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(54) MINIATURE, UNMANNED AIRCRAFT WITH ONBOARD STABILIZATION AND AUTOMATED GROUND CONTROL OF FLIGHT PATH

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(51) **Int. Cl.**[7] **B64C 13/20**

(52) **U.S. Cl.** .... **701/3**; 701/4; 701/11; 701/23; 244/76 R; 244/190; 446/57

(58) **Field of Search** .... 701/3, 4, 11, 23, 701/28; 244/75 R, 76 R, 175, 181, 190, 189; 446/7, 34, 57

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,746,082 A	*	5/1988	Syms et al.	244/137.4
H628 H	*	4/1989	McIngvale	342/33
4,964,598 A	*	10/1990	Berejik et al.	244/190
5,035,382 A	*	7/1991	Lissaman et al.	244/190
5,067,674 A	*	11/1991	Heyche et al.	244/190
5,537,909 A		7/1996	Schneider et al.	
5,904,724 A	*	5/1999	Margolin	701/120
6,062,176 A		5/2000	Berger	

* cited by examiner

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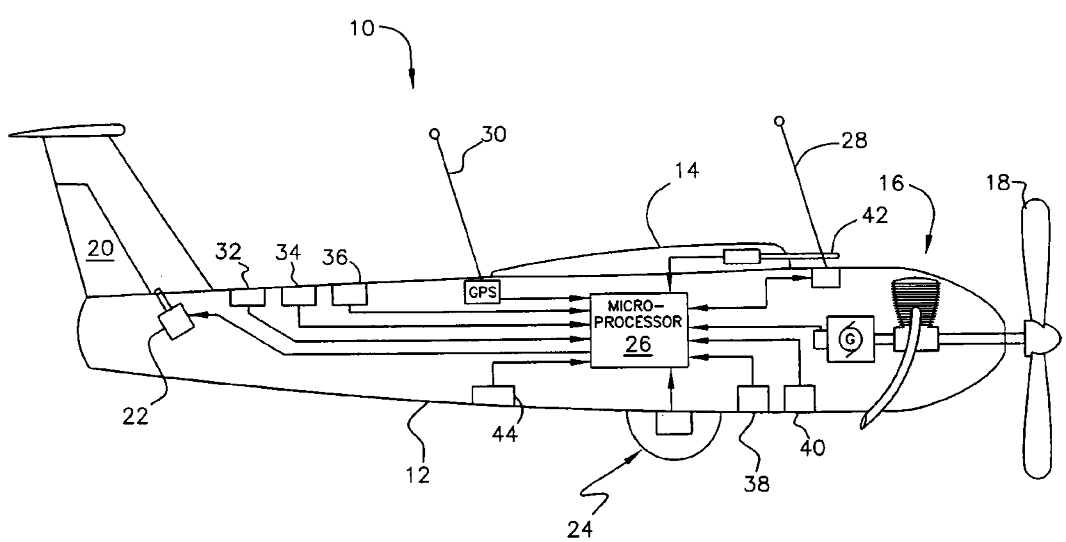
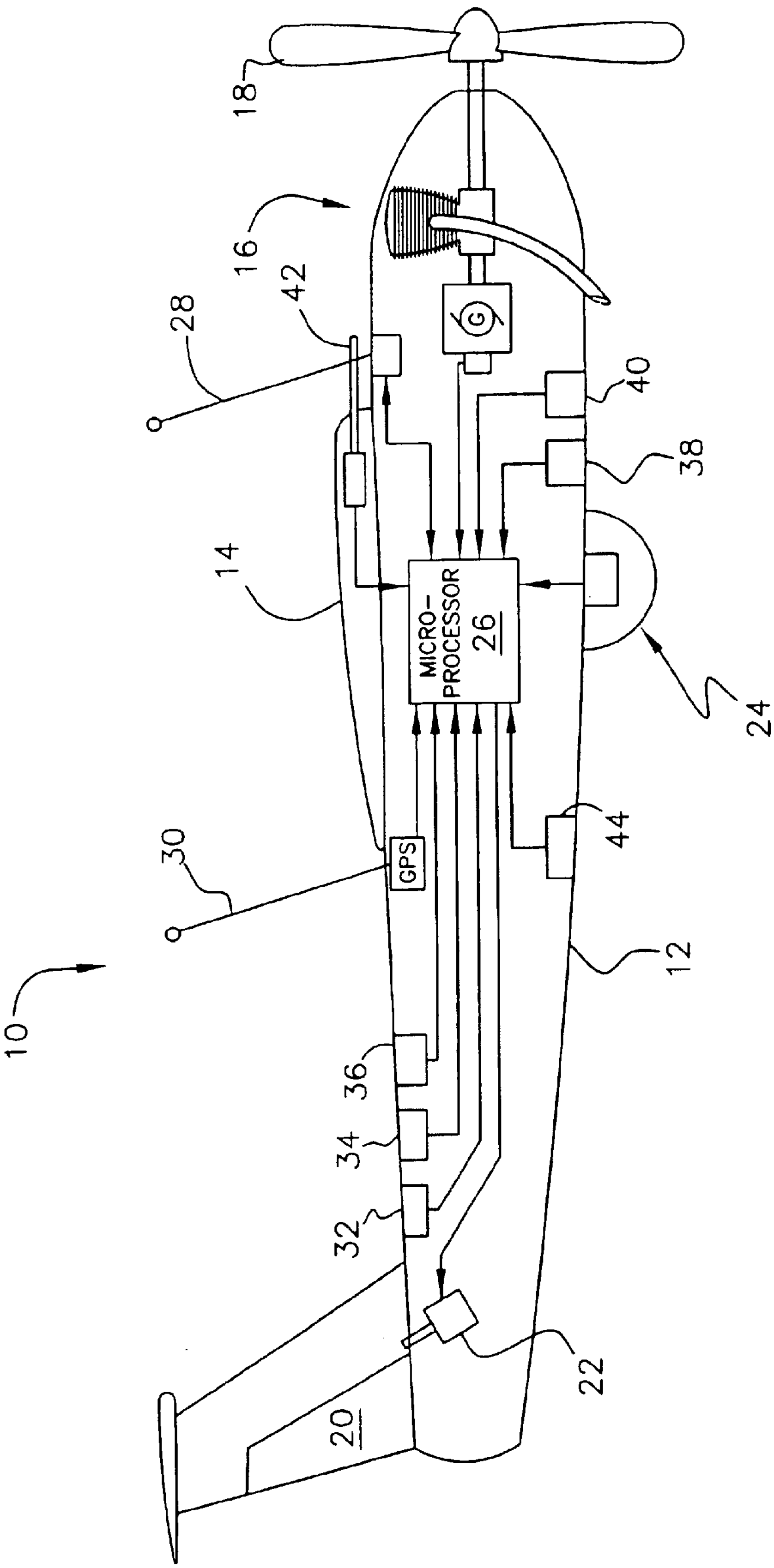
(57) **ABSTRACT**

A miniature, unmanned aircraft for acquiring and/or transmitting data, capable of automatically maintaining desired airframe stability while operating by remote directional commands. The aircraft comprises a fuselage and a wing, a piston engine and propeller, a fuel supply, at least one data sensor and/or radio transceiver, a microprocessor disposed to manage flight, a radio transceiver for receiving remotely generated flight direction commands, a GPS receiver, a plurality of control surfaces and associated servomechanisms, for controlling flight stabilization and direction, roll, pitch, yaw, velocity, and altitude sensors. The microprocessor uses roll, pitch, yaw, and altitude data to control attitude and altitude of the aircraft automatically, but controls flight direction solely based on external commands. The aircraft does not exceed fifty-five pounds.

19 Claims, 1 Drawing Sheet

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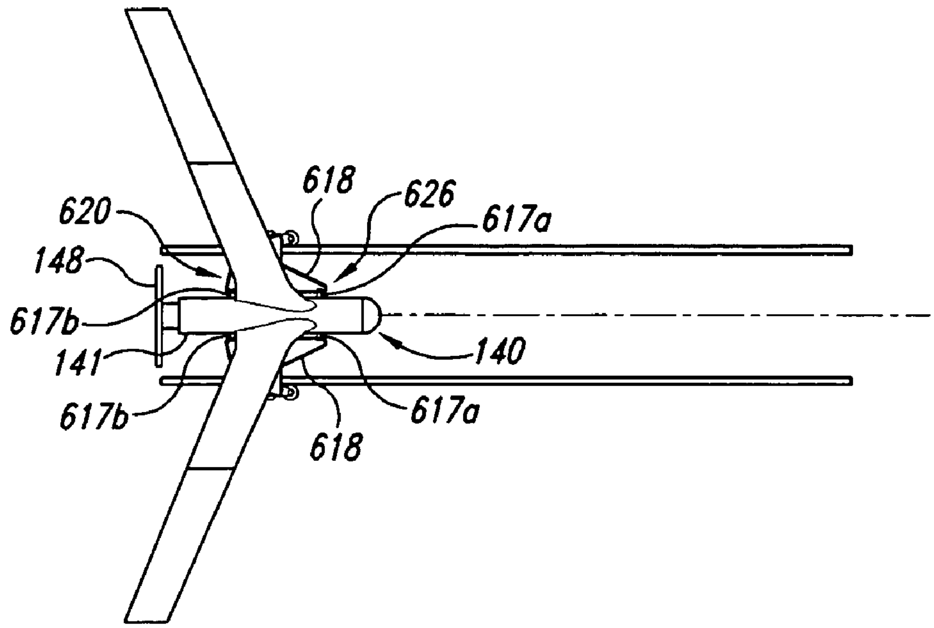
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Fig. 6C

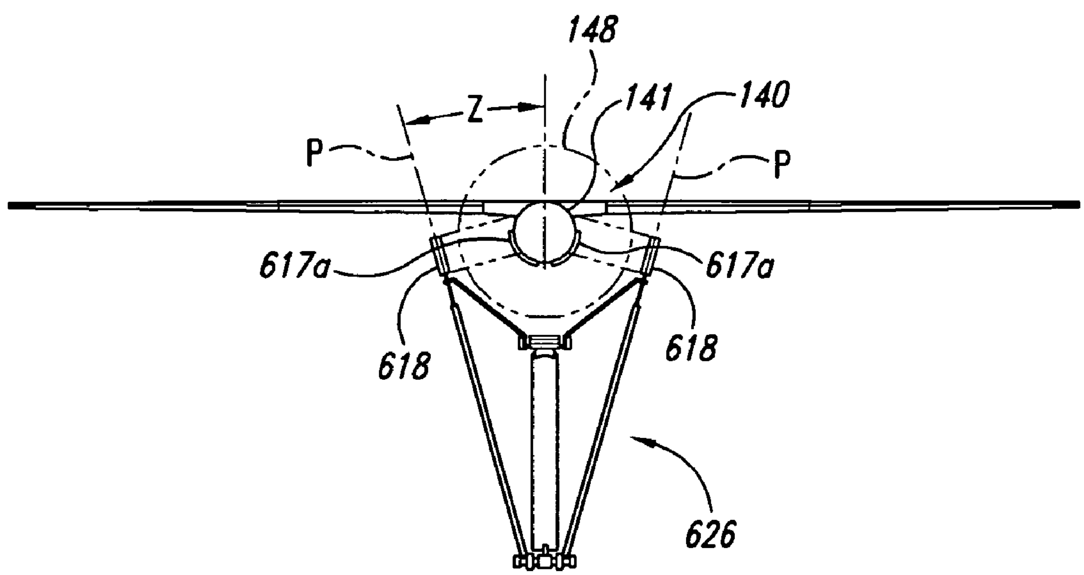
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Fig. 6D

obtained by sensors such as, for example, digital cameras from the air. Aircraft **10** has an airframe including a fuselage **12**, a wing **14**, a reciprocating piston internal combustion engine **16** and associated fuel supply system (not separately shown) carried aboard the airframe, and a propeller **18** drivably connected to engine **16**. The engine will be understood to include a fuel supply system (not separately shown) carried aboard the airframe. The airframe supports control surfaces such as elevator, rudder, flaps, and ailerons. The latter are shown representatively by rudder **20**. Each control surface has a servomechanism, shown representatively as servomechanism **22**.

Aircraft **10** is capable of acquiring data or transmitting data or both acquiring and transmitting data. To this end, a mission data handling apparatus **24** disposed selectively to acquire data or transmit data or to both acquire and transmit data is provided. Apparatus **24** may be, for example, a multispectral instrument, an infrared or near infrared sensor, or any other sensor which may be carried aboard miniature, remotely controlled data gathering or transmitting aircraft.

Aircraft **10** has a remotely controlled guidance system having a microprocessor **26** disposed to manage flight, a radio frequency transceiver **28** carried aboard the aircraft and disposed to receive remotely generated flight direction commands and to communicate flight direction commands to microprocessor **26**, a Global Positioning System (GPS) receiver **30**, and a plurality of sensors disposed to sense data relating to stabilization and altitude of aircraft **10**. These sensors include flight stabilization sensors including a roll sensor **32**, a pitch sensor **34**, and a yaw sensor **36**, and redundant altitude sensors including a laser or acoustic altimeter **38** and a barometric pressure altimeter **40**. A pitot tube **42** serves as a velocity sensor. A flux gate compass **44** determines direction of aircraft **10**. The functions of pitot tube **42** and flux gate compass **44** may be redundantly supplemented by calculations using GPS signals considered with respect to time.

Microprocessor **26** will be understood to be a complete system including all necessary programming and memory devices (neither separately shown).

In operation, aircraft **10** is controlled from a suitable ground station (not shown) or other source of radio frequency command signals. These signals include directional commands which constitute the only source of directional instruction. No programming contained within microprocessor **26** includes predetermined directional instruction. However, programming provided within microprocessor is capable of processing inputs from the attitude and altitude sensors, and of generating command signals which are then transmitted to servomechanisms represented by servomechanism **22**. In the preferred embodiment, microprocessor **26** can, by considering inputs from the various sensors and also GPS receiver **30**, determine its location, attitude, altitude, and velocity. These characteristics may be transmitted to the ground station via transceiver **28**. This arrangement avoids the restrictions which may be imposed on aircraft capable of guiding their own flight, since although the ground station operator knows where aircraft **10** is, where aircraft **10** is headed, and its velocity, only attitude and altitude data and internally derived command signals are generated within aircraft **10**.

The invention is a method of controlling aircraft **10** such that flight stabilization is automatically performed within aircraft **10**, and flight direction is performed exclusively by external remotely generated signals. The method comprises an initial step of providing aircraft **10** in the form described above.

A subsequent step is that of receiving remotely generated radio frequency flight direction commands on transceiver **28** and transmitting the flight direction commands to microprocessor **26**.

Another step is that of causing at least one and preferably all of the flight stabilization sensors **32**, **34**, **36** to transmit sensed data to microprocessor **26**. A further step is that of causing microprocessor **26** to process flight direction commands and sensed data relating to stabilization to generate stabilization and directional command signals, and transmitting generated stabilization and directional command signals to each of the servomechanisms represented by servomechanism **22**.

A further step is that of determining the stabilization command signals to be transmitted to each servomechanism (e.g., servomechanism **22**) at least in part from data sensed by the flight stabilization sensors.

Another step is that of determining directional command signals transmitted to each servomechanism based entirely and exclusively on direction commands received by transceiver **28**.

The basic method set forth above may be expanded to include further steps of, first, receiving GPS signals on GPS receiver **30**; next, processing received GPS signals within microprocessor **26** to determine altitude of aircraft **10**; and next, generating altitude control commands for maintaining a selected altitude under control of microprocessor **26** and transmitting generated altitude control commands to each servomechanism (e.g., servomechanism **22**).

A step of providing a plurality of attitude sensors of different types may be practiced. This is satisfied by providing roll sensor **32**, a pitch sensor **34**, and yaw sensor **36**, or any other sensors providing equivalent function.

The basic method may be modified by adding a further step of providing an altitude sensor, such as laser or acoustic altimeter **38** or a barometric pressure altimeter **40** or both.

An advantageous additional step is that of limiting the gross weight of the aircraft to fifty-five pounds. Suitable construction for achieving this weight limit is set forth in copending application entitled, MINIATURE, UNMANNED AIRCRAFT WITH INTERCHANGEABLE DATA MODULE, Ser. No. 10/255,186, to which the reader is referred.

It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims.

I claim:

1. A method of controlling a miniature, unmanned aircraft capable of acquiring data or transmitting data or both acquiring and transmitting data, such that flight stabilization is automatically performed within the aircraft and flight direction is performed by external remotely generated signals, comprising the steps of:

providing a miniature, unmanned aircraft having an airframe including a fuselage, a wing, at least one control surface and at least one servomechanism disposed to operate a respective control surface, a reciprocating piston internal combustion engine and fuel supply system carried aboard the airframe, a propeller drivably connected to the engine, a mission data handling apparatus disposed selectively to acquire data or transmit data or to both acquire and transmit data, and a remotely controlled guidance system having a microprocessor disposed to manage flight, a radio frequency transceiver carried aboard the aircraft and disposed to receive remotely generated flight direction commands and to communicate flight direction commands to the microprocessor, and at least one flight stabilization sensor disposed to sense data relating to stabilization of the aircraft;

receiving remotely generated radio frequency flight direction commands on the transceiver and transmitting the flight direction commands to the microprocessor;

causing the flight stabilization sensor to transmit sensed data to the microprocessor;

causing the microprocessor to process flight direction commands and sensed data relating to stabilization to generate stabilization and directional command signals, and transmitting generated stabilization and directional command signals to at least one servomechanism;

determining the stabilization command signals transmitted to each servomechanism exclusively from data sensed by the flight stabilization sensor; and

determining the directional command signals transmitted to each servomechanism based entirely and exclusively on direction commands received by the radio frequency transceiver.

2. The method according to claim **1**, comprising the further steps of:

receiving GPS signals on a radio frequency receiver, processing received GPS signals within the microprocessor to determine altitude of the aircraft; and

generating altitude control commands for maintaining a selected altitude by the microprocessor and transmitting generated altitude control commands to at least one servomechanism.

3. The method according to claim **1**, wherein said step of providing a miniature, unmanned aircraft comprises the further step of providing a plurality of attitude sensors of different types.

4. The method according to claim **1**, wherein said step of providing a miniature, unmanned aircraft comprises the further step of providing at least one of the group including a roll sensor, a pitch sensor, and yaw sensor.

5. The method according to claim **1**, wherein said step of providing a miniature, unmanned aircraft comprises the further step of providing an altitude sensor.

6. The method according to claim **1**, comprising the further step of limiting the gross weight of the aircraft to fifty-five pounds.

7. A miniature, unmanned, powered aircraft having remote guidance capability comprising:

a) an airframe comprising an internal combustion engine adapted to provide motive power to said aircraft, a plurality of control surfaces adapted to respectively control at least a direction of flight, an attitude, and an altitude of said aircraft, each of said control surfaces being operatively connected to and actuated by a respective servomechanism responsive to a control signal provided thereto from a microprocessor;

b) a radio receiver disposed within said airframe adapted to receive a directional control signal from a transmitter located remotely therefrom, said receiver generating a directional control output signal;

c) a microprocessor having a plurality of inputs, at least one of said plurality of inputs being operatively connected to said output of said radio receiver and adapted to receive said directional control output signal therefrom, said microprocessor having a plurality of outputs connected to respective ones of said servomechanisms for providing said control signals thereto;

d) a plurality of sensors for sensing flight conditions of said aircraft and for generating output signals representative of said flight conditions a respective outputs thereof, said outputs each being operatively connected to respective ones of said plurality of microprocessor inputs, said plurality of sensors being disposed proximate said airframe;

wherein said microprocessor, acting upon said output signals from said plurality of sensors, and said directional control signal from said radio receiver provides all control signals required to fly said aircraft to said servomechanisms, and wherein directional control information is received exclusively from said remote location via said radio receiver, and all other information required to fly said aircraft is received exclusively from said plurality of sensors.

8. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **7**, wherein at least one of said plurality of sensors comprises a GPS receiver.

9. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **8**, wherein said GPS receiver is used to sense at least one of the parameters: altitude, position, and time.

10. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **7**, wherein at least one of said plurality of sensors comprises at least of the group: roll sensor, pitch sensor, and yaw sensor.

11. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **10**, wherein at least one of said plurality of sensors comprises an altimeter.

12. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **11**, wherein said altimeter comprises at least one of the group: GPS altimeter, barometric pressure altimeter, laser altimeter, and acoustic altimeter.

13. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **12**, wherein said altimeter comprises redundant altimeter comprising at least two altimeters from the group: GPS altimeter, barometric pressure altimeter, laser altimeter, and acoustic altimeter.

14. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **13**, wherein each of said at least two altimeters comprises a different type of altimeter.

15. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **7**, wherein at least one of said plurality of control surfaces comprises at least of the group: a rudder, a flap, an elevators, and an aileron.

16. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **7**, wherein at least one of said plurality of sensors comprises a flux gate compass.

17. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **7**, wherein at least one of said plurality of sensors comprises a pilot tube velocity sensor.

18. The miniature, unmanned, powered aircraft having remote guidance capability as recited in claim **7**, wherein said aircraft weight no more than fifty-five pounds.

19. A miniature, unmanned, powered aircraft having remote guidance capability, comprising:

a) an airframe comprising an internal combustion engine adapted to provide motive power to said aircraft, a plurality of control surfaces comprising at least one control surface from the group: a rudder, a flap, an elevators, and an aileron, said at least one control surface being adapted to respectively control at least a direction of flight, an attitude, and an altitude of said aircraft, each of said control surfaces being operatively connected to and actuated by a respective servomechanism responsive to a control signal provided thereto from a microprocessor;

b) a radio receiver disposed within said airframe adapted to receive a directional control signal from a transmitter located remotely therefrom, said receiver generating a directional control output signal

c) a microprocessor having a plurality of inputs, at least one of said plurality of inputs being operatively connected to said output of said radio receiver and adapted to receive said direction control output signal therefrom, said microprocessor having a plurality of outputs connected to respective ones of said servomechanisms for providing said control signals thereto;

d) a plurality of sensors comprising at least one of the group: roll sensor, pitch sensor, and yaw sensor, an altimeter, a compass, and a velocity sensor for sensing flight conditions of said aircraft and for generating output signals representative of said flight conditions at respective outputs thereof, said outputs each being operatively connected to respective ones of said plurality of microprocessor inputs, said plurality of sensors being disposed proximate said airframe;

wherein said microprocessor, acting upon said output signals from said plurality of sensors, and said directional control signal from said radio receiver provides all control signals required to fly said aircraft to said servomechanisms, and wherein directional control information is received exclusively from said remote location via said radio receiver, and all other information required to fly said aircraft is received exclusively from said plurality of sensors, said aircraft weighing no more than fifty-five pounds.

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