

flight and the auxiliary power unit is in a started state, if the signal corresponds to a power level that is at or above the threshold value.

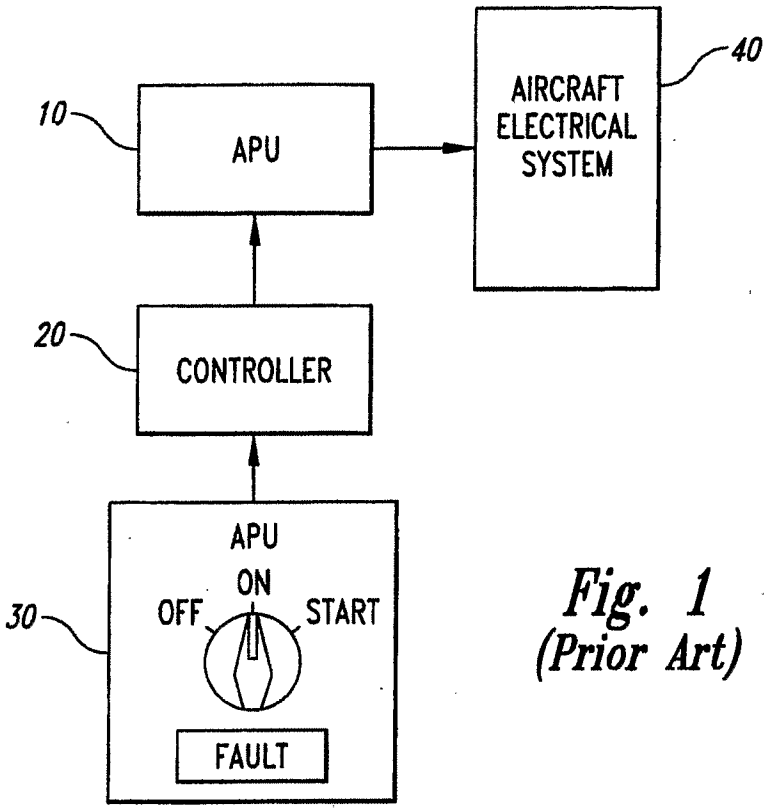


Fig. 1
(Prior Art)

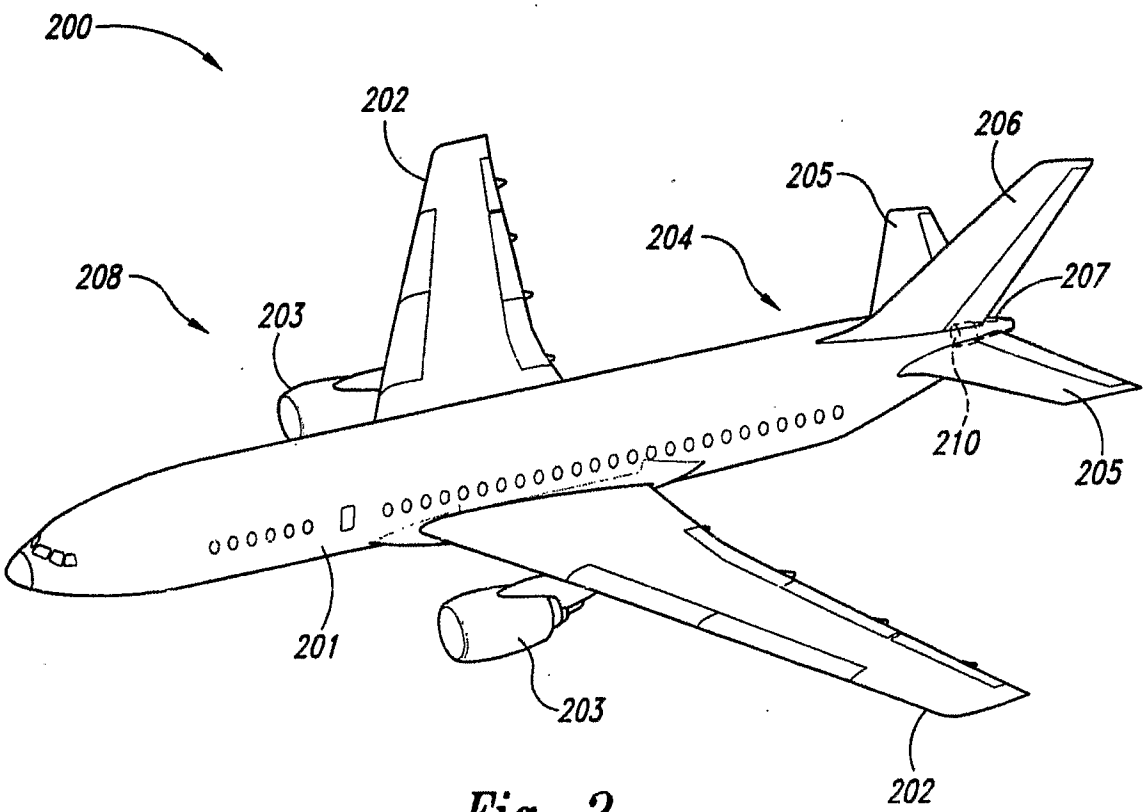


Fig. 2

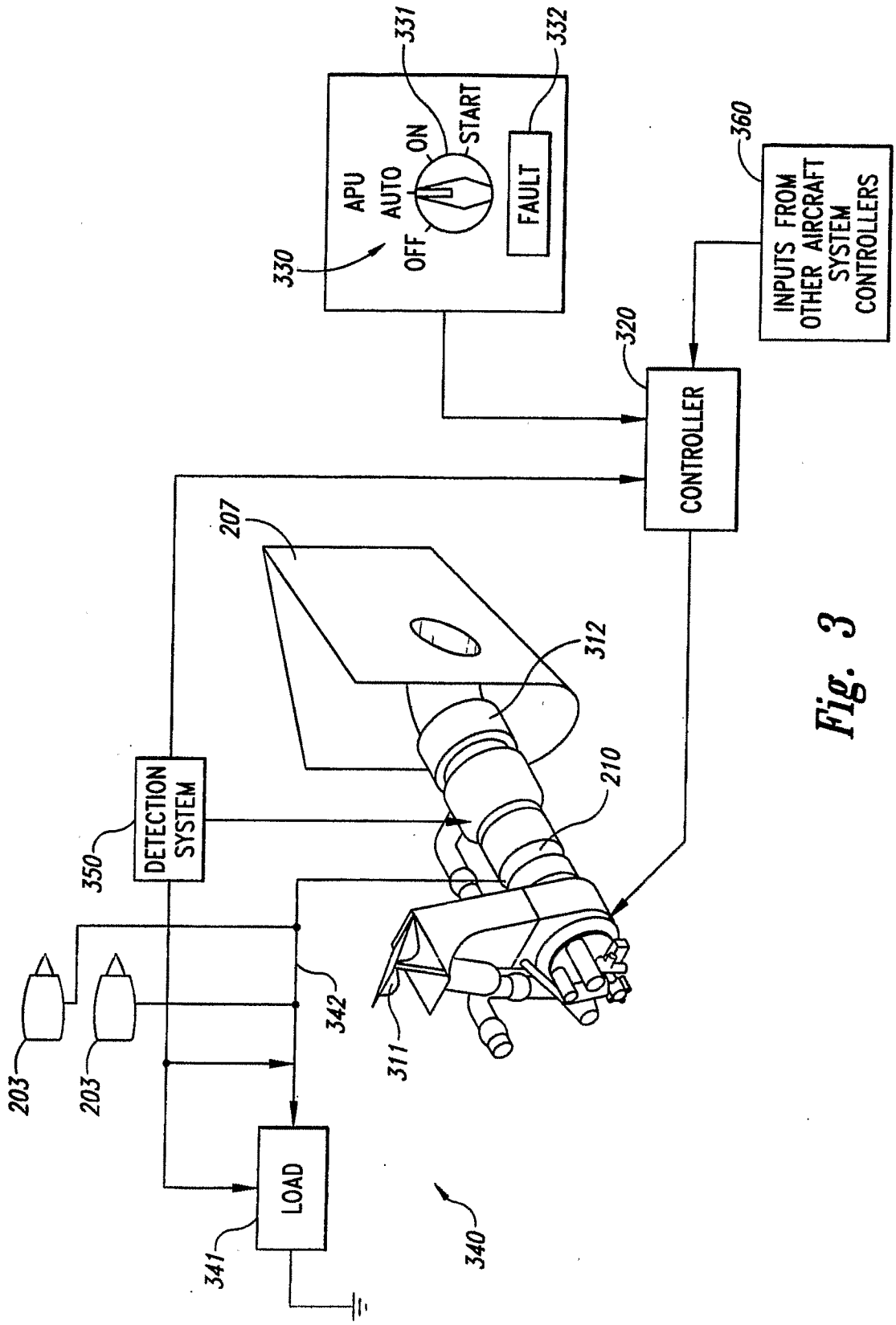

331
332
APU
AUTO
OFF
ON
START
FAULT
330
360
INPUTS FROM OTHER AIRCRAFT SYSTEM CONTROLLERS
320
CONTROLLER
207
312
210
DETECTION SYSTEM
350
203
203
342
311
LOAD
341
340

Fig. 3

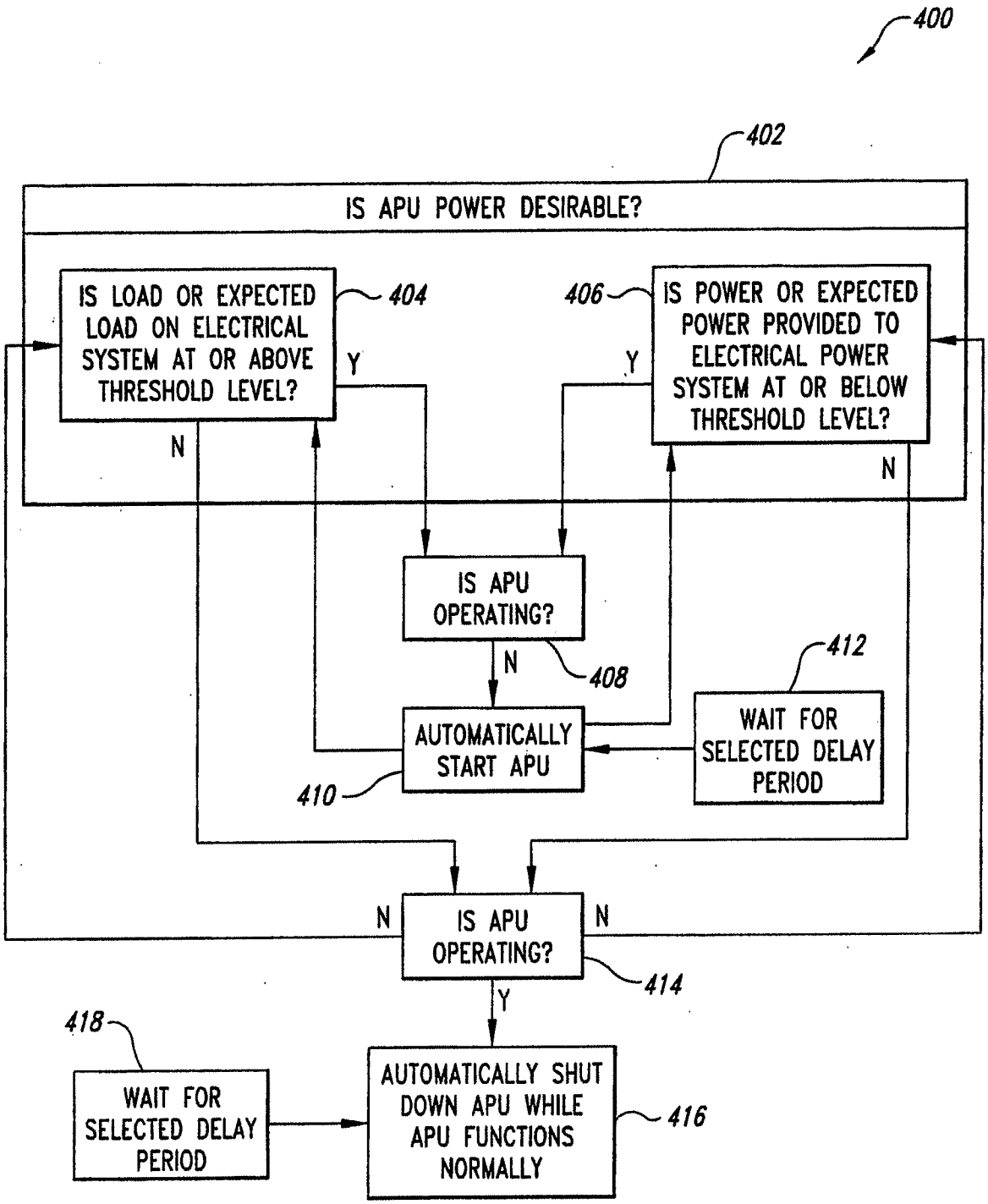

400
402
IS APU POWER DESIRABLE?
IS LOAD OR EXPECTED LOAD ON ELECTRICAL SYSTEM AT OR ABOVE THRESHOLD LEVEL?
404
Y
N
406
IS POWER OR EXPECTED POWER PROVIDED TO ELECTRICAL POWER SYSTEM AT OR BELOW THRESHOLD LEVEL?
Y
N
IS APU OPERATING?
N
408
412
WAIT FOR SELECTED DELAY PERIOD
AUTOMATICALLY START APU
410
N
IS APU OPERATING?
N
414
Y
418
WAIT FOR SELECTED DELAY PERIOD
AUTOMATICALLY SHUT DOWN APU WHILE APU FUNCTIONS NORMALLY
416

Fig. 4