587731

ISSUE CLASSIFICATION	
Class	Subclass
701	120

[redacted]

5904724

UTILITY SERIAL NUMBER	PATENT DATE	PATENT NUMBER
08/587731	MAY 18 1999	5904724

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
08/587,731	[illegible]	~~340~~ 701	~~439~~ 120	~~3614~~ 3661	NGUYEN, T.

APPLICANTS

JED MARGOLIN, SAN JOSE, CA.

CONTINUING DATA*******************
VERIFIED
TN

FOREIGN/PCT APPLICATIONS**********
VERIFIED
TN

**** SMALL ENTITY ****

Foreign priority claimed 35 USC 119 conditions met	AS FILED	STATE OR COUNTRY	SHEETS DRWGS.	TOTAL CLAIMS	INDEP. CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
☐ yes ☒ no / ☐ yes ☒ no — Verified and Acknowledged: TN (Examiner's initials)	→	CA	7	49	5	$772.00	004995.P004

ADDRESS

BLAKELY, SOKOLOFF, TAYLOR AND ZAFMAN
12400 WILSHIRE BOULEVARD
7TH FLOOR
LOS ANGELES, CA 90025

TITLE

METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

U.S. DEPT. OF COMM./PAT. & TM—PTO-436L (Rev.12-94)

PARTS OF APPLICATION FILED SEPARATELY

Applications Examiner

NOTICE OF ALLOWANCE MAILED	
AUG 24 1998	

Assistant Examiner

ISSUE FEE	
Amount Due	Date Paid
660.00	12-3-98

TAN Q. NGUYEN
PATENT EXAMINER
ART UNIT 3614
Primary Examiner

CLAIMS ALLOWED	
Total Claims	Print Claim
20	1

DRAWING		
Sheets Drwg.	Figs. Drwg.	Print Figs.
7	7	3 and 4

ISSUE BATCH NUMBER: I16

PREPARED FOR ISSUE

Label Area

WARNING: The information disclosed herein may be restricted. Unauthorized disclosure may be prohibited by the United States Code Title 35, Sections 122, 181 and 368. Possession outside the U.S. Patent & Trademark Office is restricted to authorized employees and contractors only.

Form PTO-436A
(Rev. 8/92)

ISSUE FEE IN FILE

(FACE)

08/587731

PATENT APPLICATION

08587731

APPROVED FOR LICENSE ☐

INITIALS _____

CONTENTS

Date Entered or Counted			Date Received or Mailed
	1.	Application _____ papers.	
	2.	Information Disclosure Statement	1-19-96
7-18	3.	rej 3 month	7-23-97
	4.	INTERVIEW SUMMARY	9-12-97
10-5-97	5.	Amdt A	9-11-97
10-14	6.	Letter	10/14/97
10-23	7.	Letter Response	10-21-97
11-21	8.	rej 3mos w/ATT	11-28-97
	9.	IDS	2 March 1998 / Cpm
	10.	Amdt B	2 March 1998 / 2/27
5/4	11.	FINAL Rej 3mo	MAY - 4 1998
	12.	Req for Recon	9 July 1998
7/24	13.	Advisory Action	JUL 24 1998 cpm 8/4/98
8-12-98	14.	Amdt C (DRAFT) Amy	7/24/98
	15.	Access Ack Notice of Allowance	8-21-98
	16.	PTOL-37	AUG 24 1998 8/24
6/1	17.	Suppl 37	12-1-98
	18.	PTO GRANT MAY 18 1999	
	19.		
	20.		
	21.		
	22.		
	23.		
	24.		
	25.		
	26.		
	27.		
	28.		
	29.		
	30.		
	31.		
	32.		

(FRONT)

[redacted]

SEARCHED

Class	Sub.	Date	Exmr.
364	423.099	07/7/97	TN
	424.012		
	424.013		
	424.021		
	424.022		
	449.2		
	449.7		
	460, 439		
	424028		
340	825.69		
	825.72		
	967		
	989		
	991		
	992		
	993		
244	189	07/14/97	TN
	190		
	181		
	17 #13		
	3.11		
	3.15		
update search as above		11/20/97	TN
348	42		
	51		
	113		
	114		
	117		
	123		
	143		
382	154		
395	118, 119		
	125		
update search as above		04/30/98	TN

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.
701	2	08/20/98	TN
	24		
	120		
	213		
244	189		
	190		
348	114		

439

Noted: Class 364/423.099, 424.012, 424028 424.013, 424.021, 424.022, 449.2, 449.7, 460 have been changed to 701/2, 3, 4, 11, 12, 24, 202, 213, 300, 120.

SEARCH NOTES

	Date	Exmr.
Maya search	06/25/97	TN
APS search	07/1297	TN

(FILE 'USPAT' ENTERED AT 13.11.32 ON 12 JUL 1997)

SET PAGE SCROLL

L1 501 S REMOT? (P) PILOT? (P) (?CRAFT OR AERIA?)
L2 337363 S VIDEO OR IMAG? OR CAMERA
L3 169 S L1 AND L2
L4 8893 S FLIGHT AND (POSITION OR LOCAT?) AND (ORIENTA? OR ATTITUDE)
L5 72 S L3 AND L4

APS search	07/14/97	TN

(FILE 'USPAT' ENTERED AT 09.40.55 ON 14 JUL 1997)
L1 762 S UNMANNED AERIAL OR UAV OR REMOT### PILOT### VEHICLE OR R
PV
L2 337363 S VIDEO OR IMAG? OR CAMERA OR PROJECT? (4A) IMAG?
L3 235 S L1 AND L2
L4 1626 S DATA (2A) BASE (P) DIGITAL
L5 77567 S (THREE OR 3) (5A) DIMENSION?
L6 3 S L3 AND L4
L7 48 S L3 AND L5
L8 143 S L3 AND REMOT?
L9 141 S L8 AND (POSITION? OR ORIENT? OR DIRECTION? OR LOCAT?)
L10 1238915 S GROUND? OR BASE?
L11 125 S L9 AND L10
L12

STN search	07/14/97	TN

FILE 'WPIDS' ENTERED AT 15:36 45 ON 14 JUL 1997
L1 89 S UAV OR RPV
L2 402488 S CAMERA OR VIDEO OR IMAG?
L3 6 S L1 AND L2
L4 55179 S AIRCRAFT OR CRAFT OR AERIAL OR AIRBORNE
L5 10 S L1 AND L4

IBEE search	07/15/97	TN

Search Options:
Search for both singular and plurals: YES
Search for spelling variants : YES
Display intermediate result sets : NO

Num	Search	Hits
#1	remot? and pilot? and (aircraft or craft or aeri? or missile)	17

APS search	11/20/97	TN

(FILE 'USPAT' ENTERED AT 09.46:11 ON 20 NOV 1997)
SET PAGELENGTH 99
SET AUHELP NONE
L1 1645 S (?CRAFT OR RPV OR REMOT? PILOT? VEHICLE) AND (THREE DIMEN
L2 82 S L1 AND DISPLAY? AND MAP? AND TERRAI
L3 80 S L2 AND (POSITION OR COORDINAT?) AND (DIRECTION? OR ORIENT?)
L4 0 S (RPV OR REMOT? PILOT? VEHICLE) (P) (THREE DIMENSION? OR 3D)
L5 11 S (RPV OR REMOT? PILOT? VEHICLE OR DRONE) (P) (THREE DIMENSIO
L6 7150 S (THREE DIMENSION? OR 3D) (P) DISPLAY?
L7 740 S RPV OR REMOT? PILOT? VEHICLE OR DRONE
L8 19 S L6 (L) L7

APS search	04/30/98	TN

(FILE 'USPAT' ENTERED AT 15:27:52 ON 30 APR 1998)
L1 1324 S REMOT? (5A) ?CRAFT OR RPV OR REMOT? (3A) PILOT? (3A) VEH
ICL
L2 403 S (CAMERA OR IMAG? OR VIDEO OR CAMCORDER) AND L1
L3 1030874 S (POSITION? OR LOCAT?) AND (ORIENTING OR ORIENTATION OR D
IRE
L4 911 S L1 AND L3
L5 310 S L2 AND L4
L6 9 S L5 AND DIGITAL (5A) (DATA(3A)BASE OR TERRAIN)

(RIGHT OUTSIDE)

Staple Issue Slip Here

POSITION		ID NO.	DATE
CLASSIFIER		55	2/27/96
EXAMINER		WJH	2/28/96
TYPIST		BA	3-1-96
VERIFIER		JH	3-12-96
CORPS CORR.			
SPEC. HAND			
FILE MAINT.			
DRAFTING			

INDEX OF CLAIMS

Claim Final	Claim Original	Date 07/18/97	11/20/97	05/01/98	07/23/98	08/20/98
1	(1)	✓	✓	✓	=	=
2	2					
3	3					
4	4					
5	5					
6	6					
7	7					
8	8			✓		
9	9				=	=
	~~10~~					
	~~11~~					
10	12			✓	=	=
11	13					
13	(14)					
14	15					
15	16					
16	17					
17	18			✓	=	=
	~~19~~					
	~~20~~					
18	21			✓	=	=
19	22				=	=
20	23				=	=
	~~24~~				✓	
	~~25~~					
	26					
	27					
	28					
	29					
	30					
	31					
	(32)					
	33					
	34					
	35					
	36					
	37					
	38					
	(39)	✓				
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47					
	48					
	49					
12	50			✓	=	=

SYMBOLS

✓ ..... Rejected
= ..... Allowed
- (Through numberal) Canceled
+ ..... Restricted
N ..... Non-elected
I ..... Interference
A ..... Appeal
O ..... Objected

Claim Final	Claim Original	Date 05/01/98	07/23/98	08/20/98
	~~51~~	✓	✓	
	~~52~~	✓	✓	
	~~53~~	✓	✓	
	54			
	55			
	56			
	57			
	58			
	59			
	60			
	61			
	62			
	63			
	64			
	65			
	66			
	67			
	68			
	69			
	70			
	71			
	72			
	73			
	74			
	75			
	76			
	77			
	78			
	79			
	80			
	81			
	82			
	83			
	84			
	85			
	86			
	87			
	88			
	89			
	90			
	91			
	92			
	93			
	94			
	95			
	96			
	97			
	98			
	99			
	100			

(LEFT INSIDE)

US005904724A

United States Patent [19]

Margolin

[11] Patent Number: 5,904,724

[45] Date of Patent: May 18, 1999

[54] **METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT**

[76] Inventor: **Jed Margolin**, 3570 Pleasant Echo, San Jose, Calif. 95148

[21] Appl. No.: **08/587,731**

[22] Filed: **Jan. 19, 1996**

[51] **Int. Cl.**[6] **G06F 165/00**; H04N 7/18

[52] **U.S. Cl.** **701/120**; 701/2; 701/24; 244/189; 244/190; 348/114

[58] **Field of Search** 364/423.099, 424.012, 364/424.013, 424.021, 424.022, 449.2, 449.7, 460, 439, 424.028; 340/825.69, 825.72, 967, 989, 991, 992, 993; 244/189, 190, 181, 17.13, 3.11, 3.15; 348/42, 51, 113, 114, 117, 123, 143; 382/154; 395/118, 119, 125

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,742,495	6/1973	Diamantides	342/64
3,795,909	3/1974	Vehrs, Jr.	343/7
4,218,702	8/1980	Brocard et al.	348/144
4,405,943	9/1983	Kanaly	358/133
4,467,429	8/1984	Kendig	343/433
4,660,157	4/1987	Beckwith et al.	345/421
4,739,327	4/1988	Konig et al.	342/26
4,760,396	7/1988	Barney et al.	342/65
4,835,532	5/1989	Fant	382/284
4,855,822	8/1989	Naredra et al.	364/423.099
4,964,598	10/1990	Berejik et al.	244/190
5,015,187	5/1991	Lord	364/462
5,072,396	12/1991	Fitzpatrick et al.	364/450
5,086,396	2/1992	Waruszewski, Jr.	364/454
5,155,683	10/1992	Rahim	364/424.029
5,179,638	1/1993	Dawson et al.	395/125
5,240,207	8/1993	Eiband et al.	364/423.099
5,257,347	10/1993	Busbridge et al.	395/129
5,266,799	11/1993	Steinitz et al.	324/330
5,272,639	12/1993	McGuffin	364/449
5,335,181	8/1994	McGuffin	364/443
5,381,338	1/1995	Wysocki et al.	348/116
5,406,286	4/1995	Tran et al.	342/13
5,446,666	8/1995	Bauer	364/434
5,552,983	9/1996	Thornberg et al	364/424.027
5,581,250	12/1996	Khvilivitzky	340/961

OTHER PUBLICATIONS

Lyons, J W., "Some Navigational Concepts for Remotely Piloted Vehicles", AGARD Conference Proceed, n 176, Med. Accur. Low Cost Navig. at Avion, Panel Tec. Meeting, 5-1-5-15, Sep. 1975.

"US GeoData Digital Line Graphs", U.S. Dept. of the Interior, U.S. Geolg. Surv. Earth Sci. Info Ctr. (Factsheet) Jun. 1993.

"US GeoData Digital Elevation Models", U.S. Dept. of the Interior. U.S. Geolg. Surv. Earth Sci. Info Ctr. (Factsheet) Jun. 1993.

Shifrin, Carole A., "Gripen Likely to Fly Again Soon," *Aviation Week & Space Technology*, Aug. 23, 1993, pp. 72-73.

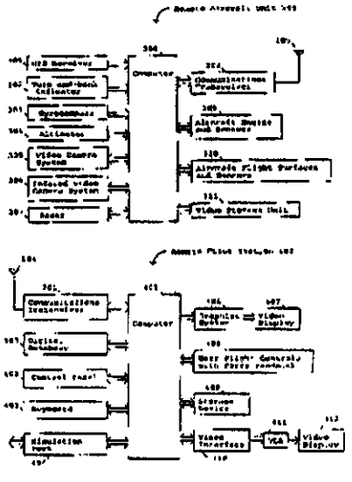
Primary Examiner—Tan Q. Nguyen

Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor and Zafman LLP

[57] **ABSTRACT**

A method and apparatus that allows a remote aircraft to be controlled by a remotely located pilot who is presented with a synthesized three-dimensional projected view representing the environment around the remote aircraft. According to one aspect of the invention, a remote aircraft transmits its three-dimensional position and orientation to a remote pilot station. The remote pilot station applies this information to a digital database containing a three dimensional description of the environment around the remote aircraft to present the remote pilot with a three dimensional projected view of this environment. The remote pilot reacts to this view and interacts with the pilot controls, whose signals are transmitted back to the remote aircraft. In addition, the system compensates for the communications delay between the remote aircraft and the remote pilot station by controlling the sensitivity of the pilot controls.

20 Claims, 7 Drawing Sheets



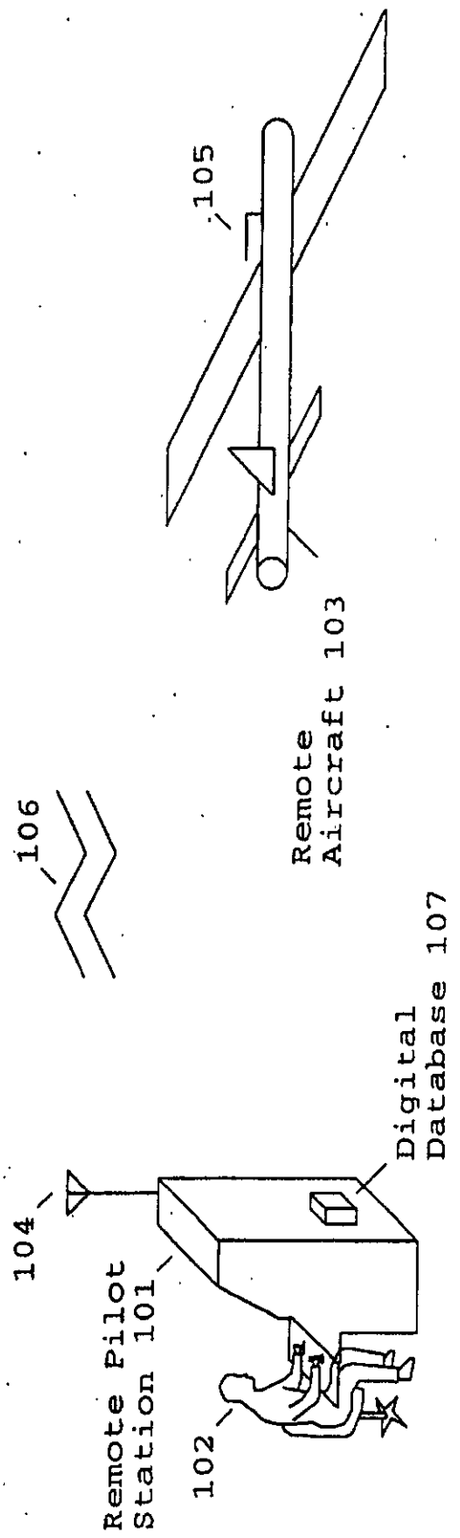

105
Remote Aircraft 103
106
Digital Database 107
104
Remote Pilot Station 101
102

Fig. 1

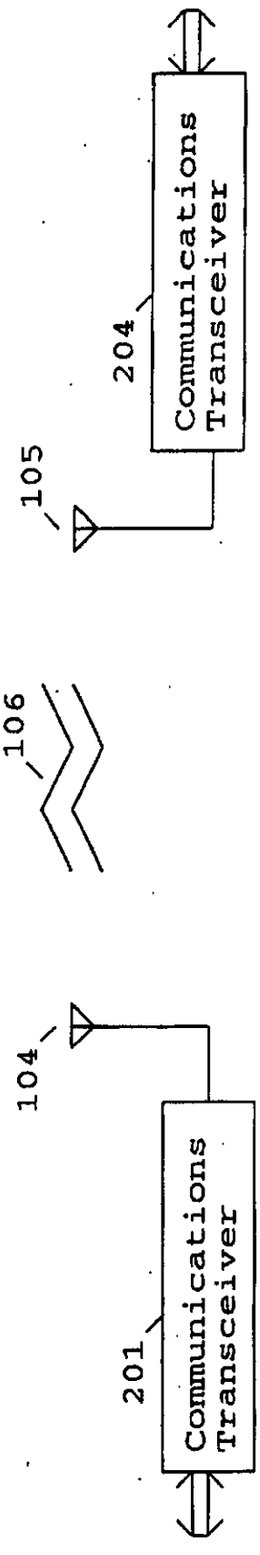

Communications Transceiver
204
105
106
104
Communications Transceiver
201

Fig. 2

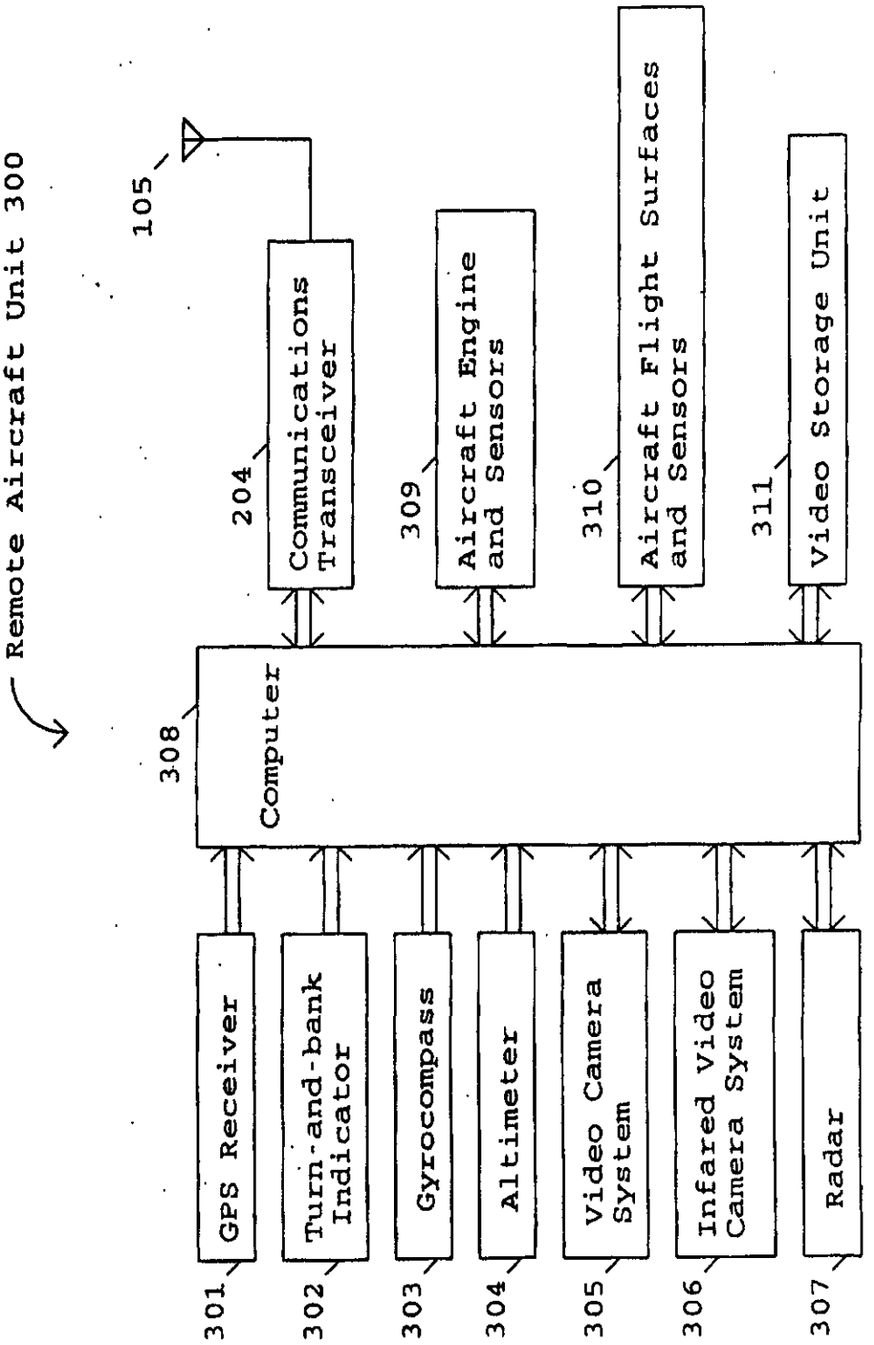

Remote Aircraft Unit 300
105
204
Communications Transceiver
309
Aircraft Engine and Sensors
310
Aircraft Flight Surfaces and Sensors
311
Video Storage Unit
308
Computer
301
GPS Receiver
302
Turn-and-bank Indicator
303
Gyrocompass
304
Altimeter
305
Video Camera System
306
Infared Video Camera System
307
Radar

Fig. 3

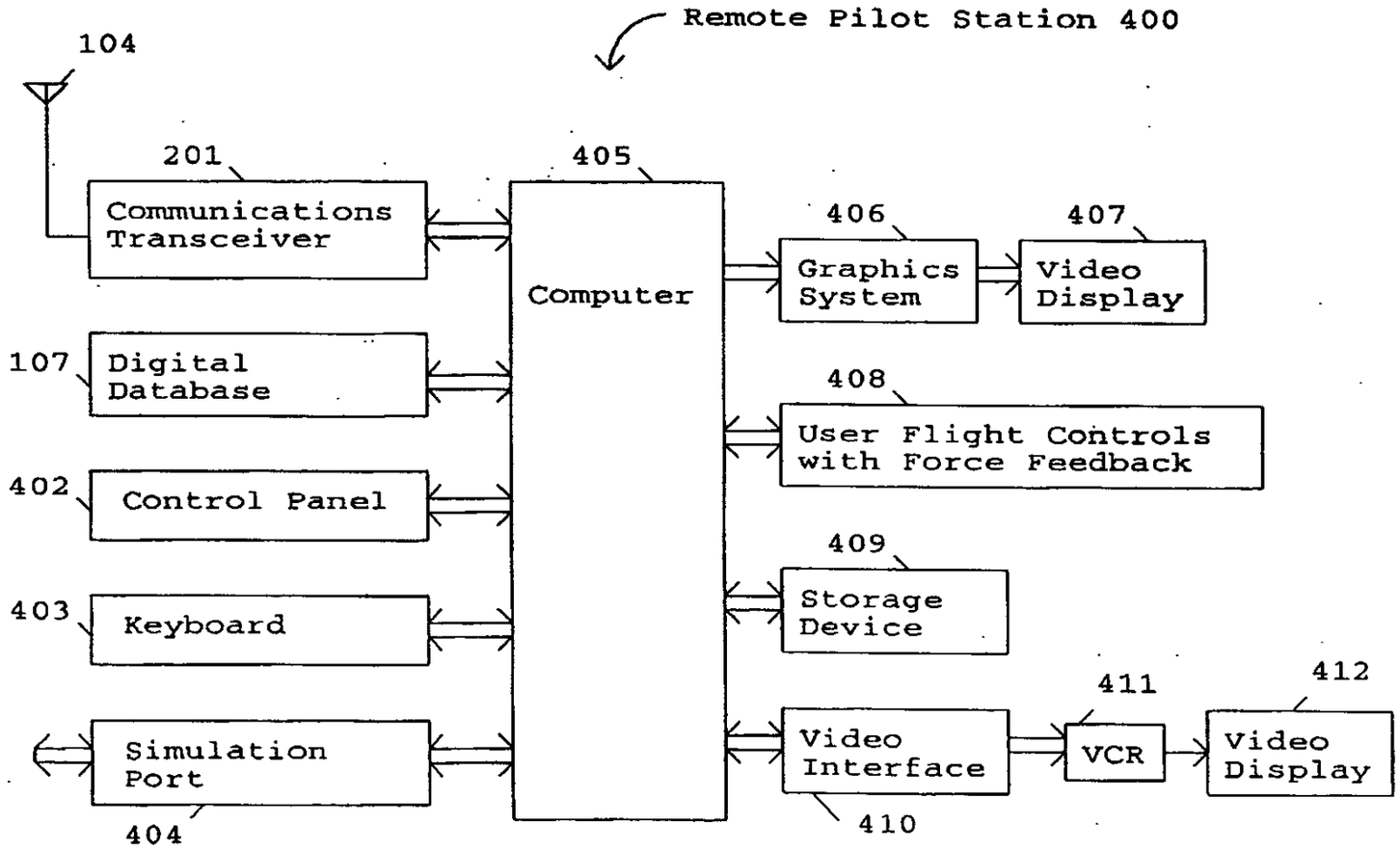

Remote Pilot Station 400
104
201
Communications Transceiver
405
Computer
406
Graphics System
407
Video Display
107
Digital Database
408
User Flight Controls with Force Feedback
402
Control Panel
409
Storage Device
403
Keyboard
411
412
Video Interface
VCR
Video Display
Simulation Port
404
410

Fig. 4

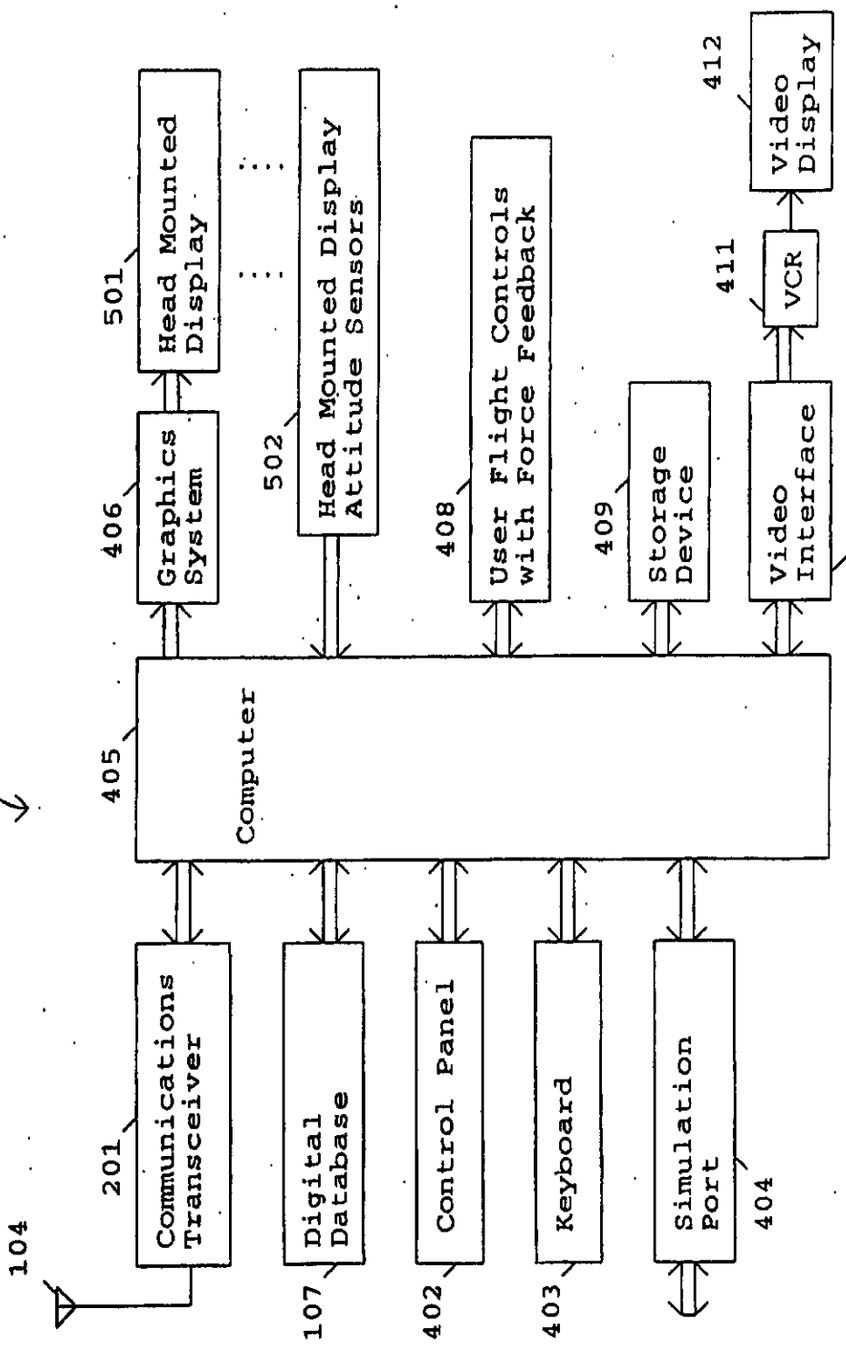

Remote Pilot Station 500
104
201
Communications Transceiver
107
Digital Database
402
Control Panel
403
Keyboard
404
Simulation Port
405
Computer
406
Graphics System
501
Head Mounted Display
502
Head Mounted Display Attitude Sensors
408
User Flight Controls with Force Feedback
409
Storage Device
410
Video Interface
411
VCR
412
Video Display

Fig. 5

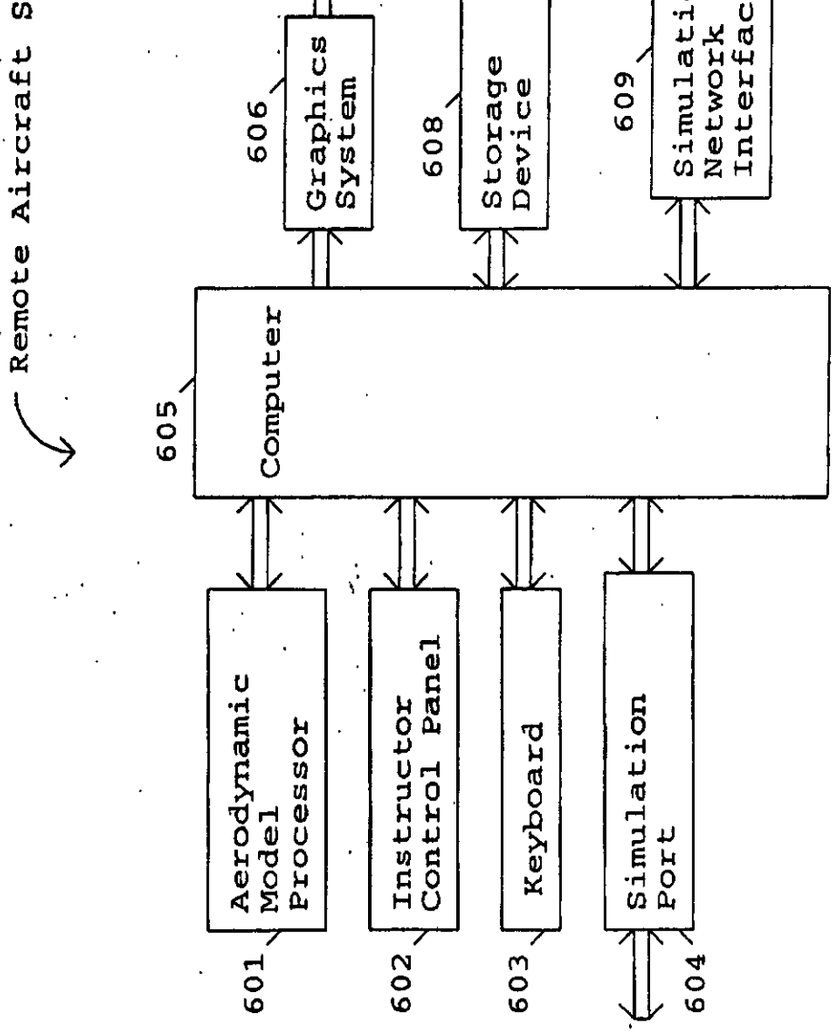

Remote Aircraft Simulator 600
605
Computer
601
Aerodynamic Model Processor
602
Instructor Control Panel
603
Keyboard
604
Simulation Port
606
Graphics System
607
Video Display
608
Storage Device
609
Simulation Network Interface

Fig. 6

Figure 7

METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

BACKGROUND OF THE INVENTION—CROSS REFERENCES TO RELATED APPLICATIONS

"Pilot Aid Using a Synthetic Environment", Ser. No. 08/274,394 filed Jul. 11, 1994. "Digital Map Generator and Display System", Ser. No. 08/543,590, filed Oct. 16, 1995.

1. Field of Invention

This invention relates to the field of remotely piloted vehicles (RPVs) and unmanned aerial vehicles (UAVs).

2. Discussion of Prior Art

RPVs can be used for any number of purposes. For example, there is a large organization that promotes the use of remote controlled planes. Certain RPVs are controlled by viewing the plane with the naked eye and using a hand held controller to control its flight Other RPVs are controlled by a remote pilot using simple joysticks while watching the video produced by a camera in the remote aircraft. This camera is also used to produce the reconnaissance video. There are tradeoffs involving the resolution of the video, the rate at which the video is updated, and the bandwidth needed to transmit it. The wider the bandwidth the more difficult it is to secure the signal. The freedom to balance these tradeoffs is limited because this video is also used to pilot the aircraft and must therefore be updated frequently.

Certain UAVs are preprogrammed to follow a predetermined course and lack the flexibility to deal with unexpected situations.

The 1983 patent to Kanaly (U.S. Pat. No. 4,405,943) shows a control and communications system for a remotely piloted vehicle where an oculometer determines where the remote operator is looking and signals the remote vehicle to send the high resolution imagery corresponding to the area around where the remote operator is looking and low resolution imagery corresponding to the remote operator's peripheral vision. The objective is to minimize the bandwidth of the information transmitted to the remote operator.

SUMMARY

A method and apparatus is described that allows a remote aircraft to be controlled by a remotely located pilot who is presented with a synthesized three-dimensional projected view representing the environment around the remote aircraft According to one aspect of the invention, a system is used that includes an aircraft and a remote pilot station.

The aircraft uses a communications link to send its location, attitude, and other operating conditions to the remote pilot station. The remote pilot station receives the data and uses a database describing the terrain and manmade structures in the remote aircraffs environment to produce a 3D view of the remote aircraft environment and present it to the remote human pilot.

The remote pilot responds to the information and manipulates the remote flight controls, whose positions and forces are transmitted to the remote aircraft. Since the amount of data is small, it can be readily secured through encryption and spreadspectrum techniques.

Also, because the video reconnaissance cameras are no longer needed to remotely pilot the aircraft there is great flexibility in their use. To minimize bandwidth and reduce the possibility of being detected, the video data can be sent at a slow update rate. The data can also be stored on the remote aircraft for later transmission. Alternatively, low resolution pictures can be sent in real-time, while the corresponding high resolution pictures can be at a later time. The reconnaissance video can even be transmitted through a different communications link than the control data. There may also be more than one reconnaissance camera.

The delay in the control link must be minimized in order that the remote aircraft can be properly flown. The system can measure the link delay and make this information available to the pilot. This delay link measurement can also be used to modify the control software through which the remote pilot flies the remote aircraft. This is to prevent pilot-induced-oscillation.

The computers in the system allow for several modes of operation. For example, the remote aircraft can be instructed to fly to given coordinates without further input from the remote pilot. It also makes it possible to provide computer assistance to the remote pilot. In this mode, the remote flight control controls absolute pitch and roll angles instead pitch and roll rates which is the normal mode for aircraft In addition, adverse yaw can be automatically corrected so that the resulting control laws make the remote aircraft extremely easy to fly. Because this comes at the expense of being able to put the remote aircraft into unusual attitudes, for complete control of the remote aircraft a standard control mode is provided to give the remote pilot the same type of control that is used to fly a manned aircraft. Since the remote aircraft is unmanned, the remote pilot can subject the remote aircraft to high-G maneuvers that would not be safe for a pilot present in the aircraft.

To facilitate training, a simulated remote aircraft is provided that allows an instructor to set up the training mission and parameters. This is especially useful in giving remote pilots experience flying with different control link delays. In this simulated mode, the system can be further linked to a battlefield simulator such as SIMNET.

In the first embodiment, the remote pilot is provided with a standard video display. Additional display channels can be provided to give the remote pilot a greater field of view. There can even be a display channel to give a rearward facing view.

A second embodiment uses a head mounted display for the remote pilot instead of a standard display. This permits the remote station to be made more compact so that it can be used in a wider variety of installations. An example would be in a manned aircraft flying several hundred miles away.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may best be understood by referring to the following description and accompanying drawings which illustrate the invention. In the drawings:

FIG. 1 is a general illustration showing a remote pilot at a remote pilot station operating a remote aircraft according to one embodiment of the invention.

FIG. 2 is a block diagram showing the communications link between a remote pilot station and a remote aircraft according to one embodiment of the invention.

FIG. 3 is a block diagram of a remote aircraft according to one embodiment of the invention.

FIG. 4 is a block diagram of a remote pilot station according to one embodiment of the invention.

FIG. 5 is a block diagram of a remote pilot station according to another embodiment of the invention.

FIG. 6 is a block diagram of a remote aircraft simulator used for training remote pilots according to one embodiment of the invention.

FIG. 7 is an example of a three dimensional projected image presented to a remote pilot by a remote pilot station according to one embodiment of the invention.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth to provide a thorough understanding of the invention. However, it is understood that the invention may be practiced without these specific details. In other instances, well-known circuits, structures and techniques have not been shown in detail in order not to obscure the invention.

A method and apparatus is described that allows a remote aircraft to be controlled by a remotely located pilot who is presented with a synthesized three-dimensional projected view representing the environment around the remote aircraft. Since the video from a reconnaissance camera located on the remote aircraft is not used to pilot the remote aircraft, the amount of data transmitted between the remote aircraft and the remote pilot is small. This provides greater flexibility in how the remote aircraft is used and allows the transmitted data to be made more secure. The remote aircraft may be of any type, for example a remote control plane or helicopter as used by recreational enthusiast.

FIG. **1** is a general illustration showing a remote pilot at a remote pilot station operating a remote aircraft according to one embodiment of the invention. FIG. **1** shows Remote Pilot **102** interacting with Remote Pilot Station **101** and controlling Remote Aircraft **103**. Remote Pilot Station **101** and Remote Aircraft **103** respectively include an Antenna **104** and an Antenna **105** for communicating Information **106**.

In one embodiment, Information **106** includes status information concerning the status of Remote Aircraft **103** and flight control information for controlling the flight of Remote Aircraft **103**. The status information is generated by Remote Aircraft **103** and includes the three dimensional position and the orientation (also termed attitude, and comprising heading, roll, pitch) of Remote Aircraft **103**. The status information may also include information concerning the flight surfaces, the engine, an additional altitude reading, etc. Remote Pilot Station **101** uses this status information to retrieve data from a Digital Database **107** which contains a three-dimensional description of terrain and manmade structures over which Remote Aircraft **103** is flying. Based on the three dimensional data retrieved from Digital Database **107**, Remote Pilot Station **101** projects a synthesized three-dimensional projected view of the terrain and manmade structures in the vicinity of Remote Aircraft **103**. Based on this view of the terrain and manmade structures, the Remote Pilot Station **101**, on its own and/or in response to input from Remote Pilot **102**, generates and transmits flight control information to Remote Aircraft **103** which adjusts its flight accordingly.

In one embodiment, the Remote Aircraft **103** is a remote controlled plane or helicopter used for recreational purposes. Since remote controlled planes and helicopters tend to be small in size, the circuitry in such remote aircraft to generate and receive Information **106** is minimized. In such systems, the Remote Pilot Station **101** may be implemented by including additional attachments to an existing portable computer. This allows the user to easily transport the remote aircraft and pilot station to an appropriate location for flight.

FIG. **2** is a block diagram showing a bi-directional communications link between a remote pilot station and a remote aircraft according to one embodiment of the invention. FIG. **2** shows Communications Transceiver **201** coupled to Antenna **104** of Remote Pilot Station **101**, as well as Communications Transceiver **204** coupled to Antenna **105** of Remote Aircraft **103**. In addition, FIG. **2** shows Information **106** being communicated between Antenna **104** and Antenna **105**.

FIG. **3** is a block diagram of a remote aircraft unit used in the remote aircraft according to one embodiment of the invention. FIG. **3** shows Remote Aircraft Unit **300** including Computer **308** coupled to GPS Receiver **301**, Turn-and-bank Indicator **302**, Gyrocompass **303**, Communications Transceiver **204**, Aircraft Engine and Sensors **309**, and Aircraft Flight Surfaces and Sensors **310**. GPS Receiver **301** receives signals from the satellites that make up the global positioning system (GPS) and calculates the aircraft's position in three dimensions. Turn-and-bank Indicator **302** and Gyrocompass **303** provide the aircraft's orientation which comprises heading, roll, and pitch. This data is sent to Computer **308** for transformation into the previously described status information. Computer **308** transmits this status information to Communications Transceiver **204** which produces a radio signal and supplies it to Antenna **105**.

The Aircraft Engine and Sensors **309** are coupled to control the aircraft's engine, while the Aircraft Flight Surfaces and Sensors **310** are coupled to control the aircraft's flight surfaces. The flight control information is received from the remote pilot station by Computer **308** through Antenna **105** and Communications Transceiver **204**. This flight control information is processed by Computer **308** into the necessary signals for transmission to Aircraft Engine and Sensors **309** and Aircraft Flight Surfaces and Sensors **310** to control the aircraft's engine and flight surfaces, respectively. The operation of the aircraft's flight control surfaces will be later described with reference to FIG. **4**.

In order to protect against ECM, the communications link between the Remote Pilot Station **101** and the Remote Aircraft **103** may be secured. While any number of different techniques may be used to secure this link, in one embodiment Computer **308** is implemented to encryptdecrypt the data transmitted and Communications Transceiver **204** is implemented to use spread spectrum techniques.

Computer **308** may optionally be coupled to Altimeter **304**, Video Camera System **305**, Infrared Video Camera System **306**, Radar **307**, and/or Video Storage Unit **311**. Altimeter **304** provides an output of the aircraft's altitude as a safety check in the event GPS Receiver **301** malfunctions. Thus, this additional altitude reading may also be transmitted to Remote Pilot Station **101** as part of the status information.

Video Camera System **305** is controlled by Computer **308** which determines where the camera is pointing as well as focusing and the zoom factor. The video produced by the camera is not used by the remote pilot for flying the remote aircraft, so there is more flexibility in using the video. As a result, any number of techniques can be used for receiving the images captured by Video Camera System **305**. As examples:

1. High resolution, high update images may be sent back in real-time through the Communications Link, when the high bandwidth needed can be tolerated.
2. High resolution, low update images may be sent back in real-time through the Communications Link to reduce the bandwidth.
3. The video may be recorded in Video Storage Unit **311** for later transmission.
4. The video may be transmitted through a separate communications link.
5. There may be multiple video cameras.

Infrared Video Camera System **306** is similar to Video Camera System **305** and has the same operating modes.

Radar **307** in Remote Aircraft **103** may be passive or active. It may scan a particular pattern or it may track a

selected object. Radar **307** may consist of several Radar units. The information from Radar **307** is processed by Computer **308** so that only the desired information is transmitted over the communication link to the Remote Pilot Station **101** for display.

FIG. **4** is a block diagram of a remote pilot station according to one embodiment of the invention. FIG. **4** shows a Remote Pilot Station **400** including a Computer **405** coupled to Communications Transceiver **201**, Digital Database **107**, Graphics System **406**, User Flight Controls with Force Feedback **408**, and a Storage Device **409**. The Storage Device **409** represents one or more mechanisms for storing data. For example, the Storage Device **409** may include read only memory TROM), random access memory (RAM), magnetic disk storage mediums, optical storage mediums, flash memory devices, and/or other machine-readable mediums. Of course, Digital Database **107** may be stored in one or more. machine-readable mediums and/or in Storage Device **409**.

As previously described, Antenna **104** receives the radio signals transmitted by Remote Aircraft **103** representing the status information of Remote Aircraft **103**. These radio signals are transformed by Communications Transceiver **201** and sent to Computer **405**. Communications Transceiver **201** is set to the same mode as Communications Transceiver **204**, so that if, for example, spread spectrum techniques are used, the signal will be transparently received. Computer **405** recovers the data (de-encrypting, if required) so that the data communications from Computer **308** in the Remote Aircraft to Computer **405** in the Remote Pilot Station is transparent. Thus, the bi-directional communications link comprises the combination of Communications Transceiver **201**, Antenna **104**, Antenna **105**, and Communications Transceiver **204**.

As previously described, the status information received by Computer **405** includes the three dimensional position and the orientation of Remote Aircraft **103**. The status information may also include information concerning the flight surfaces, flight sensors, the engine, an additional altitude reading, etc. Computer **405** uses this status information to retrieve data from Digital Database **107** which contains a three-dimensional description of terrain and manmade structures over which Remote Aircraft **103** is flying. The composition and creation of the Digital Database **107** is further described later. Based on the three dimensional data retrieved from Digital Database **107**, Computer **405** performs the mathematical operations to transform and project the three dimensional data to generate video data representing a synthesized three-dimensional projected view of the terrain (and, if desired, manmade structures) in the vicinity or environment of Remote Aircraft **103**. This video data is transmitted to Graphics System **406**, which displays the synthesized three-dimensional projected view on Video Display **407**.

Since the image is generated from the digital database, virtually any image of the environment of the Remote Aircraft **103** can be generated. As examples, the pilot may select the environment to be: 1) a simulated image of what would be seen out of the cockpit of a manned aircraft on a similar flight path; 3) a simulated image of what would be seen when looking in any direction (e.g., backwards, out a side window, etc.); 3) a simulated image of what would be seen if a camera were tailing the remotely piloted aircraft; etc. In addition, the simulated image may be set to any magnification. Thus, the phrase environment of Remote Aircraft **103** is intended to include any image generated with reference to the remote aircraft's position.

The User Flight controls with Force Feedback **408** are used by the remote pilot to input flight path information. The User Flight Controls may be of any number of different types, some of which are further described later herein. The status information received by Computer **405** also includes information received from Aircraft Flight Surfaces and Sensors **310**. This information is used to actuate force feedback circuitry in User Flight Controls With Force Feedback **408**. Remote Pilot **102** observes the synthesized three-dimensional environment displayed on Video Display **407**, feels the forces on User Flight Controls With Force Feedback **408** and moves the controls accordingly. This flight control information is sent through the communications link, to Computer **308**, and is used to control the aircraft flight surfaces in Aircraft Flight Surfaces and Sensors **310**. Remote Pilot **102** also receives data from Aircraft Engine and Sensors **309** through the communications link and is able to send data back to control the engine.

Flight Control

To illustrate the operation of the remote aircraft, a fixed-wing airplane will be described as an example. However, the basic principles apply to other types of aircraft as well. The basic control surfaces of an airplane consist of the ailerons, the horizontal elevators, and the rudder. The ailerons are moved differentially (one up, one down) to rotate the airplane around its roll axis; the horizontal elevators cause the airplane to rotate around its pitch axis; and the rudder causes the airplane to rotate around its yaw axis.

When the ailerons are used to modify the lift characteristics of the wings, one wing creates more lift while the other wing creates less lift. This also changes the drag characteristics of the wings and results in a yaw force that is opposite to the yaw force that results from the tail section causing the airplane to weather-cock into the relative wind. It is this yaw force caused by the airplane weather-cocking into the relative wind that causes a banked airplane to turn. The opposite yaw force produced by using the ailerons is called adverse yaw; the rudder control is used to counteract this force to produce a coordinated turn.

The simplest type of flight control consists of a joystick and a set of rudder pedals. The controls are directly connected to the flight control surfaces. With a joystick, moving the stick left and right moves the ailerons, while moving the stick forward and backward moves the horizontal elevators The rudder is controlled by two foot pedals, one for each foot, that are mounted on a common shaft and hinged in the middle like a seesaw. Pressing one foot pedal forward causes the other foot pedal to move backward and causes the rudder to also move in one direction. Pressing the other foot pedal causes it to move forward and the opposite pedal to move backward and causes the rudder to move in the opposite direction.

An alternative to the joystick is the control yoke which consists of a wheel attached to a shaft that moves in and out of the control housing. Turning the wheel clockwise or counterclockwise moves the ailerons; moving the wheel shaft in and out moves the horizontal elevators. The rudder pedals as the same as those used with a joystick.

In order to aid in a description of remote aircraft operation, it is thought worthwhile to first describe the operation of non-remotely piloted vehicles. Non-remotely piloted vehicles can be operated in one of two ways (also termed as flight control modes); direct control or computer control (also termed as computer mediated).

Direct Control Non-Remotely Piloted Vehicles

When the flight controls are connected directly to the control surfaces the result is a second order system. Using

the joystick as an example, moving the joystick left or right establishes a roll rate. The airplane continues to roll until the joystick is returned to the center position, after which the airplane remains in the bank angle thus established. The foot pedals are used to counteract the adverse yaw as previously described. Moving the joystick forward or backward establishes a pitch rate. The airplane continues to pitch until the joystick is returned to the center position, after which the airplane remains in the pitch angle thus established. Both the roll rate and the pitch rate are subject to the limits of the airplane's design.

Since the joystick is directly connected to the control surfaces, the aerodynamic forces on the control surfaces are transmitted back to the pilot, giving him or her valuable feedback on how the airplane is flying.

The successful operation of the second order system with the pilot in the loop depends on several factors such as the area and placement of the control surfaces, how much the control surfaces move in response to the movement of the pilot controls, and how long the airplane takes to respond to changes of the control surfaces. The total system characteristics also depend on the reaction time of the pilot. If the resulting system is poorly designed it may be unstable, which means it may not be possible for a human pilot to fly it safely. An example of an unstable system is where the pilot desires to perform a gentle roll to the right and so moves the joystick to the right, the airplane's roll rate is faster than the pilot desires so he/she attempts to compensate by moving the joystick to the left, the airplane rolls left at a rate that is faster than the pilot desires so he/she moves the joystick to the right, and so on, with the pilot constantly overcorrecting and with the aircraft's rolling motions constantly getting larger and larger until the aircraft gets into a condition from which it may not be possible to recover, (e.g., spinning into the ground). The type of loss of control described is usually referred to as 'pilot induced oscillation' and although it may be caused by an inexperienced or inattentive pilot, it is more often caused by poor airplane design. Therefore, new airplane designs are extensively tested to make sure they can be safely flown. Examples of airplanes that use direct control of the control surfaces (Direct Control Second Order Systems) are the Cessna 150 and the Piper Cub.

Computer Mediated Non-Remotely Piloted Vehicles

Computer mediated control systems use a computer between the pilot controls and the control surfaces. The pilot controls are read by the computer, the data are modified in a particular way, and the computer sends control signals to the control surfaces. The computer may also sense the forces on the control surface and use it to control force feedback to the pilot controls. This type of computer mediated control may be used to fly an airplane that would otherwise be unstable, such as the F16 or the F117. Aircraft such as the F16 and F117 are also second order systems because the position of the pilot's joystick represents rate of rotation.

There are risks inherent in a computer mediated system. Although the program can be simulated extensively before using it in an actual airplane, the computer program may be quite large and therefore difficult to simulate under all possible conditions. An example of this is the Swedish JAS 39 Gripen Fighter. Despite extensive simulation of the flight control system, during a test flight a Gripen crashed due to "... the flight control system's high amplification of stick commands combined with the pilot's" large, rapid stick movements"." The pilot had entered a low-speed high-banked turn at a 280 meter altitude with lit afterburners and was leaving the turn when his actions led to 'pilot-induced oscillation'. (Aviation Week & Space Technology, Aug. 23, 1993, pages 72–73).

Having described techniques for operating non-remotely piloted vehicles, the Fight Control Modes for RPVs will be described.

Second Order RPV Flight Control Mode

A second order control system for an RPV is inherently computer mediated because the remote pilot must interact through two computers: the computer in the remote aircraft and the computer in the remote pilot station.

Flying an RPV is further complicated because there are additional time delays in the loop. The computer in the remote aircraft must first determine the aircraft's position and orientation. The additional processing for transmitting a secure signal by encryption and/or spread spectrum techniques may create additional delays. Transmission delay of signals between the remote aircraft and remote pilot station is negligible for a direct path. However, if the signals are relayed through other facilities the delay time may be appreciable, especially if an orbiting satellite is used There are additional delays in the remote pilot station as the remote aircraft's position and orientation are used to transform the data from the digital database to present the pilot with the synthesized 3D projected view from the remote aircraft. In one embodiment, the RPV system measures the various delays and modifies the control laws used by the computer in the remote pilot aircraft and in the feedback provided by the computer in the remote pilot station to the remote pilot. For example, the computer may adjust the sensitivity of the User Flight Controls **408** according to the delay (e.g., as the delay increases, the computer will decrease the sensitivity of the flight controls). The system also displays the measured delay to the remote pilot.

First Order RPV Flight Control Mode

The stability of the flight control system, and thus the flyability of an RPV, can be improved considerably by using a first order system. In one embodiment of such a first order system the position of the remote pilot's joystick represents an angle relative to the horizon, instead of representing a rate of rotation as in a second order system. The position of the joystick is transmitted to the computer in the remote aircraft which moves the control surfaces as required to place the remote aircraft in the requested orientation The control system in the remote aircraft is still a second order system but the delays in the communications link and the remote pilot station are no longer a part of the system's loop.

When a joystick is centered, the remote aircraft will fly straight and level. When the joystick is to the right of center the remote aircraft will be in a right banked turn. When the joystick is to the left of center the remote aircraft will be in a left banked turn. When the joystick is backward from center the remote aircraft will be in a pitch up orientation. When the joystick is forward of center the remote aircraft will be in a pitch down orientation.

The amount of bank and pitch permitted depends on the design of the remote aircraft. A high performance remote aircraft will be capable of a greater amount of pitch and bank than will a low performance remote aircraft.

Referring again to FIG. 4, Computer **405** may optionally be coupled to Control Panel **402**, Keyboard **403**, Simulation Port **404**, Video Interface **410**, VCR **411**, and/or Video Display **412**. In one embodiment, Control Panel **402** con-

tains specialized lights, displays, and switches to allow a quicker response to situations than can be provided by Keyboard **403**. Control Panel **402** can be arranged to approximate the look and feel of an actual aircraft cockpit. Keyboard **403** allows the remote pilot to select various operating modes. For training purposes, Simulation Port **404** allows the remote pilot station to be connected to a remote aircraft simulator instead of an actual remote aircraft. The remote aircraft simulator will be further described with reference to FIG. **6**. Storage Device **409** allows the flight data to be recorded. During playback this previously recorded data is substituted for real-time data from the remote aircraft to replay the mission for analysis. Any video received from any reconnaissance cameras on the Remote Aircraft **103** is converted by Video Interface **410** so that it can be recorded on VCR **411** and displayed on Video Display **412**. VCR **411** can also operate in straight-through mode so that the reconnaissance video can be viewed in real time.

FIG. **5** is a block diagram of a remote pilot station according to another embodiment of the invention. FIG. **5** shows Remote Pilot Station **500**. Remote Pilot Station **500** is similar to Remote Pilot Station **400** of FIG. **4**, except Video Display **407** is replaced by Head Mounted Display **501**. In addition, Head Mounted Display Attitude Sensors **502** are coupled to Computer **405**. Head Mounted Display Attitude Sensors **502** measure the attitude of Head Mounted Display **501**. This information is used by Computer **405** to produce an additional three dimensional transformation of the data from Digital Database **107** to account for the attitude of the remote pilots Head Mounted Display **501**. This does not require any additional data from the remote aircraft. Of course, alternative embodiments could include both a video display and a head mounted display.

FIG. **6** is a block diagram of a simulated remote aircraft used for training remote pilots according to one embodiment of the invention. FIG. **6** shows Remote Aircraft Simulator **600** including Computer **605** coupled to Aerodynamic Model Processor **601**, Instructor Control Panel **602**, Keyboard **603**, Simulation Port **604**, Graphics System **606**, Storage Device **608**, and Simulation Network Interface **609**. Remote Aircraft Simulator **600** communicates with Remote Pilot Station **400** or **500** through Simulation Port **604**. Aerodynamic Model Processor **601** executes a mathematical model that simulates the behavior of a remote aircraft. An instructor uses Instructor Control Panel **602** and Keyboard **603** to select various training scenarios. Graphics System **606** and Video Display **607** are used to observe the operation of the system. Storage Device **608** is used to record the training session for later evaluation of the session. In addition to proficiency training, the Remote Aircraft Simulator can also be used to practice a proposed mission. The data communicated to the remote pilot station can include training and evaluation data for processing and/or display. This training and evaluation data can include any relevant information, such as flight path accuracy, etc.

Simulation Network Interface **609** permits participation in a battlefield simulation system such as SIMNET, mixing aircraft, tanks, and ground troops for training in the coordination of mixed forces. Thus, the system is designed to allow for the communication of this battlefield simulation information between the remote aircraft simulator and the remote pilot station. This allows the remote pilot station to display one or more other simulated entities (e.g., tanks, ground troops, other aircraft, etc.) described by the battlefield simulation information.

The Database

The Digital Database **107** can be comprised of any type of data from which a three dimensional image can be generated. For example, the U.S. Geological Survey (USGS) makes available various databases, two of which are of particular interest The first is the Digital Elevation Model data which consist of an array of regularly spaced terrain elevations.

The other USGS database is the Digital Line Graph data which includes: political and administrative boundaries; hydrography consisting of all flowing water, standing water, and wetlands; major transportation systems consisting of roads and trails, railroads, pipelines, transmission lines, and airports; and significant manmade structures. The Digital Line Graph data is two-dimensional. In the present invention features such as water, roads, railroads, and pipelines are represented as polygons with elevations determined from the Digital Elevation Model data. Transmission lines and significant manmade structures are defined as three-dimensional objects made of polygons and are placed according to the elevations determined from the Digital Elevation Model data. The different types of objects are tagged so that the remote pilot can select them to be highlighted by category or by specific object.

Data from additional digital databases can also be incorporated. An example of such a database is from Jeppesen Sanderson whose NavData Services division provides aeronautical charts and makes this information available in digital form.

The procedure for generating the synthesized three-dimensional view from the Digital Database may use any number of techniques, including those disclosed in the 1987 patent to Beckwith et al. (U.S. Pat. No 4,660,157 REAL TIME VIDEO PERSPECTIVE DIGITAL MAP DISPLAY METHOD), and the 1993 patent to Dawson et al. (U S Pat No. 5,179,638 METHOD AND APPARATUS FOR GENERATING A TEXTURE MAPPED PERSPECTIVE VIEW). One disadvantage of generating the synthesized three-dimensional view from these elevation databases in real time is the amount of storage space they require. To avoid this large amount of data storage, one embodiment of Digital Database **107** is composed of terrain data that represents the real terrain using polygons. This database may be generated using any number of techniques. For example, this database may be generated by transforming one or more elevation databases into a polygon database using the technique taught in "Pilot Aid Using a Synthetic Environment", Ser. No. 08/274,394 filed Jul. 11, 1994. Another method for transforming one or more elevation databases into a polygon database is taught in "Digital Map Generator and Display System", Ser. No. 08/543,590, filed Oct. 16, 1995. An example of a three dimensional projected image created from this database is shown in FIG. **7**.

While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The method and apparatus of the invention can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative instead of limiting on the invention.

What is claimed is:

1. A system comprising:

a remotely piloted aircraft including,

a position determining system to locate said remotely piloted aircraft's position in three dimensions, and

an orientation determining system for determining said remotely piloted aircraft's orientation in three dimensional space;

a communications system for communicating flight data between a computer and said remotely piloted aircraft,

said flight data including said remotely piloted aircraft's position and orientation, said flight data also including flight control information for controlling said remotely piloted aircraft;

a digital database comprising terrain data;

said computer to access said terrain data according to said remotely piloted aircraft's position and to transform said terrain data to provide three dimensional projected image data according to said remotely piloted aircraft's orientation;

a display for displaying said three dimensional projected image data; and

a set of one or more remote flight controls coupled to said computer for inputting said flight control information, wherein said computer is also for determining a delay time for communicating said flight data between said computer and said remotely piloted aircraft, and wherein said computer adjusts the sensitivity of said set of one or more remote flight controls based on said delay time.

2. The system of claim 1, wherein:

said remotely piloted aircraft includes a device for capturing image data; and

said system operates in at least a first mode in which said image data is not transmitted from said remotely piloted aircraft to said computer at a sufficient data rate to allow for real time piloting of the remotely piloted aircraft.

3. The system of claim 1, wherein the flight data communicated between said remotely piloted aircraft and said computer is secured.

4. The system of claim 1, wherein said remotely piloted aircraft further comprises a set of one or more video cameras.

5. The system of claim 4, wherein said communications system is also for communicating video data representing images captured by said set of one or more video cameras, said video data for displaying said images.

6. The system of claim 5, wherein said video data is transmitted on a different communication link than said flight data.

7. The system of claim 4, wherein at least one camera in said set of one or more video cameras is an infrared camera.

8. The system of claim 1, wherein said display is a head mounted display.

9. The system of claim 1, wherein said set of one or more remote flight controls is responsive to manual manipulations.

10. The system of claim 1, wherein said set of one or more remote flight controls allows for inputting absolute pitch and roll angles instead of pitch and roll rates.

11. The system of claim 1, wherein said computer is also used for correcting adverse yaw without requiring input from said set of one or more remote flight controls.

12. The system of claim 1, wherein:

said remotely piloted aircraft includes a device for capturing image data; and said system operates in at least a first mode in which said image data is not transmitted from said remotely piloted craft to said computer but stored in said remotely piloted aircraft.

13. A station for flying a remotely piloted aircraft that is real or simulated comprising:

a database comprising terrain data;

a set of remote flight controls for inputting flight control information;

a computer having a communications unit configured to receive status information identifying said remotely piloted aircraft's position and orientation in three dimensional space, said computer configured to access said terrain data according to said status information and configured to transform said terrain data to provide three dimensional projected image data representing said remotely piloted aircraft's environment, said computer coupled to said set of remote flight controls and said communications unit for transmitting said flight control information to control said remotely piloted aircraft, said computer also to determine a delay time for communicating said flight control information between said computer and said remotely piloted aircraft, and said computer to adjust the sensitivity of said set of remote flight controls based on said delay time; and

a display configured to display said three dimensional projected image data.

14. The station of claim 13, wherein said communications unit is also configured to receive video data representing images captured by a set of video cameras on said remotely piloted aircraft, said video data for displaying said images.

15. The station of claim 14, wherein said video data is transmitted on a different communication link that said flight control information and said status information.

16. The station of claim 13, wherein said display is a head mounted display.

17. The station of claim 13, wherein said set of remote flight controls is responsive to manual manipulations

18. The station of claim 13, wherein said set of remote flight controls are configured to allow inputting absolute pitch and roll angles instead of pitch and roll rates.

19. The station of claim 13, wherein said computer is also configured to correct adverse yaw without requiring input from said set of remote flight controls.

20. The station of claim 13, wherein said communications unit includes at least one of a communications transceiver and a simulation port.

* * * * *

PATENT APPLICATION SERIAL NO. 08/587731

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

280 JS 02/09/96 08587731 1 201 772.00 CK

PTO-1556
(5/87)

BAR CODE LABEL

U.S. PATENT APPLICATION

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT
08/587,731	01/19/96	364	2304

INVENTOR:

JED MARGOLIN, SAN JOSE, CA.

CONTINUING DATA********
VERIFIED

_____

FOREIGN/PCT. APPLICATIONS********
VERIFIED

_____

STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS	FILING FEE RECEIVED	ATTORNEY DOCKET NO.
CA	7	49	5	$772.00	002055.P004

ADDRESS:

BLAKELY SOKOLOFF TAYLOR AND ZAFMAN
12400 WILSHIRE BOULEVARD
7TH FLOOR
LOS ANGELES CA 90025

TITLE:

METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

This is to certify that annexed hereto is a true copy from the records of the United States Patent and Trademark Office of the application which is identified above.

By authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

Date Certifying Officer

2055.P004 Patent

UNITED STATES PATENT APPLICATION

FOR

A METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

INVENTORS:

JED MARGOLIN

PREPARED BY:

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN
12400 WILSHIRE BOULEVARD
SEVENTH FLOOR
LOS ANGELES, CA 90025-1026

(408) 720-8598

EXPRESS MAIL CERTIFICATE OF MAILING

"Express Mail" mailing label number EM281965992US

Date of Deposit January 19, 1996

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Dulce G. Stinson
(Typed or printed name of person mailing paper or fee)

Dulce G. Stinson
(Signature of person mailing paper or fee)

08/587731

ABSTRACT OF THE DISCLOSURE

A method and apparatus that allows a remote aircraft to be controlled by a remotely located pilot who is presented with a synthesized three-dimensional projected view representing the environment around the remote aircraft. According to one aspect of the invention, a remote aircraft transmits its three-dimensional position and orientation to a remote pilot station. The remote pilot station applies this information to a digital database containing a three dimensional description of the environment around the remote aircraft to present the remote pilot with a three dimensional projected view of this environment. The remote pilot reacts to this view and interacts with the pilot controls, whose signals are transmitted back to the remote aircraft. In addition, the system compensates for the communications delay between the remote aircraft and the remote pilot station by controlling the sensitivity of the pilot controls.

A METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

BACKGROUND OF THE INVENTION - Cross References to Related Applications

"Pilot Aid Using a Synthetic Environment", serial no. 08/274,394 filed July 11, 1994. "Digital Map Generator and Display System", serial no. 08/543,590 , filed October 16, 1995.

BACKGROUND OF THE INVENTION - Field of Invention

This invention relates to the field of remotely piloted vehicles (RPVs) and unmanned aerial vehicles (UAVs).

BACKGROUND OF THE INVENTION - Discussion of Prior Art

RPVs can be used for any number of purposes. For example, there is a large organization that promotes the use of remote controlled planes. Certain RPVs are controlled by viewing the plane with the naked eye and using a hand held controller to control its flight. Other RPVs are controlled by a remote pilot using simple joysticks while watching the video produced by a camera in the remote aircraft. This camera is also used to produce the reconnaissance video. There are tradeoffs involving the resolution of the video, the rate at which the video is updated, and the bandwidth needed to transmit it. The wider the bandwidth the more difficult it is to secure the signal. The freedom to balance these tradeoffs is limited because this video is also used to pilot the aircraft and must therefore be updated frequently.

Certain UAVs are preprogrammed to follow a predetermined course and lack the flexibility to deal with unexpected situations.

The 1983 patent to Kanaly (U.S. Patent No. 4,405,943) shows a control and communications system for a remotely piloted vehicle where an oculometer determines where the remote operator is looking and signals the remote vehicle to send the high resolution imagery corresponding to the area around where the remote operator is looking and low resolution imagery corresponding to the remote operator's peripheral vision. The objective is to minimize the bandwidth of the information transmitted to the remote operator.

SUMMARY

A method and apparatus is described that allows a remote aircraft to be controlled by a remotely located pilot who is presented with a synthesized three-dimensional projected view representing the environment around the remote aircraft. According to one aspect of the invention, a system is used that includes an aircraft and a remote pilot station.

The aircraft uses a communications link to send its location, attitude, and other operating conditions to the remote pilot station. The remote pilot station receives the data and uses a database describing the terrain and manmade structures in the remote aircraft's environment to produce a 3D view of the remote aircraft's environment and present it to the remote human pilot.

The remote pilot responds to the information and manipulates the remote flight controls, whose positions and forces are transmitted to the remote aircraft. Since the amount of data is small, it can be readily secured through encryption and spread-spectrum techniques.

Also, because the video reconnaissance cameras are no longer needed to remotely pilot the aircraft there is great flexibility in their use. To minimize bandwidth and reduce the possibility of being detected, the video data can be sent at a slow update rate. The data can also be stored on the remote aircraft for later transmission. Alternatively, low resolution pictures can be sent in real-time, while the corresponding high resolution pictures can be at a later time. The reconnaissance video can even be transmitted through a different communications link than the control data. There may also be more than one reconnaissance camera.

The delay in the control link must be minimized in order that the remote aircraft can be properly flown. The system can measure the link delay and make this information available to the pilot. This delay link measurement can also be used to modify the control software through which the remote pilot flies the remote aircraft. This is to prevent pilot-induced-oscillation.

The computers in the system allow for several modes of operation. For example, the remote aircraft can be instructed to fly to given coordinates without further input from the remote pilot. It also makes it possible to provide computer assistance to the remote pilot. In this mode, the remote flight control controls absolute pitch and roll angles instead pitch and roll rates which is the normal mode for aircraft. In addition, adverse yaw can be automatically corrected so that the resulting control laws make the remote aircraft extremely easy to fly. Because this comes at the expense of being able to put the remote aircraft into unusual attitudes, for complete control of the remote aircraft a standard control mode is provided to give the remote pilot the same type of control that is used to fly a manned aircraft. Since the remote aircraft is unmanned, the remote pilot can subject the remote aircraft to high-G maneuvers that would not be safe for a pilot present in the aircraft.

To facilitate training, a simulated remote aircraft is provided that allows an instructor to set up the training mission and parameters. This is especially useful in giving remote pilots experience flying with different control link delays. In this simulated mode, the system can be further linked to a battlefield simulator such as SIMNET.

In the first embodiment, the remote pilot is provided with a standard video display. Additional display channels can be provided to give the remote pilot a greater field of view. There can even be a display channel to give a rearward facing view.

A second embodiment uses a head mounted display for the remote pilot instead of a standard display. This permits the remote station to be made more compact so that it can be used in a wider variety of installations. An example would be in a manned aircraft flying several hundred miles away.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may best be understood by referring to the following description and accompanying drawings which illustrate the invention. In the drawings:

FIG. 1 is a general illustration showing a remote pilot at a remote pilot station operating a remote aircraft according to one embodiment of the invention.

FIG. 2 is a block diagram showing the communications link between a remote pilot station and a remote aircraft according to one embodiment of the invention.

FIG. 3 is a block diagram of a remote aircraft according to one embodiment of the invention.

FIG. 4 is a block diagram of a remote pilot station according to one embodiment of the invention.

FIG. 5 is a block diagram of a remote pilot station according to another embodiment of the invention.

FIG. 6 is a block diagram of a remote aircraft simulator used for training remote pilots according to one embodiment of the invention.

FIG. 7 is an example of a three dimensional projected image presented to a remote pilot by a remote pilot station according to one embodiment of the invention.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth to provide a thorough understanding of the invention. However, it is understood that the invention may be practiced without these specific details. In other instances, well-known circuits, structures and techniques have not been shown in detail in order not to obscure the invention.

A method and apparatus is described that allows a remote aircraft to be controlled by a remotely located pilot who is presented with a synthesized three-dimensional projected view representing the environment around the remote aircraft. Since the video from a reconnaissance camera located on the remote aircraft is not used to pilot the remote aircraft, the amount of data transmitted between the remote aircraft and the remote pilot is small. This provides greater flexibility in how the remote aircraft is used and allows the transmitted data to be made more secure. The remote aircraft may be of any type, for example a remote control plane or helicopter as used by recreational enthusiast.

FIG. 1 is a general illustration showing a remote pilot at a remote pilot station operating a remote aircraft according to one embodiment of the invention. FIG. 1 shows Remote Pilot 102 interacting with Remote Pilot Station 101 and controlling Remote Aircraft 103. Remote Pilot Station 101 and Remote Aircraft 103 respectively include an Antenna 104 and an Antenna 105 for communicating Information 106.

In one embodiment, Information 106 includes status information concerning the status of Remote Aircraft 103 and flight control information for controlling the flight of Remote Aircraft 103. The status information is generated by Remote Aircraft

103 and includes the three dimensional position and the orientation (also termed attitude, and comprising heading, roll, pitch) of Remote Aircraft 103. The status information may also include information concerning the flight surfaces, the engine, an additional altitude reading, etc. Remote Pilot Station 101 uses this status information to retrieve data from a Digital Database 107 which contains a three-dimensional description of terrain and manmade structures over which Remote Aircraft 103 is flying. Based on the three dimensional data retrieved from Digital Database 107, Remote Pilot Station 101 projects a synthesized three-dimensional projected view of the terrain and manmade structures in the vicinity of Remote Aircraft 103. Based on this view of the terrain and manmade structures, the Remote Pilot Station 101, on its own and/or in response to input from Remote Pilot 102, generates and transmits flight control information to Remote Aircraft 103 which adjusts its flight accordingly.

In one embodiment, the Remote Aircraft 103 is a remote controlled plane or helicopter used for recreational purposes. Since remote controlled planes and helicopters tend to be small in size, the circuitry in such remote aircraft to generate and receive Information 106 is minimized. In such systems, the Remote Pilot Station 101 may be implemented by including additional attachments to an existing portable computer. This allows the user to easily transport the remote aircraft and pilot station to an appropriate location for flight.

FIG. 2 is a block diagram showing a bi-directional communications link between a remote pilot station and a remote aircraft according to one embodiment of the invention. FIG. 2 shows Communications Transceiver 201 coupled to Antenna

104 of Remote Pilot Station 101, as well as Communications Transceiver 204 coupled to Antenna 105 of Remote Aircraft 103. In addition, FIG. 2 shows Information 106 being communicated between Antenna 104 and Antenna 105.

FIG. 3 is a block diagram of a remote aircraft unit used in the remote aircraft according to one embodiment of the invention. FIG. 3 shows Remote Aircraft Unit 300 including Computer 308 coupled to GPS Receiver 301, Turn-and-bank Indicator 302, Gyrocompass 303, Communications Transceiver 204, Aircraft Engine and Sensors 309, and Aircraft Flight Surfaces and Sensors 310. GPS Receiver 301 receives signals from the satellites that make up the global positioning system (GPS) and calculates the aircraft's position in three dimensions. Turn-and-bank Indicator 302 and Gyrocompass 303 provide the aircraft's orientation which comprises heading, roll, and pitch. This data is sent to Computer 308 for transformation into the previously described status information. Computer 308 transmits this status information to Communications Transceiver 204 which produces a radio signal and supplies it to Antenna 105.

The Aircraft Engine and Sensors 309 are coupled to control the aircraft's engine, while the Aircraft Flight Surfaces and Sensors 310 are coupled to control the aircraft's flight surfaces. The flight control information is received from the remote pilot station by Computer 308 through Antenna 105 and Communications Transceiver 204. This flight control information is processed by Computer 308 into the necessary signals for transmission to Aircraft Engine and Sensors 309 and Aircraft Flight Surfaces and Sensors 310 to control the aircraft's engine and flight surfaces,

respectively. The operation of the aircraft's flight control surfaces will be later described with reference to FIG. 4.

In order to protect against ECM, the communications link between the Remote Pilot Station 101 and the Remote Aircraft 103 may be secured. While any number of different techniques may be used to secure this link, in one embodiment Computer 308 is implemented to encrypt/decrypt the data transmitted and Communications Transceiver 204 is implemented to use spread spectrum techniques.

Computer 308 may optionally be coupled to Altimeter 304, Video Camera System 305, Infrared Video Camera System 306, Radar 307, and/or Video Storage Unit 311. Altimeter 304 provides an output of the aircraft's altitude as a safety check in the event GPS Receiver 301 malfunctions. Thus, this additional altitude reading may also be transmitted to Remote Pilot Station 101 as part of the status information.

Video Camera System 305 is controlled by Computer 308 which determines where the camera is pointing as well as focusing and the zoom factor. The video produced by the camera is not used by the remote pilot for flying the remote aircraft, so there is more flexibility in using the video. As a result, any number of techniques can be used for receiving the images captured by Video Camera System 305. As examples:

1. High resolution, high update images may be sent back in real-time through the Communications Link, when the high bandwidth needed can be tolerated.

2. High resolution, low update images may be sent back in real-time through the Communications Link to reduce the bandwidth.

3. The video may be recorded in Video Storage Unit 311 for later transmission.

4. The video may be transmitted through a separate communications link.

5. There may be multiple video cameras.

Infrared Video Camera System 306 is similar to Video Camera System 305 and has the same operating modes.

Radar 307 in Remote Aircraft 103 may be passive or active. It may scan a particular pattern or it may track a selected object. Radar 307 may consist of several Radar units. The information from Radar 307 is processed by Computer 308 so that only the desired information is transmitted over the communication link to the Remote Pilot Station 101 for display.

FIG. 4 is a block diagram of a remote pilot station according to one embodiment of the invention. FIG. 4 shows a Remote Pilot Station 400 including a Computer 405 coupled to Communications Transceiver 201, Digital Database 107, Graphics System 406, User Flight Controls with Force Feedback 408, and a Storage Device 409. The Storage Device 409 represents one or more mechanisms for storing data. For example, the Storage Device 409 may include read only memory (ROM), random access memory (RAM), magnetic disk storage mediums, optical storage mediums, flash memory devices, and/or other machine-readable mediums. Of course, Digital Database 107 may be stored in one or more machine-readable mediums and/or in Storage Device 409.

As previously described, Antenna 104 receives the radio signals transmitted by Remote Aircraft 103 representing the status information of Remote Aircraft 103.

These radio signals are transformed by Communications Transceiver 201 and sent to Computer 405. Communications Transceiver 201 is set to the same mode as Communications Transceiver 204, so that if, for example, spread spectrum techniques are used, the signal will be transparently received. Computer 405 recovers the data (de-encrypting, if required) so that the data communications from Computer 308 in the Remote Aircraft to Computer 405 in the Remote Pilot Station is transparent. Thus, the bi-directional communications link comprises the combination of Communications Transceiver 201, Antenna 104, Antenna 105, and Communications Transceiver 204.

As previously described, the status information received by Computer 405 includes the three dimensional position and the orientation of Remote Aircraft 103. The status information may also include information concerning the flight surfaces, flight sensors, the engine, an additional altitude reading, etc. Computer 405 uses this status information to retrieve data from Digital Database 107 which contains a three-dimensional description of terrain and manmade structures over which Remote Aircraft 103 is flying. The composition and creation of the Digital Database 107 is further described later. Based on the three dimensional data retrieved from Digital Database 107, Computer 405 performs the mathematical operations to transform and project the three dimensional data to generate video data representing a synthesized three-dimensional projected view of the terrain (and, if desired, manmade structures) in the vicinity or environment of Remote Aircraft 103. This video data is transmitted to Graphics System 406, which displays the synthesized three-dimensional projected view on Video Display 407.

Since the image is generated from the digital database, virtually any image of the environment of the Remote Aircraft 103 can be generated. As examples, the pilot may select the environment to be: 1) a simulated image of what would be seen out of the cockpit of a manned aircraft on a similar flight path; 3) a simulated image of what would be seen when looking in any direction (e.g., backwards, out a side window, etc.); 3) a simulated image of what would be seen if a camera were tailing the remotely piloted aircraft; etc. In addition, the simulated image may be set to any magnification. Thus, the phrase environment of Remote Aircraft 103 is intended to include any image generated with reference to the remote aircraft's position.

The User Flight controls with Force Feedback 408 are used by the remote pilot to input flight path information. The User Flight Controls may be of any number of different types, some of which are further described later herein. The status information received by Computer 405 also includes information received from Aircraft Flight Surfaces and Sensors 310. This information is used to actuate force feedback circuitry in User Flight Controls With Force Feedback 408. Remote Pilot 102 observes the synthesized three-dimensional environment displayed on Video Display 407, feels the forces on User Flight Controls With Force Feedback 408 and moves the controls accordingly. This flight control information is sent through the communications link, to Computer 308, and is used to control the aircraft flight surfaces in Aircraft Flight Surfaces and Sensors 310. Remote Pilot 102 also receives data from Aircraft Engine and Sensors 309 through the communications link and is able to send data back to control the engine.

Flight Control

To illustrate the operation of the remote aircraft, a fixed-wing airplane will be described as an example. However, the basic principles apply to other types of aircraft as well. The basic control surfaces of an airplane consist of the ailerons, the horizontal elevators, and the rudder. The ailerons are moved differentially (one up, one down) to rotate the airplane around its roll axis; the horizontal elevators cause the airplane to rotate around its pitch axis; and the rudder causes the airplane to rotate around its yaw axis.

When the ailerons are used to modify the lift characteristics of the wings, one wing creates more lift while the other wing creates less lift. This also changes the drag characteristics of the wings and results in a yaw force that is opposite to the yaw force that results from the tail section causing the airplane to weather-cock into the relative wind. It is this yaw force caused by the airplane weather-cocking into the relative wind that causes a banked airplane to turn. The opposite yaw force produced by using the ailerons is called adverse yaw; the rudder control is used to counteract this force to produce a coordinated turn.

The simplest type of flight control consists of a joystick and a set of rudder pedals. The controls are directly connected to the flight control surfaces. With a joystick, moving the stick left and right moves the ailerons, while moving the stick forward and backward moves the horizontal elevators. The rudder is controlled by two foot pedals, one for each foot, that are mounted on a common shaft and hinged in the middle like a seesaw. Pressing one foot pedal forward causes the other foot pedal to move backward and causes the rudder to also move in one direction. Pressing the

other foot pedal causes it to move forward and the opposite pedal to move backward and causes the rudder to move in the opposite direction.

An alternative to the joystick is the control yoke which consists of a wheel attached to a shaft that moves in and out of the control housing. Turning the wheel clockwise or counterclockwise moves the ailerons; moving the wheel shaft in and out moves the horizontal elevators. The rudder pedals as the same as those used with a joystick.

In order to aid in a description of remote aircraft operation, it is thought worthwhile to first describe the operation of non-remotely piloted vehicles. Non-remotely piloted vehicles can be operated in one of two ways (also termed as flight control modes); direct control or computer control (also termed as computer mediated).

Direct Control Non-Remotely Piloted Vehicles

When the flight controls are connected directly to the control surfaces the result is a second order system. Using the joystick as an example, moving the joystick left or right establishes a roll rate. The airplane continues to roll until the joystick is returned to the center position, after which the airplane remains in the bank angle thus established. The foot pedals are used to counteract the adverse yaw as previously described. Moving the joystick forward or backward establishes a pitch rate. The airplane continues to pitch until the joystick is returned to the center position, after which the airplane remains in the pitch angle thus established. Both the roll rate and the pitch rate are subject to the limits of the airplane's design.

Since the joystick is directly connected to the control surfaces, the aerodynamic forces on the control surfaces are transmitted back to the pilot, giving him or her valuable feedback on how the airplane is flying.

The successful operation of the second order system with the pilot in the loop depends on several factors such as the area and placement of the control surfaces, how much the control surfaces move in response to the movement of the pilot controls, and how long the airplane takes to respond to changes of the control surfaces. The total system characteristics also depend on the reaction time of the pilot. If the resulting system is poorly designed it may be unstable, which means it may not be possible for a human pilot to fly it safely. An example of an unstable system is where the pilot desires to perform a gentle roll to the right and so moves the joystick to the right, the airplane's roll rate is faster than the pilot desires so he/she attempts to compensate by moving the joystick to the left, the airplane rolls left at a rate that is faster than the pilot desires so he/she moves the joystick to the right, and so on, with the pilot constantly overcorrecting and with the aircraft's rolling motions constantly getting larger and larger until the aircraft gets into a condition from which it may not be possible to recover, (e.g., spinning into the ground). The type of loss of control described is usually referred to as 'pilot induced oscillation' and although it may be caused by an inexperienced or inattentive pilot, it is more often caused by poor airplane design. Therefore, new airplane designs are extensively tested to make sure they can be safely flown. Examples of airplanes that use direct control of the control surfaces (Direct Control Second Order Systems) are the Cessna 150 and the Piper Cub.

Computer Mediated Non-Remotely Piloted Vehicles

Computer mediated control systems use a computer between the pilot controls and the control surfaces. The pilot controls are read by the computer, the data are modified in a particular way, and the computer sends control signals to the control surfaces. The computer may also sense the forces on the control surface and use it to control force feedback to the pilot controls. This type of computer mediated control may be used to fly an airplane that would otherwise be unstable, such as the F16 or the F117. Aircraft such as the F16 and F117 are also second order systems because the position of the pilot's joystick represents rate of rotation.

There are risks inherent in a computer mediated system. Although the program can be simulated extensively before using it in an actual airplane, the computer program may be quite large and therefore difficult to simulate under all possible conditions. An example of this is the Swedish JAS 39 Gripen Fighter. Despite extensive simulation of the flight control system, during a test flight a Gripen crashed due to "...the flight control system's high amplification of stick commands combined with the pilot's" large, rapid stick movements"." The pilot had entered a low-speed high-banked turn at a 280 meter altitude with lit afterburners and was leaving the turn when his actions led to 'pilot-induced oscillation'. (Aviation Week & Space Technology, August 23, 1993, pages 72-73).

Having described techniques for operating non-remotely piloted vehicles, the Fight Control Modes for RPVs will be described.

Second Order RPV Flight Control Mode

A second order control system for an RPV is inherently computer mediated because the remote pilot must interact through two computers: the computer in the remote aircraft and the computer in the remote pilot station.

Flying an RPV is further complicated because there are additional time delays in the loop. The computer in the remote aircraft must first determine the aircraft's position and orientation. The additional processing for transmitting a secure signal by encryption and/or spread spectrum techniques may create additional delays. Transmission delay of signals between the remote aircraft and remote pilot station is negligible for a direct path. However, if the signals are relayed through other facilities the delay time may be appreciable, especially if an orbiting satellite is used. There are additional delays in the remote pilot station as the remote aircraft's position and orientation are used to transform the data from the digital database to present the pilot with the synthesized 3D projected view from the remote aircraft. In one embodiment, the RPV system measures the various delays and modifies the control laws used by the computer in the remote pilot aircraft and in the feedback provided by the computer in the remote pilot station to the remote pilot. For example, the computer may adjust the sensitivity of the User Flight Controls 408 according to the delay (e.g., as the delay increases, the computer will decrease the sensitivity of the flight controls). The system also displays the measured delay to the remote pilot.

First Order RPV Flight Control Mode

The stability of the flight control system, and thus the flyability of an RPV, can be improved considerably by using a first order system. In one embodiment of

such a first order system the position of the remote pilot's joystick represents an angle relative to the horizon, instead of representing a rate of rotation as in a second order system. The position of the joystick is transmitted to the computer in the remote aircraft which moves the control surfaces as required to place the remote aircraft in the requested orientation. The control system in the remote aircraft is still a second order system but the delays in the communications link and the remote pilot station are no longer a part of the system's loop.

When a joystick is centered, the remote aircraft will fly straight and level. When the joystick is to the right of center the remote aircraft will be in a right banked turn. When the joystick is to the left of center the remote aircraft will be in a left banked turn. When the joystick is backward from center the remote aircraft will be in a pitch up orientation. When the joystick is forward of center the remote aircraft will be in a pitch down orientation.

The amount of bank and pitch permitted depends on the design of the remote aircraft. A high performance remote aircraft will be capable of a greater amount of pitch and bank than will a low performance remote aircraft.

Referring again to FIG. 4, Computer 405 may optionally be coupled to Control Panel 402, Keyboard 403, Simulation Port 404, Video Interface 410, VCR 411, and/or Video Display 412. In one embodiment, Control Panel 402 contains specialized lights, displays, and switches to allow a quicker response to situations than can be provided by Keyboard 403. Control Panel 402 can be arranged to approximate the look and feel of an actual aircraft cockpit. Keyboard 403 allows the remote pilot to select various operating modes. For training purposes, Simulation Port

404 allows the remote pilot station to be connected to a remote aircraft simulator instead of an actual remote aircraft. The remote aircraft simulator will be further described with reference to FIG. 6. Storage Device 409 allows the flight data to be recorded. During playback this previously recorded data is substituted for real-time data from the remote aircraft to replay the mission for analysis. Any video received from any reconnaissance cameras on the Remote Aircraft 103 is converted by Video Interface 410 so that it can be recorded on VCR 411 and displayed on Video Display 412. VCR 411 can also operate in straight-through mode so that the reconnaissance video can be viewed in real time.

FIG. 5 is a block diagram of a remote pilot station according to another embodiment of the invention. FIG. 5 shows Remote Pilot Station 500. Remote Pilot Station 500 is similar to Remote Pilot Station 400 of FIG. 4, except Video Display 407 is replaced by Head Mounted Display 501. In addition, Head Mounted Display Attitude Sensors 502 are coupled to Computer 405. Head Mounted Display Attitude Sensors 502 measure the attitude of Head Mounted Display 501. This information is used by Computer 405 to produce an additional three dimensional transformation of the data from Digital Database 107 to account for the attitude of the remote pilot's Head Mounted Display 501. This does not require any additional data from the remote aircraft. Of course, alternative embodiments could include both a video display and a head mounted display.

FIG. 6 is a block diagram of a simulated remote aircraft used for training remote pilots according to one embodiment of the invention. FIG. 6 shows Remote Aircraft Simulator 600 including Computer 605 coupled to Aerodynamic Model

Processor 601, Instructor Control Panel 602, Keyboard 603, Simulation Port 604, Graphics System 606, Storage Device 608, and Simulation Network Interface 609. Remote Aircraft Simulator 600 communicates with Remote Pilot Station 400 or 500 through Simulation Port 604. Aerodynamic Model Processor 601 executes a mathematical model that simulates the behavior of a remote aircraft. An instructor uses Instructor Control Panel 602 and Keyboard 603 to select various training scenarios. Graphics System 606 and Video Display 607 are used to observe the operation of the system. Storage Device 608 is used to record the training session for later evaluation of the session. In addition to proficiency training, the Remote Aircraft Simulator can also be used to practice a proposed mission. The data communicated to the remote pilot station can include training and evaluation data for processing and/or display. This training and evaluation data can include any relevant information, such as flight path accuracy, etc.

Simulation Network Interface 609 permits participation in a battlefield simulation system such as SIMNET, mixing aircraft, tanks, and ground troops for training in the coordination of mixed forces. Thus, the system is designed to allow for the communication of this battlefield simulation information between the remote aircraft simulator and the remote pilot station. This allows the remote pilot station to display one or more other simulated entities (e.g., tanks, ground troops, other aircraft, etc.) described by the battlefield simulation information.

The Database

The Digital Database 107 can be comprised of any type of data from which a three dimensional image can be generated. For example, the U.S. Geological Survey

(USGS) makes available various databases, two of which are of particular interest. The first is the Digital Elevation Model data which consist of an array of regularly spaced terrain elevations.

The other USGS database is the Digital Line Graph data which includes: political and administrative boundaries; hydrography consisting of all flowing water, standing water, and wetlands; major transportation systems consisting of roads and trails, railroads, pipelines, transmission lines, and airports; and significant manmade structures. The Digital Line Graph data is two-dimensional. In the present invention features such as water, roads, railroads, and pipelines are represented as polygons with elevations determined from the Digital Elevation Model data. Transmission lines and significant manmade structures are defined as three-dimensional objects made of polygons and are placed according to the elevations determined from the Digital Elevation Model data. The different types of objects are tagged so that the remote pilot can select them to be highlighted by category or by specific object.

Data from additional digital databases can also be incorporated. An example of such a database is from Jeppesen Sanderson whose NavData Services division provides aeronautical charts and makes this information available in digital form.

The procedure for generating the synthesized three-dimensional view from the Digital Database may use any number of techniques, including those disclosed in the 1987 patent to Beckwith et al. (U.S. Patent No. 4,660,157 REAL TIME VIDEO PERSPECTIVE DIGITAL MAP DISPLAY METHOD), and the 1993 patent to Dawson et al. (U.S. Patent No. 5,179,638 METHOD AND APPARATUS FOR GENERATING A TEXTURE MAPPED PERSPECTIVE VIEW). One disadvantage

of generating the synthesized three-dimensional view from these elevation databases in real time is the amount of storage space they require. To avoid this large amount of data storage, one embodiment of Digital Database 107 is composed of terrain data that represents the real terrain using polygons. This database may be generated using any number of techniques. For example, this database may be generated by transforming one or more elevation databases into a polygon database using the technique taught in "Pilot Aid Using a Synthetic Environment", serial no. 08/274,394 filed July 11, 1994. Another method for transforming one or more elevation databases into a polygon database is taught in "Digital Map Generator and Display System", serial no. 08/543,590, filed October 16, 1995. An example of a three dimensional projected image created from this database is shown in Fig. 7.

While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The method and apparatus of the invention can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative instead of limiting on the invention.

CLAIMS

What is claimed is:

Sub B1

1. A system comprising:

a remotely piloted aircraft;

a communications system for communicating flight data between a computer and said remotely piloted aircraft, said flight data including said remotely piloted aircraft's position and orientation, said flight data also including flight control information for controlling said remotely piloted aircraft;

a digital database comprising terrain data;

said computer to access said terrain data according to said remotely piloted aircraft's position and to transform said terrain data to provide three dimensional projected image data according to said remotely piloted aircraft's orientation;

a display for displaying said three dimensional projected image data; and

a set of one or more remote flight controls coupled to said computer for inputting said flight control information.

2. The system of claim 1, said remotely piloted aircraft including:

a position determining system for locating said remotely piloted aircraft's position in three dimensions; and

an orientation determining system for determining said remotely piloted aircraft's orientation in three dimensional space.

3. The system of claim 1, wherein the flight data communicated between said remotely piloted aircraft and said computer is secured.

4. The system of claim 1, wherein said remotely piloted aircraft further comprises a set of one or more video cameras.

5. The system of claim 4, wherein said communications system is also for communicating video data representing images captured by said set of one or more video cameras, said video data for displaying said images.

6. The system of claim 5, wherein said video data is transmitted on a different communication link than said flight data.

7. The system of claim 4, wherein at least one camera in said set of one or more video cameras is an infrared camera.

8. The system of claim 1, wherein said display is a head mounted display.

9. The system of claim 1, wherein said set of one or more remote flight controls is responsive to manual manipulations.

10. The system of claim 1, wherein said computer is also for determining a delay time for communicating said flight data between said computer and said remotely piloted aircraft.

11. The system of claim 10, wherein said computer adjusts the sensitivity of said set of one or more remote flight controls based on said delay time.

12. The system of claim 1, wherein said set of one or more remote flight controls allows for inputting absolute pitch and roll angles instead of pitch and roll rates.

13. The system of claim 1, wherein said computer is also used for correcting adverse yaw without requiring input from said set of one or more remote flight controls.

14. A station for flying a remotely piloted aircraft that is real or simulated comprising:

a database comprising terrain data;

a set of remote flight controls for inputting flight control information;

a computer having a communications unit configured to receive status information identifying said remotely piloted aircraft's position and orientation in three dimensional space, said computer configured to access said terrain data according to said status information and configured to transform said terrain data to provide three dimensional projected image data representing said remotely piloted aircraft's

environment, said computer coupled to said set of remote flight controls and said communications unit for transmitting said flight control information to control said remotely piloted aircraft; and

a display configured to display said three dimensional projected image data.

15. The station of claim 14, wherein said communications unit is also configured to receive video data representing images captured by a set of video cameras on said remotely piloted aircraft, said video data for displaying said images.

16. The station of claim 15, wherein said video data is transmitted on a different communication link that said flight control information and said status information.

17. The station of claim 14, wherein said display is a head mounted display.

18. The station of claim 14, wherein said set of remote flight controls is responsive to manual manipulations.

19. The station of claim 14, wherein said computer is also for determining a delay time for communicating said flight control information between said computer and said remotely piloted aircraft.

20. The station of claim 19, wherein said computer adjusts the sensitivity of said set of remote flight controls based on said delay time.

21. The station of claim 14, wherein said set of remote flight controls are configured to allow inputting absolute pitch and roll angles instead of pitch and roll rates.

22. The station of claim 14, wherein said computer is also configured to correct adverse yaw without requiring input from said set of remote flight controls.

23. The station of claim 14, wherein said communications unit includes at least one of a communications transceiver and a simulation port.

24. A remotely piloted aircraft comprising:

a position determining system;

an orientation determining system;

a communications system for transmitting status information, including said remotely piloted aircraft's position and orientation, to a pilot station for transformation into a three dimensional projected image of said remotely piloted aircraft's environment according to a database representing real terrestrial terrain using polygons, said communications system also for receiving from said pilot station flight control information; and

a control system for adjusting said remotely piloted aircraft's flight in response to said flight control information.

25. The remotely piloted aircraft of claim 24, wherein said status information and said flight control information is communicated between said remotely piloted aircraft and said pilot station using a secured communications link.

26. The remotely piloted aircraft of claim 24, wherein said remotely piloted aircraft further comprises a set of video cameras.

27. The remotely piloted aircraft of claim 26, further comprising a video storage unit for storing images captured by said set of video cameras.

28. The remotely piloted aircraft of claim 26, wherein said communications system is also for transmitting to said pilot station video data representing images captured by said set of video cameras, said video data for displaying said images.

29. The remotely piloted aircraft of claim 28, wherein said video data is transmitted real-time.

30. The remotely piloted aircraft of claim 28, wherein said video data is transmitted on a different communication link than said status information.

31. The remotely piloted aircraft of claim 28, wherein at least one camera in said set of video cameras is an infrared camera.

32. ~~A method for flying a remotely piloted aircraft, said remotely piloted aircraft~~ having a current position and a current orientation, said method comprising the steps of:

determining the current position of said remotely piloted aircraft in three dimensions;

determining the current orientation of said remotely piloted aircraft in three dimensions;

communicating said current position and current orientation from said remotely piloted aircraft to a pilot station;

accessing a database comprising terrain data that represents real terrestrial terrain as a set of polygons;

transforming said terrain data into image data representing a simulated three dimensional view according to the current position and orientation of said remotely piloted aircraft;

displaying said simulated three dimensional view using said image data; and

communicating flight control information from said pilot station to said remotely piloted aircraft, said remotely piloted aircraft flying in accordance with said flight control information.

33. The method of claim 32, further comprising the steps of:

determining a delay time for communicating said flight control information to said remotely piloted aircraft;

~~adjusting said flight control information in response to said delay time.~~

34. The method of claim 32 further comprising the steps of:

generating said flight control information in response to manual manipulations of a set of manual flight controls on said pilot station.

35. The method of claim 32 further comprising the steps of:

recording images using a set of cameras on said remotely piloted aircraft.

36. The method of claim 35 further comprising the steps of:

communicating video data representing said images from said remotely piloted aircraft to said pilot station.

37. The method of claim 36, wherein said step of communicating video data is performed real-time.

38. The method of claim 36, wherein said step of communicating said video data is performed using a different communications link than said flight control information.

39. A system comprising:

a simulation unit configured to simulate at least a remotely piloted aircraft;

a communications system configured to communicate flight data between a computer and said simulation unit, said flight data including said remotely piloted

aircraft's position and orientation, said flight data also including flight control information for controlling said remotely piloted aircraft;

a digital database comprising terrain data;

said computer configured to access said terrain data according to said remotely piloted aircraft's position and to transform said terrain data to provide three dimensional projected image data according to said remotely piloted aircraft's orientation;

a display configured to display said three dimensional projected image data; and

a set of one or more remote flight controls coupled to said computer for inputting said flight control information.

40. The system of claim 39, wherein said simulation unit includes a simulation network interface configured to communicate battlefield simulation information with a simulation network, said communications system also configured to communicate said battlefield simulation information between said simulation unit and said computer, said computer also configured to display one or more other simulated entities described by said battlefield simulation information.

41. The system of claim 40, wherein said simulation network is SIMNET.

42. The system of claim 41, wherein said simulation unit is also configured to communicate to said computer via said communications system training and evaluation information for processing, recording, or display by said computer.

43. The system of claim 39, wherein said simulation unit further comprises:

a aerodynamic model processor for aiding in simulating said remotely piloted aircraft.

44. The system of claim 39, wherein said display is a head mounted display.

45. The system of claim 39, wherein said set of one or more remote flight controls is responsive to manual manipulations.

46. The system of claim 39, wherein said computer is also for determining a delay time for communicating said flight data between said computer and said remotely piloted aircraft.

47. The system of claim 46, wherein said computer adjusts the sensitivity of said set of one or more remote flight controls based on said delay time.

48. The system of claim 39, wherein said set of one or more remote flight controls allows for inputting absolute pitch and roll angles instead of pitch and roll rates.

49. The system of claim 39, wherein said computer is also used for correcting adverse yaw without requiring input from said set of one or more remote flight controls.

ADD B4

Attorney's Docket No.: 002055.P004 Patent

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

the specification of which

XXX is attached hereto.

_____ was filed on _____ as United States Application Number _____ or PCT International Application Number _____ and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below

(Application Number)	Filing Date
(Application Number)	Filing Date

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Number)	Filing Date	(Status -- patented, pending, abandoned)
(Application Number)	Filing Date	(Status -- patented, pending, abandoned)

I hereby appoint Aloysius T. C. AuYeung, Reg. No. 35,432; William Thomas Babbitt, Reg. No. P39,591; Bradley J. Bereznak, Reg. No. 33,474; Michael A. Bernadicou, Reg. No. 35,934; Roger W. Blakely, Jr., Reg. No. 25,831; Thomas M. Coester, Reg. No. P39,637; William Donald Davis, Reg. No. 38,428; Daniel M. De Vos, Reg. 37,813; Karen L. Feisthamel, Reg. No. P40,264; Scot A. Griffin, Reg. No. 38,167; David R. Halvorson, Reg. No. 33,395; Brian Don Hickman, Reg. No. 35,894; Eric Ho, Reg. No. P39,711; George W Hoover II, Reg. No. 32,992; Eric S. Hyman, Reg. No. 30,139; Jeff D. Jacobs, Reg. No. P40,029; Dag H. Johansen, Reg No. 36,172; Stephen L. King, Reg. No. 19,180; Daniel C. Mallery; Reg. 33,532; Michael J. Mallie, Reg. No. 36,591; Kimberley G. Nobles, Reg. No. 38,255; Ronald W. Reagin, Reg. No. 20,340; James H. Salter, Reg. No. 35,668; William W. Schaal, Reg. No. P39,018; James C. Scheller, Reg. No. 31,195; Edward W. Scott, IV, Reg. No. 36,000; Maria McCormack Sobrino, Reg. No. 31,639; Stanley W. Sokoloff, Reg. No. 25,128; Allan T. Sponseller, Reg. No. 38,318; Steven R. Sponseller, Reg. No. 39,384; David R. Stevens, Reg. No. 38,626; Edwin H. Taylor, Reg. No. 25,129; Lester J. Vincent, Reg. No. 31,460; John Patrick Ward, Reg. No. P40,216; Ben J. Yorks, Reg. No. 33,609; and Norman Zafman, Reg. No. 26,250; my attorneys; and Roland B. Cortes, Reg. No. 39,152; Gary B. Goates, Reg. No. 35,159; Thomas X. Li, Reg. No. 37,079; and Edwin A. Sloane, Reg. No. 34,728; my patent agents; of BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN, with offices located at 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025, telephone (310) 207-3800, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

40

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

100

Full Name of Sole/First Inventor (given name, family name) Jed Margolin

Inventor's Signature Jed Margolin Date 1-19-96

Residence San Jose, California CA Citizenship U.S.A.
(City, State) (Country)

Post Office Address 3570 Pleasant Echo
San Jose, CA 95148

Full Name of Second/Joint Inventor (given name, family name) _____

Inventor's Signature _____ Date _____

Residence _____ Citizenship _____
(City, State) (Country)

Post Office Address _____

Full Name of Third/Joint Inventor (given name, family name) _____

Inventor's Signature _____ Date _____

Residence _____ Citizenship _____
(City, State) (Country)

Post Office Address _____
_____

Full Name of Fourth/Joint Inventor (given name, family name) _____

Inventor's Signature _____ Date _____

Residence _____ Citizenship _____
(City, State) (Country)

Post Office Address _____
_____

Full Name of Fifth/Joint Inventor (given name, family name) _____

Inventor's Signature _____ Date _____

Residence _____ Citizenship _____
(City, State) (Country)

Post Office Address _____
_____

Full Name of Sixth/Joint Inventor (given name, family name) _____

Inventor's Signature _____ Date _____

Residence _____ Citizenship _____
(City, State) (Country)

Post Office Address _____
_____

Full Name of Seventh/Joint Inventor (given name, family name) _____

Inventor's Signature _____ Date _____

Residence _____ Citizenship _____
(City, State) (Country)

Post Office Address _____
_____

Applicant or Patentee: Jed Margolin
Serial or Patent No.: Not Assigned Yet
Filed or Issued: January 19, 1996
For: A METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

Attorney's Docket No. 002055.P004

JAN 19 64

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
37 CFR 1.9 (f) and 1.27(b) – INDEPENDENT INVENTOR

As the below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled:

A METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

described in

[XX] the specification filed herewith.

[ ] application serial no. _____, filed _____.

[ ] patent no. _____, issued _____.

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey or license any rights in the invention is listed below:

[XX] No such person, concern, or organization.

[ ] Persons, concerns, or organizations listed below.*

*NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

NAME: Jed Margolin
ADDRESS: 3570 Pleasant Echo, San Jose, California 95148
[X X] Individual [ ] Small Business Concern [ ] Non-Profit Organization

NAME: _____
ADDRESS: _____
[ ] Individual [ ] Small Business Concern [ ] Non-Profit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Jed Margolin		
NAME OF INVENTOR	NAME OF INVENTOR	NAME OF INVENTOR
Jed Margolin		
Signature of Inventor	Signature of Inventor	Signature of Inventor
1-19-96		
DATE	DATE	DATE

LJV/cak 10/04/94

08/587731

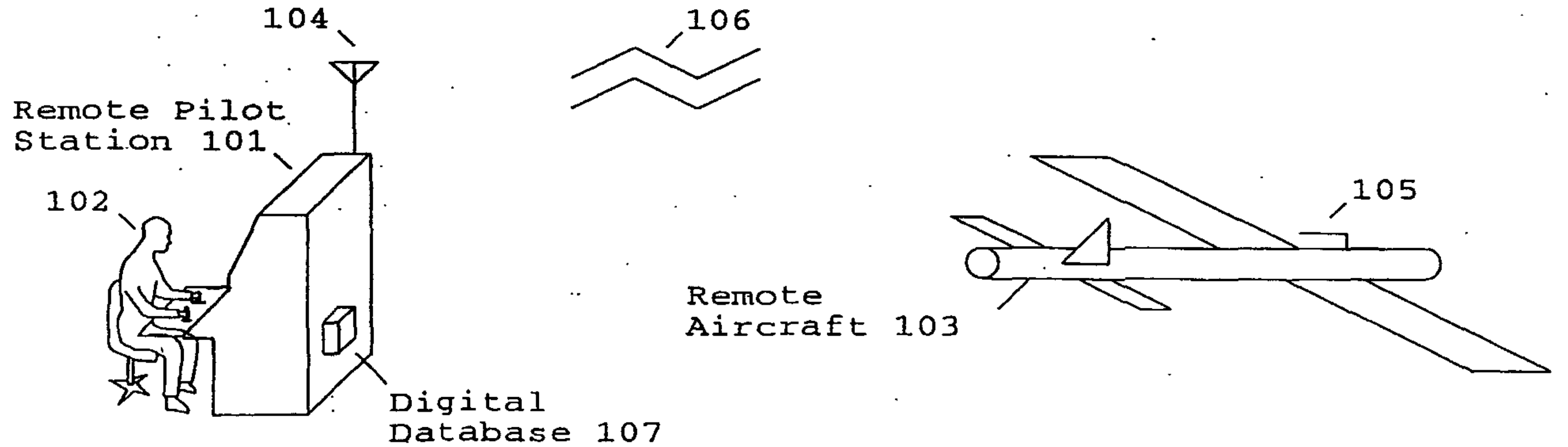


Fig. 1

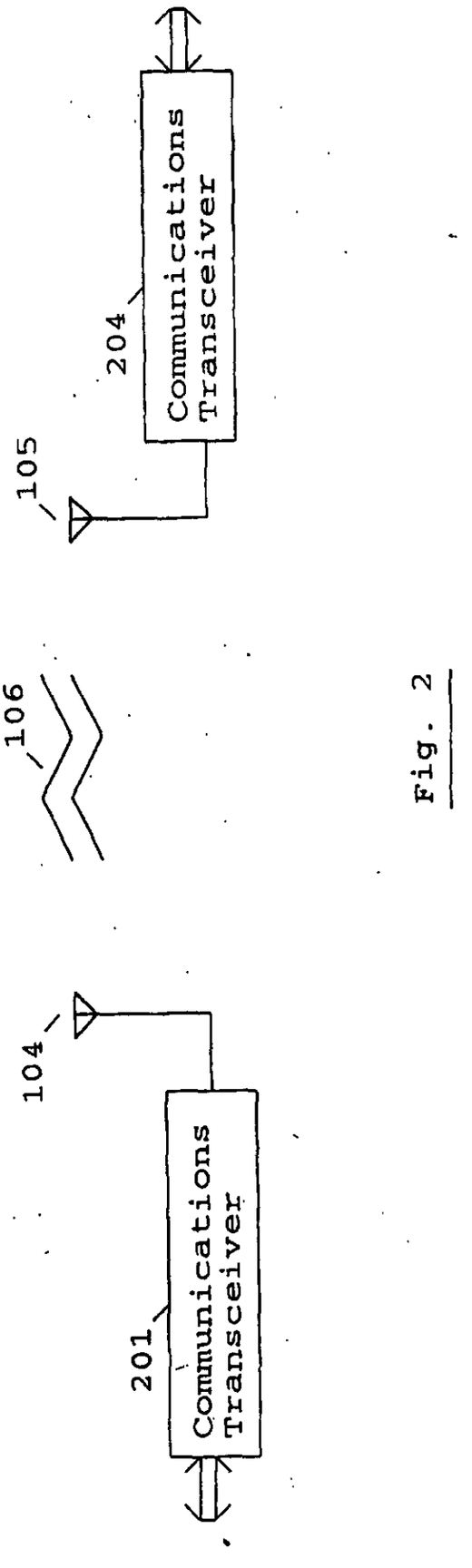


Fig. 2

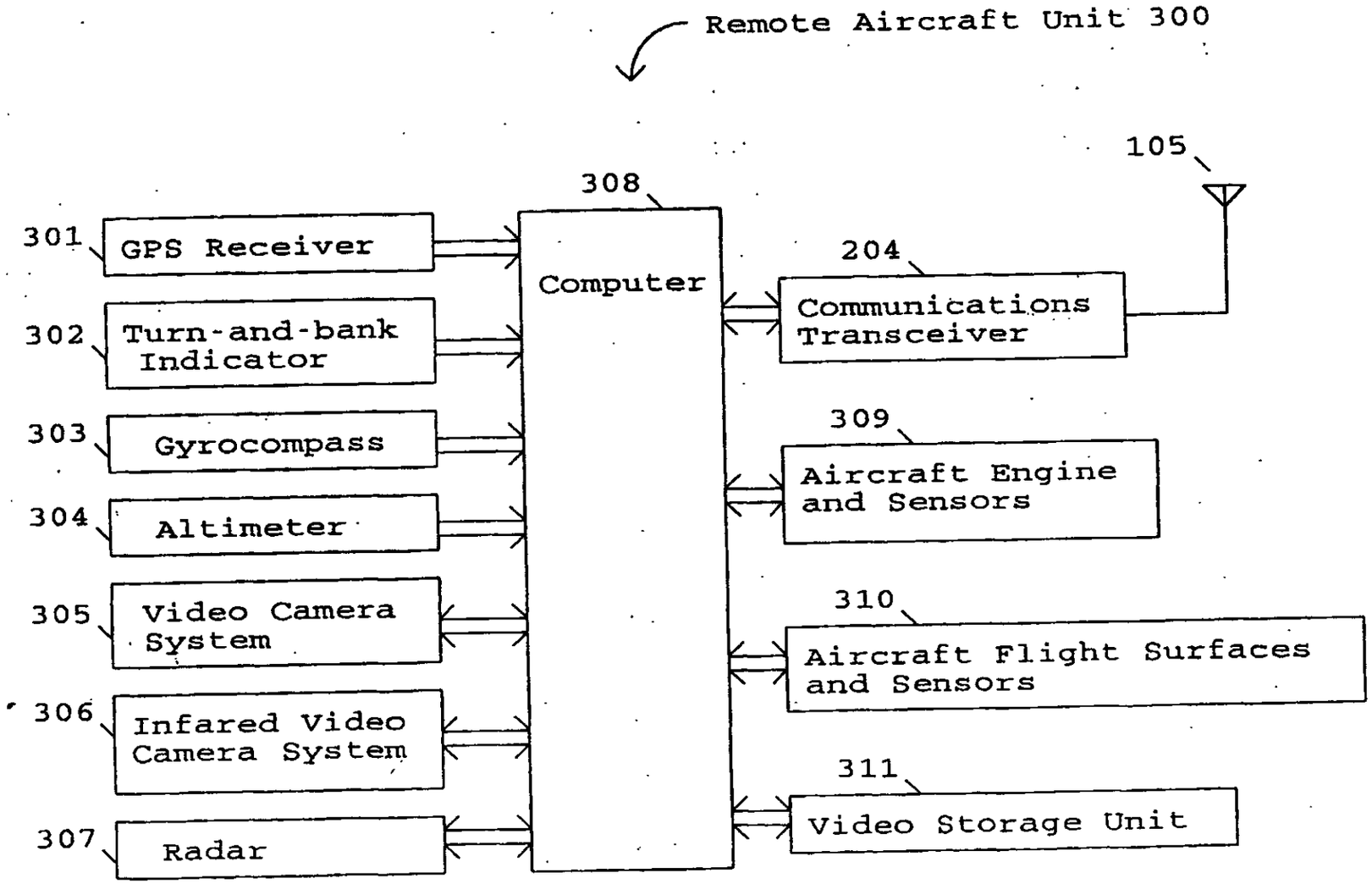


Fig. 3

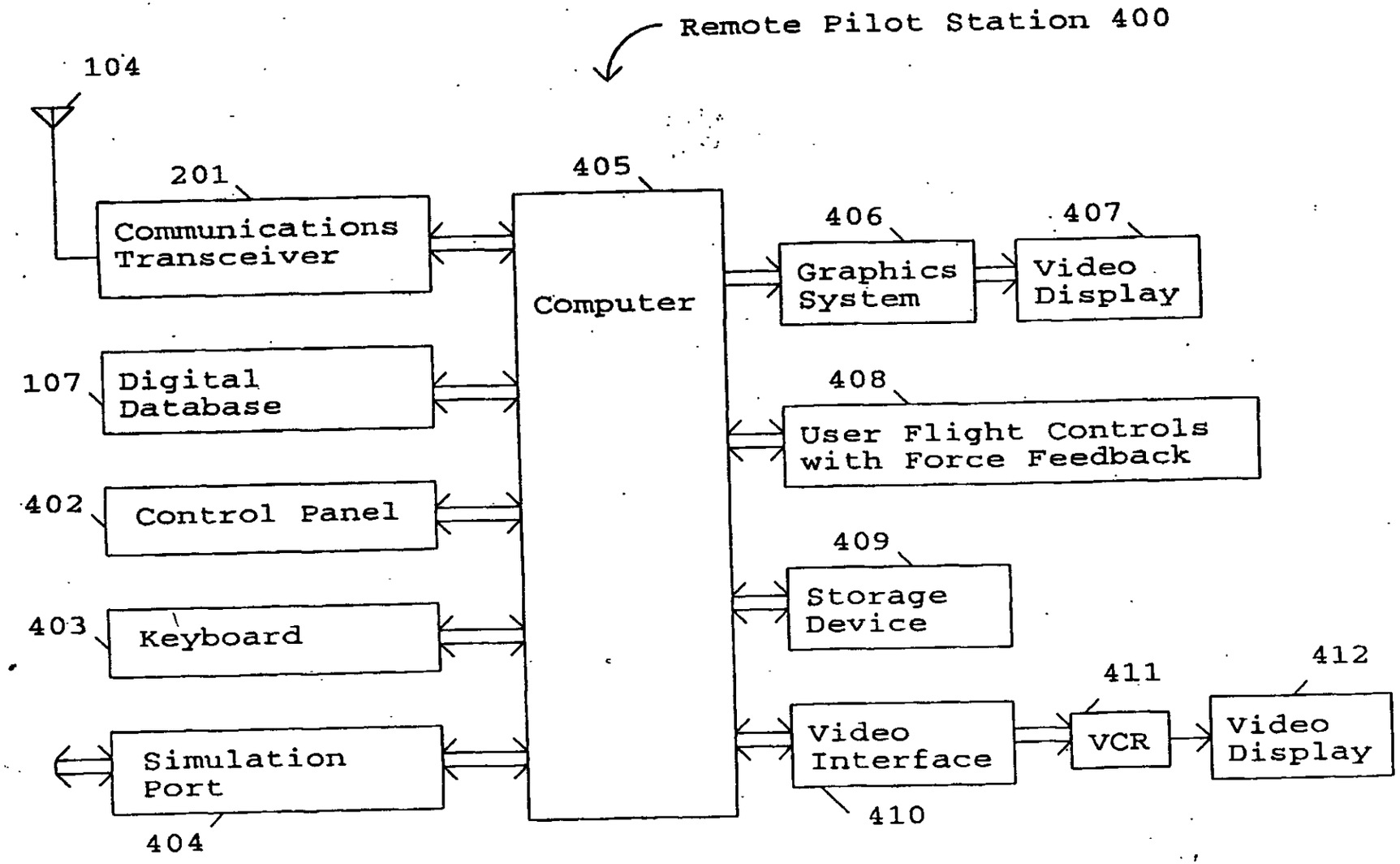


Fig. 4

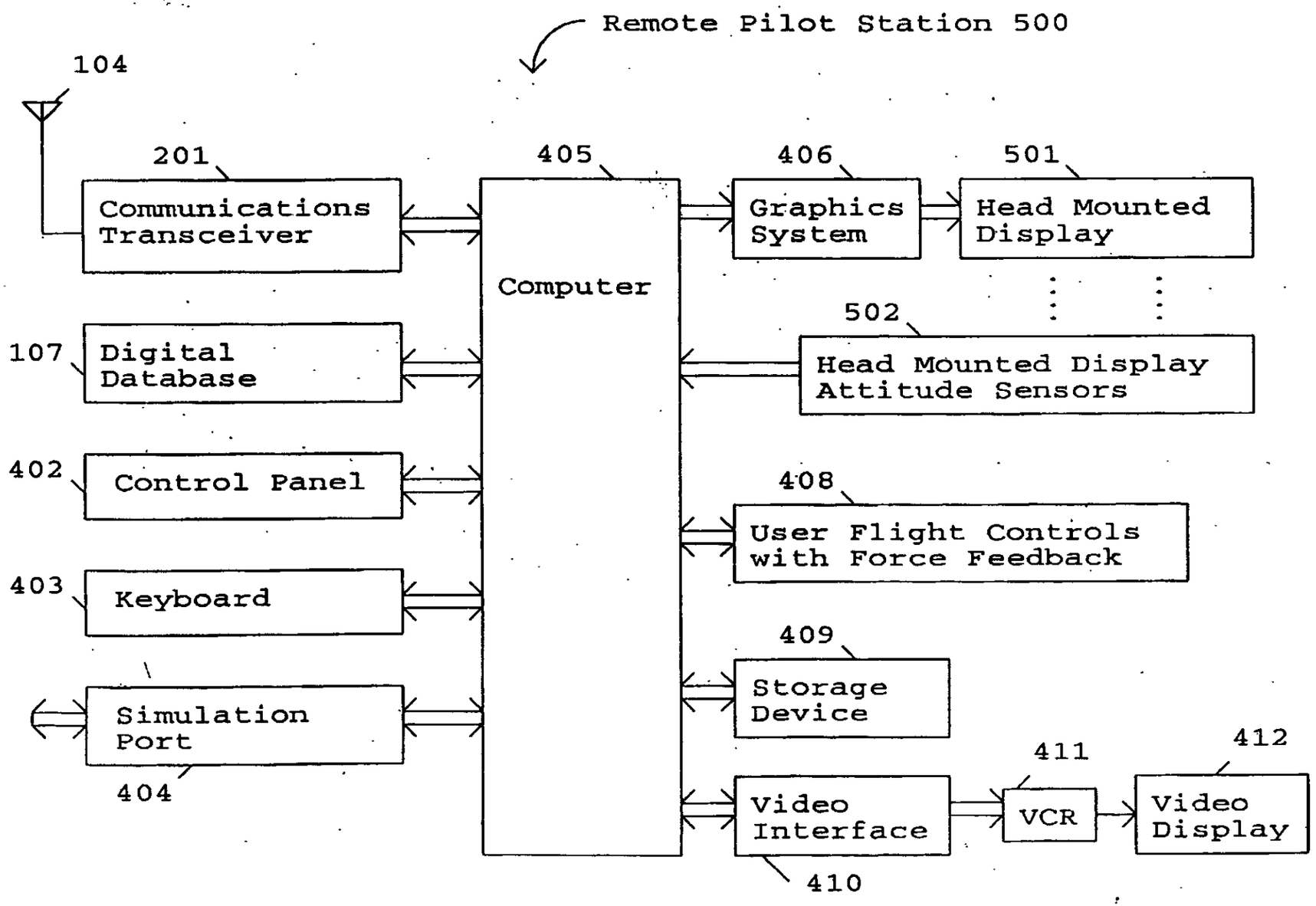


Fig. 5

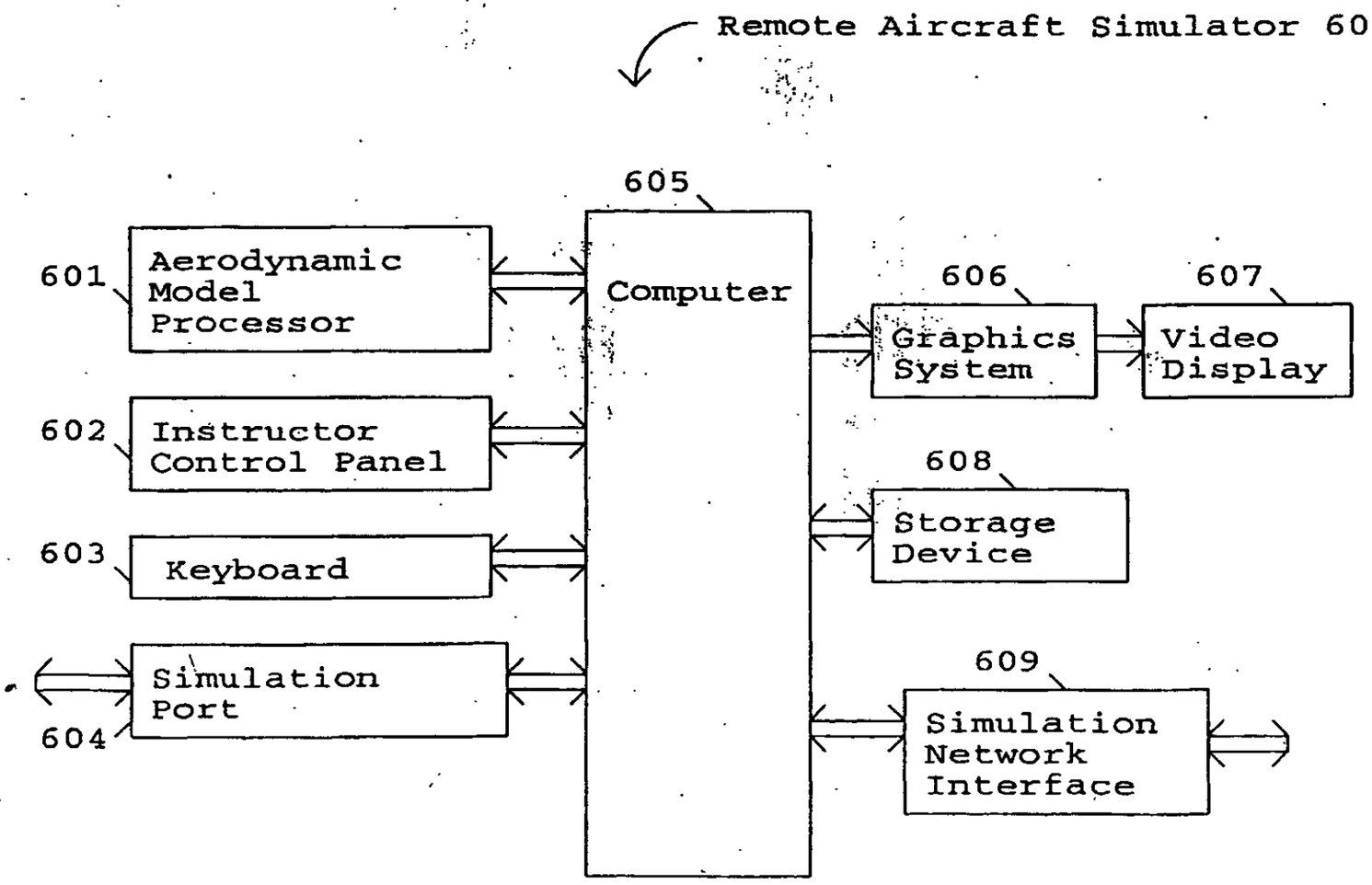


Fig. 6

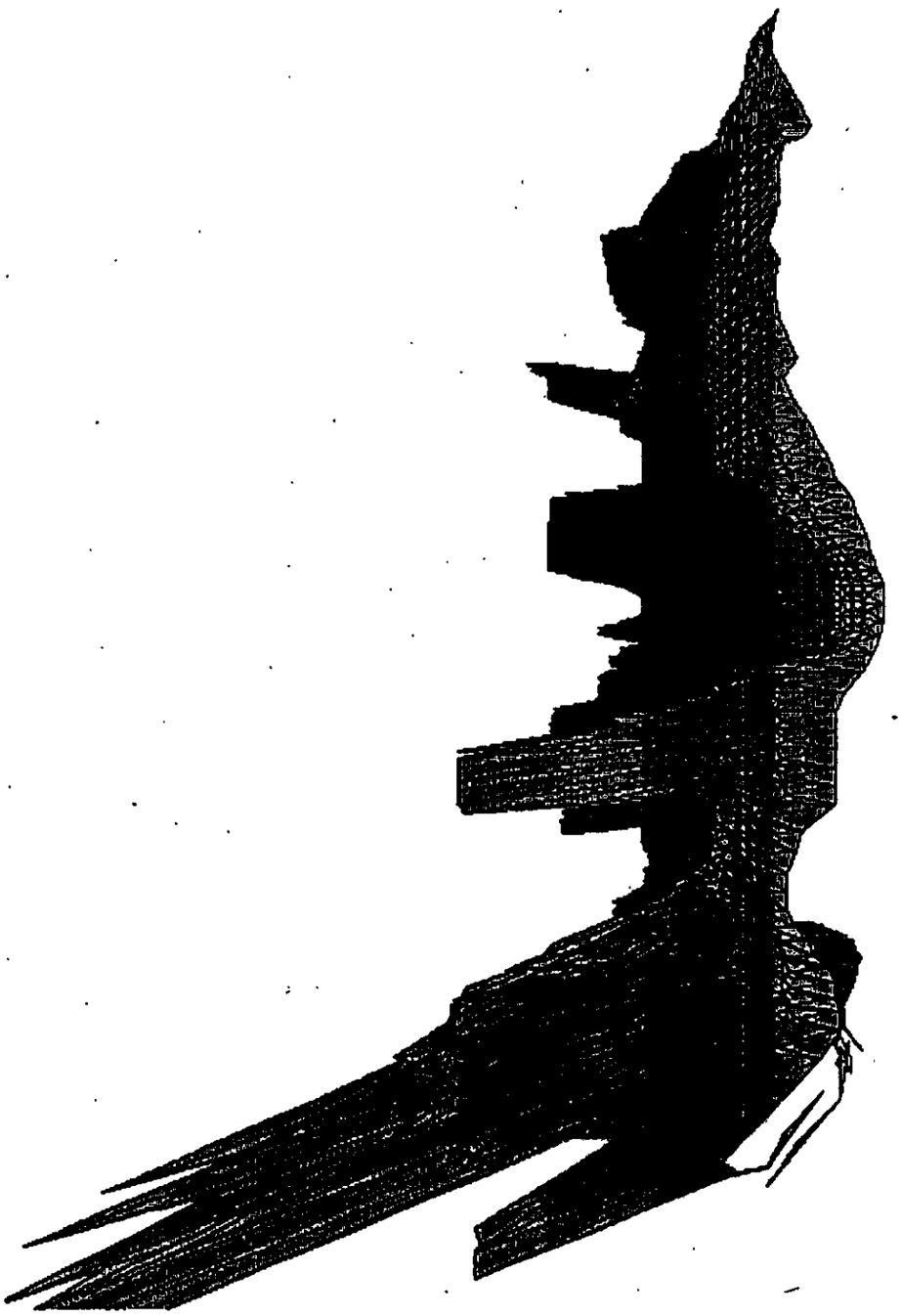


Figure 7

08/587731

Attorney's Docket No. 02055.P004

Patent

THE COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SIR: Transmitted herewith for filing is the nonprovisional patent application of

Inventor(s): Jed Margolin

For: A METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

(Title)

Enclosed are:

X 19 647 sheet(s) of Drawings.

An Assignment of the invention to

Assignment Cover Sheet Form PTO-1595.

X Declaration and Power of Attorney (XXX signed/ _____ unsigned).

X A Verified Statement to establish Small Entity Status under 37 C.F.R. §§ 1.9 and 1.27.

X Information Disclosure Statement and PTO Form 1449 with (16) references attached

The Filing Fee has been calculated as shown below:

	(Col. 1)		(Col. 2)	SMALL ENTITY		OTHER THAN A SMALL ENTITY	
For:	No. Filed		No. Extra	Rate	Fee	Rate	Fee
Basic Fee:					$ 375		$ 750
Total Claims:	49	- 20	* 29	x 11	$ 319	x 22	$
Indep. Claims:	5	- 3	* 2	x 39	$ 78	x 78	$
	Multiple Dependent Claim(s) Presented			+125	$	+250	$
				TOTAL	$ 772	TOTAL	$

* If the difference is less than zero, enter "0" in Col. 2.

X A check for $ 772.00 for the filing fee is enclosed.

A check for $ 40.00 for recordation of the Assignment is enclosed.

X The Commissioner is hereby authorized to charge payment of the following fees associated with this communication, or credit any overpayment, to our Deposit Account No. 02-2666. **A duplicate copy of this sheet is enclosed.**

X Any additional filing fees required under 37 C.F.R. § 1.16.

X Any patent application processing fees under 37 C.F.R. § 1.17.

X The Commissioner is hereby authorized to charge payment of the following fees during the pendency of this application, or credit any overpayment, to our Deposit Account No. 02-2666. **A duplicate copy of this sheet is enclosed.**

X Any processing fees under 37 C.F.R. § 1.17, including any extension fees.

X Any filing fees under 37 C.F.R. § 1.16 for presentation of extra claims.

X Send all correspondence to the undersigned at BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN, 12400 Wilshire Boulevard, Seventh Floor, Los Angeles, California 90025, and direct all telephone calls to the undersigned at (408) 720-8598.

Respectfully submitted,

BLAKELY SOKOLOFF TAYLOR & ZAFMAN

Date: 1/19/96

By _____
Daniel M. De Vos

Reg. No.: 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025
(408) 720-8598

(LJV/cak 10/02/95)

"Express Mail" mailing label number EM281965992US

Date of Deposit January 19, 1996

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Dulcie G. Stinson
(Typed or printed name of person mailing paper or fee)

Dulcie G. Stinson
(Signature of person mailing paper or fee)

08/587731

002055.P004

#2
DC
4/18/96

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Jed Margolin	Examiner:	Not Yet Assigned
Serial No.:	NOT ASSIGNED YET	Art Unit:	Not Yet Assigned
Filed:	Not Yet Assigned		
For:	A METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT		

INFORMATION DISCLOSURE STATEMENT

Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir,

Applicant hereby requests consideration of the enclosed Information Disclosure Statement pursuant to 37 C.F.R. §1.97(b)(3). Attached hereto is PTO Form 1449 along with a copy of the cited reference. If any additional fee is required, please charge Deposit Account No. 02-2666. A duplicate of this Petition is enclosed for deposit account charging purposes.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN

Dated: 1/19, 1996

Daniel M. De Vos
Reg. No. 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, CA 90025-1026
(408) 720-8598

FIRST CLASS CERTIFICATE OF MAILING
(37 C.F.R. § 1.8(a))

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail with sufficient postage in an envelope addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231

on January 19, 1996.
Date of Deposit

Dulcie G. Stinson
Name of Person Mailing Correspondence

Dulcie G. Stinson — January 19, 1996
Signature — Date

Form PTO-1449 (REV. 8-83)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTY. DOCKET NO. 002055.P004

SERIAL NO. 08/587,731 ~~Not Yet Assigned~~

APPLICANT Jed Margolin

FILING DATE 01/19/96 ~~Not Yet Assigned~~

GROUP 2764 ~~Not Yet Assigned~~

INFORMATION DISCLOSURE CITATION

(Use several sheets if necessary)

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
TN		3,795,909	03-05-74	Vehrs, Jr.	343	7	10-12-71
TN		4,467,429	08-21-84	Kendig	343	433	01-13-82
TN		4,739,327	04-19-88	Konig et al.	342	26	03-24-86
TN		4,760,396	07-26-88	Barney et al.	342	65	07-11-86
TN		5,086,396	02-04-92	Waruszewski, Jr.	364	454	02-19-91
TN		5,257,347	10-26-93	Busbridge et al.	395	129	06-06-91
TN		5,272,639	12-21-93	McGuffin	364	449	01-14-92
TN		5,335,181	08-02-94	McGuffin	364	443	01-15-92
TN		5,406,286	04-11-95	Tran et al.	342	13	11-17-92
TN		5,446,666	08-29-95	Bauer	364	434	05-17-94
TN		4,405,943	11-20-83	Kanaly	358	133	08-19-81

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

TN			Lyons, J.W., "Some Navigational Concepts for Remotely Piloted Vehicles", AGARD Conference Proceed. n 176, Med. Accur. Low Cost Navig. at Avion. Panel Tec. Meeting, 5-1-5-15, (~~1976~~) 09/75.
TN			"US GeoData Digital Line Graphs", U.S. Dept. of the Interior, U.S. Geolg. Surv. Earth Sci. Info Ctr. (Factsheet) (~~1993~~) June 1993.
TN			"US GeoData Digital Elevation Models", U.S. Dept. of the Interior, U.S. Geolg. Surv. Earth Sci. Info Ctr. (Factsheet) (~~1993~~) June 1993.

EXAMINER Jan Nguyen

DATE CONSIDERED 07/15/1997

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Form PTO-1449 (REV. 8-83)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTY. DOCKET NO.	SERIAL NO.
002055.P004	08/587,731 ~~Not Yet Assigned~~
APPLICANT: Jed Margolin	
FILING DATE: 01/19/96 ~~Not Yet Assigned~~	GROUP: 2302 ~~Not Yet Assigned~~

INFORMATION DISCLOSURE CITATION

(Use several sheets if necessary)

U.S. PATENT DOCUMENTS

EXAMINER		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
TN		4,660,157	04-21-87	Beckwith et al.	364	522	11-13-84
TN		5,179,638	01-12-93	Dawson et al.	395	125	04-26-90

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent Pages, Etc.)*

EXAMINER	DATE CONSIDERED
Jan Nguyen	07/15/1997

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

08/587,731

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/587,731	01/19/96	MARGOLIN	J 002055.P004

B3M1/0723

BLAKELY SOKOLOFF TAYLOR AND ZAFMAN
12400 WILSHIRE BOULEVARD
7TH FLOOR
LOS ANGELES CA 90025

EXAMINER	
NGUYEN, T	
ART UNIT	**PAPER NUMBER**
2304	3

DATE MAILED: 07/23/97

This is a communication from the examiner in charge of your application.
COMMISSIONER OF PATENTS AND TRADEMARKS

OFFICE ACTION SUMMARY

☒ Responsive to communication(s) filed on January 19, 1996

☐ This action is **FINAL**.

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle*, 1935 D.C. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire -3- month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claims

☒ Claim(s) 1-49 ☒ is/are pending in the application.

Of the above, claim(s) _____ is/are withdrawn from consideration.

☐ Claim(s) _____ is/are allowed.

☒ Claim(s) 1-49 is/are rejected.

☐ Claim(s) _____ is/are objected to.

☐ Claims _____ are subject to restriction or election requirement.

Application Papers

☒ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The drawing(s) filed on _____ is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on _____ is ☐ approved ☐ disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) _____.

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: _____.

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☒ Notice of Reference Cited, PTO-892

☒ Information Disclosure Statement(s), PTO-1449, Paper No(s). 2

☐ Interview Summary, PTO-413

☒ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

-- SEE OFFICE ACTION ON THE FOLLOWING PAGES --

DETAILED ACTION

Notice to Applicant(s)

1. This application has been examined. Claims 1-49 are pending.

2. The prior art submitted on January 19, 1996 has been considered.

Drawings

3. The drawings are objected to under 37 CFR § 1.84 for the reasons set forth by the draftsman. See attached PTO-948 form for details. Correction is required. However, correction of the noted defect can be deferred until the application is allowed by the examiner.

Claim Rejections - 35 USC § 102

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. § 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless --
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

5. Claims 1-9, 14-18, 23-32, and 34-45 rejected under 35 U.S.C. § 102(b) as being anticipated by Lyons et al. (an article entitled 'Some Navigation Concepts For Remotely Piloted Vehicles', AGUARD Conference Proceedings No. 176 on Medium Accuracy Low Cost Navigation, September 1975, pages 5-1 to 5-15).

a. With respect to claims 1, 14, and 39, Lyons et al. disclose the invention as claimed (see at least the abstract) including a remotely piloted aircraft (see figure 8, RPV), a communications system for communicating flight data between a computer and said remotely piloted aircraft, said flight data including said remotely piloted aircraft's position and orientation, said flight data also including flight control information for controlling said remotely piloted aircraft (see page 5-2, section Radio Navigation Using a Data Link, and figure 6 and the related text), a digital database comprising terrain data (see pages 5-3 and 5-4, section Terrain Map Correlation; and figure 8). Lyons et al. further disclose that the computer accesses said terrain data according to said remotely piloted aircraft's position and to transform said terrain data to provide three dimensional projected image data according to said remotely piloted aircraft's orientation; a display for displaying said three dimensional projected image data (see page 5-4, third paragraph, and figure 8), and a remote flight control coupled to said computer for inputting said flight control information (see figure 6).

Therefore, all of the limitations of claim 1 are met by Lyons et al.

b. With respect to claim 2, Lyons also disclose that remotely piloted aircraft including a position determining system for locating said remotely piloted aircraft's position in three dimensions and an orientation determining system for determining said remotely piloted aircraft's orientation in three dimensional space (see pages 5-4 and 5-5, section Navigation Accuracy).

c. With respect to claim 3, Lyons et al. disclose that the flight data communicated between said remotely piloted aircraft and said computer is secured (see page 5-2, first paragraph of the Radio Navigation Using Data Link section).

d. With respect to claims 4, 5, 7, and 15, Lyons et al. disclose that said remotely piloted aircraft further comprises a infra red sensor image (video camera) and means for communicating and displaying video data representing images captured by the sensor image (see page 5-3, section Map Matching, and figure 8).

e. With respect to claims 6 and 16, Lyons et al. disclose that the video data is transmitted on a different communication link (wideband transmission of video signals) than said flight data (see page 5-2, first paragraph of section Radio Navigation Using a Data Link).

f. With respect to claims 8, 17, and 44, Lyons et al. disclose that the display is a head mounted display (see figures 5 and 6).

g. With respect to claims 9, 18, and 45, Lyons et al. also disclose that the

remote flight control is responsive to manual manipulations (see figure 6).

h. With respect to claim 23, Lyons et al. disclose that the communications unit includes at least one of a communications transceiver and a simulation port (see page 5-4 and figure 6).

i. With respect to claim 24, Lyons et al. further disclose that the database representing terrain using polygons (see figure 10).

j. With respect to claims 25-28 and 30-31, the limitations of these claims have been noted in the rejection above. They are therefore considered rejected as set forth above.

k. With respect to claim 29, wherein said video data is transmitted real-time (see page 5-3, first paragraph of the section Map Matching).

l. Claims 32 and 34-38 are method claims corresponding to apparatus claims 24-31. Therefore, claims 32 and 34-38 are rejected for the same rationales set forth for claims 24-31.

m. With respect to claim 40-42, Lyons et al. disclose that the simulation unit includes a network interface configured to communicate battlefield simulation information with a simulation network, said communications system also configured to communicate said battlefield simulation information between said simulation unit and said computer, said computer also configured to display one or more other simulated

entities described by said battlefield simulation information (see the Introduction, Terrain Map Correlation sections, and figures 7, 9).

n. With respect to claim 43, Lyons et al. disclose that the simulation unit further comprises an aerodynamic model processor for aiding in simulating said remotely piloted aircraft (see page 5-4, second paragraph).

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. Claims 10, 11, 19, 20, 33, 46, and 47 are rejected under 35 U.S.C. 103(a) as

being unpatentable over Lyons et al. as applied to claims 1-9, 14-18, 23-32, and 34-45, and further in view of Kanaly (4,405,943).

Lyons et al. disclose the claimed invention as discussed above except for the determination of a delay time for communicating said flight data between said computer and said remotely piloted aircraft, and adjusting the sensitivity of said set of one or more remote flight controls based on said delay time. However, Kanaly does suggest delay time for communicating between the ground station and the remote airborne into account of controlling the remote airborne (see at least column 3, lines 15-24, and column 8, line 54 to column 9, line 6). It would have been obvious to incorporate the teaching of Kanaly into the system of Lyons et al. in order to improve the system with the enhanced capability of providing more accurate the remote flight controls to the remoted vehicle and receiving the accurate position and heading data of the vehicle from the remoted vehicle.

8. Claims 12-13, 21-22, and 48-49, rejected under 35 U.S.C. 103(a) as being unpatentable over Lyons et al. as applied to claims 1-9, 14-18, 23-32, and 34-45 above, and further in view of Thornberg et al. (5,552,983).

Lyons et al. disclose the claimed invention as discussed above except that the remote flight controls allows for inputting absolute pitch and roll angles. However,

such feature is well known in the art at the time the invention was made. For example, Thornberg et al. suggest a variable referenced control system for remotely operated vehicles which includes means for inputting absolute pitch and roll angles for remotely control the unmanned aerial vehicle (see at least figures 5 and 6). It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Thornberg et al. into the system of Lyons et al. in order to input the pitch and roll control signals as the flight control signals for remotely control the vehicle.

Conclusion

9. All claims are rejected.

10. The following references are cited as being of general interest: Diamantides (3,742,495), Brocard et al. (4,218,702), Narendra et al. (4,855,822), Loard (5,015,187), Fitzpatrick et al. (5,072,396), Rahim (5,155,683), Eiband et al. (5,240,207), Steinitz et al. (5,266,799), and Khvilivitky.

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Tan Nguyen, whose telephone number is (703) 305-9755. The examiner can normally be reached on Monday-Thursday from

7:30 AM-5:00 PM. The examiner can also be reached on alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kevin J. Teska, can be reached on (703) 305-9704.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 305-3800.

Any response to this action should be mailed to:

Commissioner of Patents and Trademarks
Washington, D.C. 20231

or faxed to:

(703) 308-9051, (for formal communications intended for entry)

Or:

(703) 308-5357 (for informal or draft communications, please label "PROPOSED" or "DRAFT")

Hand-delivered responses should be brought to Crystal Park II, 2121 Crystal Drive, Arlington. VA., Sixth Floor (Receptionist).

/tqn
July 18, 1997

TAN Q. NGUYEN
PATENT EXAMINER
GROUP 2300

Notice of References Cited

Application No.	Applicant(s)		
08/587,731	MARGOLIN		
Examiner		**Group Art Unit**	**Page** 1 of 1
TAN NGUYEN		2304	

U.S. PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	NAME	CLASS	SUBCLASS
	A	3,742,495	06/1973	DIAMANTIDES	342	64
	B	4,218,702	08/1980	BROCARD ET AL.	348	144
	C	4,855,822	08/1989	NAREDRA ET AL.	364	423.099
	D	5,015,187	05/1991	LORD	364	462
	E	5,072,396	12/1991	FITZPATRICK ET AL.	364	450
	F	5,155,683	10/1992	RAHIM	364	424.029
	G	5,240,207	08/1993	EIBAND ET AL.	364	423.099
	H	5,266,799	11/1993	STEINITZ ET AL.	324	330
	I	5,552,983	09/1996	THORNBERG ET AL.	364	424.027
	J	5,581,250	12/1996	KHVILIVITSKY	340	961
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	COUNTRY	NAME	CLASS	SUBCLASS
	N						
	O						
	P						
	Q						
	R						
	S						
	T						

NON-PATENT DOCUMENTS

*		DOCUMENT (Including Author, Title, Source, and Pertinent Pages)	DATE
	U		
	V		
	W		
	X		

* A copy of this reference is not being furnished with this Office action.
(See Manual of Patent Examining Procedure, Section 707.05(a).)

Form PTO 948 (Rev. 10-94) U.S. DEPARTMENT OF COMMERCE - Patent and Trademark Office Application No. 587731

NOTICE OF DRAFTSPERSON'S PATENT DRAWING REVIEW

PTO Draftpersons review all originally filed drawings regardless of whether they are designated as formal or informal. Additionally, patent Examiners will review the drawings for compliance with the regulations. Direct telephone inquiries concerning this review to the Drawing Review Branch, 703-305-8404.

The drawings filed (insert date) 1/19/96 are
A. ___ not objected to by the Draftsperson under 37 CFR 1.84 or 1.152.
B. X objected to by the Draftsperson under 37 CFR 1.84 or 1.152 as indicated below. The Examiner will require submission of new, corrected drawings when necessary. Corrected drawings must be submitted according to the instructions on the back of this Notice.

1. DRAWINGS. 37 CFR 1.84(a): Acceptable categories of drawings: Black ink. Color.
   - ___ Not black solid lines. Fig(s)___
   - ___ Color drawings are not acceptable until petition is granted. Fig(s) ___
2. PHOTOGRAPHS. 37 CFR 1.84(b)
   - ___ Photographs are not acceptable until petition is granted. Fig(s) ___
   - ___ Photographs not properly mounted (must use brystol board or photographic double-weight paper). Fig(s)___
   - ___ Poor quality (half-tone). Fig(s)___
3. GRAPHIC FORMS. 37 CFR 1.84 (d)
   - ___ Chemical or mathematical formula not labeled as separate figure. Fig(s)___
   - ___ Group of waveforms not presented as a single figure, using common vertical axis with time extending along horizontal axis. Fig(s)___
   - ___ Individuals waveform not identified with a separate letter designation adjacent to the vertical axis. Fig(s)___
4. TYPE OF PAPER. 37 CFR 1.84(c)
   - ___ Paper not flexible, strong, white, smooth, nonshiny, and durable. Sheet(s)___
   - ___ Erasures, alterations, overwritings, interlineations, cracks, creases, and folds copy machine marks not accepted. Fig(s) ___
   - ___ Mylar, velum paper is not acceptable (too thin). Fig(s) ___
5. SIZE OF PAPER. 37 CFR 1.84(f): Acceptable sizes:
   - 21.6 cm. by 35.6 cm. (8 1/2 by 14 inches)
   - 21.6 cm. by 33.1 cm. (8 1/2 by 13 inches)
   - 21.6 cm. by 27.9 cm. (8 1/2 by 11 inches)
   - 21.0 cm. by 29.7 cm. (DIN size A4)
   - ___ All drawing sheets not the same size. Sheet(s)___
   - ___ Drawing sheet not an acceptable size. Sheet(s) ___
6. MARGINS. 37 CFR 1.84(g): Acceptable margins:

Paper size

21.6 cm. X 35.6 cm. (8 1/2 X 14 inches)	21.6 cm X 33.1 cm. (8 1/2 X 13 inches)	21.6 cm. X 27.9 cm. (8 1/2 X 11 inches)	21.0 cm. X 29.7 cm. (DIN Size A4)
T 5.1 cm. (2")	2.5 cm. (1")	2.5 cm. (1")	2.5cm.
L .64 cm. (1/4")	.64 cm. (1/4")	.64 cm. (1/4")	2.5 cm.
R .64 cm. (1/4")	.64 cm. (1/4")	.64 cm. (1/4")	1.5 cm.
B .64 cm. (1/4")	.64 cm. (1/4")	.64 cm. (1/4")	1.0 cm.

Margins do not conform to chart above. Sheet(s)___
___Top (T) ___Left (L) ___Right (R) ___Bottom (B)

7. VIEWS. 37 CFR 1.84(h)
   REMINDER: Specification may require revision to correspond to drawing changes.
   - ___ All views not grouped together. Fig(s)___
   - ___ Views connected by projection lines or lead lines. Fig(s)___
   - Partial views. 37 CFR 1.84(h) 2
   - ___ View and enlarged view not labled separatly or properly Fig(s)___
   - Sectional views. 37 CFR 1.84 (h) 3
   - ___ Hatching not indicated for sectional portions of an object Fig(s)___
   - ___ Cross section not drawn same as view with parts in cross section with regularly spaced parallel oblique strokes. Fig(s)___
8. ARRANGEMENT OF VIEWS. 37 CFR 1.84(i)
   - ___ Words do not appear on a horizontal, left-to-right fashion when page is either upright or turned so that the top becomes the right side, except for graphs. Fig(s)___
9. SCALE. 37 CFR 1.84(k)
   - ___ Scale not large enough to show mechanism with crowding when drawing is reduced in size to two-thirds in reproduction. Fig(s)___
   - ___ Indication such as "actual size" or scale 1/2" not permitted. Fig(s)___
10. CHARACTER OF LINES, NUMBERS, & LETTERS. 37 CFR 1.84(l)
    - ___ Lines, numbers & letters not uniformly thick and well defined, clean, durable, and black (except for color drawings). Fig(s)___
11. SHADING. 37 CFR 1.84(m)
    - X Solid black shading areas not permitted. Fig(s) 7
    - ___ Shade lines, pale, rough and blurred. Fig(s)___
12. NUMBERS, LETTERS, & REFERENCE CHARACTERS. 37 CFR 1.84(p)
    - ___ Numbers and reference characters not plain and legible. 37 CFR 1.84(p)(1) Fig(s)___
    - ___ Numbers and reference characters not oriented in same direction as the view. 37 CFR 1.84(p)(1) Fig(s)___
    - ___ English alphabet not used. 37 CFR 1.84(p)(2) Fig(s)___
    - ___ Numbers, letters, and reference characters do not measure at least .32 cm. (1/8 inch) in height. 37 CFR(p)(3) Fig(s)___
13. LEAD LINES. 37 CFR 1.84(d)
    - ___ Lead lines cross each other. Fig(s)___
    - ___ Lead lines missing. Fig(s)___
14. NUMBERING OF SHEETS OF DRAWINGS. 37 CFR 1.84(t)
    - ___ Sheets not numbered consecutively, and in Arabic numerals, beginning with number 1. Sheet(s)___
15. NUMBER OF VIEWS. 37 CFR 1.84(u)
    - ___ Views not numbered consecutively, and in Arabic numerals, beginning with number 1. Fig(s)___
    - ___ View numbers not preceded by the abbreviation Fig. Fig(s)___
16. CORRECTIONS. 37 CFR 1.84(w).
    - ___ Corrections not made from prior PTO-948. Fig(s)___
17. DESIGN DRAWING. 37 CFR 1.152
    - ___ Surface shading shown not appropriate. Fig(s)___
    - ___ Solid black shading not used for color contrast. Fig(s)___

COMMENTS:

3

ATTACHMENT TO PAPER NO. ___ REVIEWER ACE DATE 3/13/96

PTO Copy

08/587,731

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

NM

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/587,731	01/19/96	MARGOLIN J	002055.P004

B3M1/0912

BLAKELY SOKOLOFF TAYLOR AND ZAFMAN
12400 WILSHIRE BOULEVARD
7TH FLOOR
LOS ANGELES CA 90025

EXAMINER	
NGUYEN, T	PAPER NUMBER 4

DATE MAILED: 09/12/97

EXAMINER INTERVIEW SUMMARY RECORD

All participants (applicant, applicant's representative, PTO personnel):

(1) DANIEL DE VOS (3) _____

(2) TAN NGUYEN (4) _____

Date of interview 09/11/97

Type: ☒ Telephonic ☐ Personal (copy is given to ☐ applicant ☐ applicant's representative).

Exhibit shown or demonstration conducted: ☒ Yes ☐ No. If yes, brief description: _____

Agreement ☒ was reached with respect to some or all of the claims in question. ☐ was not reached.

Claims discussed: 1-49

Identification of prior art discussed: Lyons et al. (an article entitled "Some Navigational Concepts For Remoted Piloted Vehicles").

Description of the general nature of what was agreed to if an agreement was reached, or any other comments: The reference has been discussed. Examiner agreed to reconsider the application in light of the above discussion and the formal amendment

(A fuller description, if necessary, and a copy of the amendments, if available, which the examiner agreed would render the claims allowable must be attached. Also, where no copy of the amendments which would render the claims allowable is available, a summary thereof must be attached.)

Unless the paragraphs below have been checked to indicate to the contrary, A FORMAL WRITTEN RESPONSE TO THE LAST OFFICE ACTION IS NOT WAIVED AND MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW (e.g., items 1-7 on the reverse side of this form). If a response to the last Office action has already been filed, then applicant is given one month from this interview date to provide a statement of the substance of the interview.

☒ It is not necessary for applicant to provide a separate record of the substance of the interview.

☐ Since the examiner's interview summary above (including any attachments) reflects a complete response to each of the objections, rejections and requirements that may be present in the last Office action, and since the claims are now allowable, this completed form is considered to fulfill the response requirements of the last Office action.

Tan Nguyen
Examiner's Signature

PTOL-413 (REV. 1-94)

ORIGINAL FOR INSERTION IN RIGHT HAND FLAP OF FILE WRAPPER

002055.P004 Patent

5/A
gmm
10-5-97

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Jed Margolin

Serial No. 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft

Examiner: T. Nguyen

Art Unit: 2304

Assistant Commissioner for Patents
Washington, D.C. 20231

AMENDMENT AND REMARK

Sir:

Responsive to the Office Action mailed on July 23, 1997, the Applicant respectfully requests the Examiner to enter the following amendment and to consider the following remark:

AMENDMENT

In the Claims:

Please cancel Claims 39-49, without prejudice.

I hereby certify that this correspondence is being transmitted by facsimile to the United States Patent and Trademark Office in accordance with 37 CFR § 1.6(d), on the date shown below.

Name: Constance Van Dalen

Signature: Constance Van Dalen

Date: September 11, 1997

08/587,731

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
A Limited Liability Partnership Including Law Corporations

1279 Oakmead Parkway
Sunnyvale, California 94086
(408) 720-8598 Telephone
(408) 720-9397 Facsimile

OFFICIAL

Facsimile Transmittal Sheet

#5

Date: 9/11/97

URGENT

Deliver to Examiner: Tan Nguyen

Fax No. (703) 308-9051

FROM BSTZ:	**U.S. PATENT & TRADEMARK OFFICE**
Attorney: Daniel De Vos	**Art Unit:** 2304
Reg. No.: 37,813	**Serial No.:** 08/587,731
Phone No. (408) 720-8598	**Filing Date:** 01-19-96
Operator: Conny Van Dalen	
Page 1 of 14	

Message:

FAX RECEIVED
SEP 30 1997
GROUP 2600

Certificate of Facsimile Transmission

I hereby certify that this correspondence is being transmitted by facsimile to the Patent and Trademarks Office in accordance with 37 CFR § 1.6(d), on 9/11/97

Constance VanDalen 9-11-97

Signature *Date*

Attorney's Docket No.: 002055.P004 Patent

In re the Application of: Jed Margolin
(inventor(s))

Application No.: 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft
(title)

ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

SIR: Transmitted herewith is an Amendment for the above application.

_____ Small entity status of this application under 37 C.F.R. §§ 1.9 and 1.27 has been established by a verified statement previously submitted.

_____ A verified statement to establish small entity status under 37 C.F.R. §§ 1.9 and 1.27 is enclosed.

__X__ No additional fee is required.

The fee has been calculated as shown below:

	(Col. 1) Claims Remaining After Amd.		(Col. 2) Highest No. Previously Paid For	(Col. 3) Present Extra	SMALL ENTITY Rate	SMALL ENTITY Additional Fee	OTHER THAN A SMALL ENTITY Rate	OTHER THAN A SMALL ENTITY Additional Fee
Total Claims	* 38	Minus	** 49	0	x11	$	x22	$ 0
Indep. Claims	* 4	Minus	*** 5	0	x40	$	x80	$ 0
[ ] First Presentation of Multiple Dependent Claim(s)					+130	$	+260	$
					Total Add. Fee	$	Total Add. Fee	$ 0

* If the entry in Col. 1 is less than the entry in Col. 2, write "0" in Col. 3.

** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.

*** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space. The "Highest No. Previously Paid For" (Total or Independent) is the highest number found from the equivalent box in Col. 1 of a prior amendment or the number of claims originally filed.

I hereby certify that this correspondence is being transmitted by facsimile to the United States Patent and Trademark Office in accordance with 37 CFR § 1.6(d), on the date shown below.

Name: Constance Van Dalen

Signature: Constance Van Dalen

Date: September 11, 1997

(LJV/cak 10/25/96)

_____ A check in the amount of $_____ is attached for presentation of additional claim(s).
_____ Applicant(s) hereby Petition(s) for an Extension of Time of _____ month(s) pursuant to 37 C.F.R. § 1.136(a).
_____ A check for $_____ is attached for processing fees under 37 C.F.R. § 1.17.
_____ Please charge my Deposit Account No. 02-2666 the amount of $_____.
A duplicate copy of this sheet is enclosed.
__X__ The Commissioner of Patents and Trademarks is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 02-2666 **(a duplicate copy of this sheet is enclosed)**:
__X__ Any additional filing fees required under 37 C.F.R. § 1.16 for presentation of extra claims.
__X__ Any extension or petition fees under 37 C.F.R. § 1.17.

BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP

Date: 9/4, 1997

Daniel M. De Vos

Reg. No. 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025
(408) 720-8598

(LJV/cak 10/25/96)

Attorney's Docket No.: 002055.P004 Patent

In re the Application of: Jed Margolin
(inventor(s))

Application No.: 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft
(title)

ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

SIR: Transmitted herewith is an Amendment for the above application.

____ Small entity status of this application under 37 C.F.R. §§ 1.9 and 1.27 has been established by a verified statement previously submitted.
____ A verified statement to establish small entity status under 37 C.F.R. §§ 1.9 and 1.27 is enclosed.
_X_ No additional fee is required.

The fee has been calculated as shown below:

	(Col. 1) Claims Remaining After Amd.		(Col. 2) Highest No. Previously Paid For	(Col. 3) Present Extra	SMALL ENTITY Rate	SMALL ENTITY Additional Fee	OTHER THAN A SMALL ENTITY Rate	OTHER THAN A SMALL ENTITY Additional Fee
Total Claims	* 38	Minus	** 49	0	x11	$	x22	$ 0
Indep. Claims	* 4	Minus	*** 5	0	x40	$	x80	$ 0
____	First Presentation of Multiple Dependent Claim(s)				+130	$	+260	$
					Total Add. Fee	$	Total Add. Fee	$ 0

* If the entry in Col. 1 is less than the entry in Col. 2, write "0" in Col. 3.

** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.

*** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space. The "Highest No. Previously Paid For" (Total or Independent) is the highest number found from the equivalent box in Col. 1 of a prior amendment or the number of claims originally filed.

I hereby certify that this correspondence is being transmitted by facsimile to the United States Patent and Trademark Office in accordance with 37 CFR § 1.6(d), on the date shown below.

Name: Constance Van Dalen

Signature: Constance Van Dalen

Date: September 11, 1997

(LJV/cak 10/25/96)

_____ A check in the amount of $_____ is attached for presentation of additional claim(s).
_____ Applicant(s) hereby Petition(s) for an Extension of Time of _____ month(s) pursuant to 37 C.F.R. § 1.136(a).
_____ A check for $_____ is attached for processing fees under 37 C.F.R. § 1.17.
_____ Please charge my Deposit Account No. 02-2666 the amount of $_____.
A duplicate copy of this sheet is enclosed.
__X__ The Commissioner of Patents and Trademarks is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 02-2666 **(a duplicate copy of this sheet is enclosed)**:
__X__ Any additional filing fees required under 37 C.F.R. § 1.16 for presentation of extra claims.
__X__ Any extension or petition fees under 37 C.F.R. § 1.17.

Date: 9/11, 1997

BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP

ORIGINAL SIGNED BY

Daniel M. De Vos DMD

Reg. No. 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025
(408) 720-8598

(LJV/cak 10/25/96)

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
08/587,731	01/19/96	MARGOLIN	002055.P004

B3M1/1014

BLAKELY SOKOLOFF TAYLOR AND ZAFMAN
12400 WILSHIRE BOULEVARD
7TH FLOOR
LOS ANGELES CA 90025

EXAMINER	
NGUYEN, T	
ART UNIT	**PAPER NUMBER**
2304	6

DATE MAILED: 10/14/97

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
ASSISTANT SECRETARY AND COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAME APPLICANT	ATTORNEY DOCKET NO.
08/587,731	01/19/96	MARGOLIN	002055.P004

BLAKELY SOKOLOFF TAYLOR AND ZAFMAN
1240 WILSHIRE BOULEVARD
7TH FLOOR
LOS ANGELES, CA 90025

EXAMINER	
TAN Q. NGUYEN	
ART UNIT	PAPER NUMBER
2304	6

DATE MAILED:

Please find below a communication from the Examiner in charge of this application.

Commissioner of Patents and Trademarks.

The communication filed on October 05, 1997 is non-responsive because it fails to include a complete or accurate record of the substance of the September 11, 1997 interview. There is no argument or discussion about the difference between claimed invention and the references cited in the amendment (the amendment contain only the request for canceling claims 39-49).

Applicant is given a **ONE MONTH** TIME LIMIT from the date of this letter, or until the expiration of the period for response set in the last office action, whichever is longer, to complete the response. NO EXTENSION OF THIS TIME LIMIT MAY BE GRANTED UNDER EITHER 37 CFR 1.136(a) OR (b).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Tan Nguyen, whose telephone number is (703) 305-9755. The examiner can normally be reached on Monday-Thursday from 7:30 AM-6:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kevin J. Teska, can be reached on (703) 305-9704.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 305-3900.

Tan Nguyen

TAN Q. NGUYEN
PATENT EXAMINER
GROUP 2300

TAN NGUYEN
October 10, 1997

Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Jed Margolin

Serial No. 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft

Examiner: T. Nguyen

Art Unit: 2304

RECEIVED
OCT 21 1997
GROUP 2300

Assistant Commissioner for Patents
Washington, D.C. 20231

AMENDMENT AND REMARK

Sir:

Responsive to the Office Action mailed on July 23, 1997, the Applicant respectfully requests the Examiner to enter the following amendment and to consider the following remark:

AMENDMENT

In the Claims:

Please cancel Claims 39-49, without prejudice.

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail with sufficient postage in an envelope addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231

on 10/21/97
Date of Deposit

Name of Person Mailing Correspondence

Signature

10/21/97
Date

REMARK

Applicant respectfully requests reconsideration of this application as amended.

35 U.S.C. §102 rejection

The Examiner has rejected claims 1-9, 14-18, 23-32, and 34-45 under 35 U.S.C. §102(b) as being anticipated by Lyons, et al., "Some Navigation Concepts for Remotely Piloted Vehicles."

1. Summary of Lyons

Applicant would like to thank the Examiner for taking the time during the telephone interview to discuss the Lyons reference. Lyons contemplates a remotely piloted vehicle (RPV) transmitting information to a control center (Figure 1),used by the pilot to fly the RPV. To display the position of the RPV to the pilot, the control center provides a "moving map display." As contemplated by Lyons, "the most convenient display mode for the present application is the rolling map or 'passing scene' technique where a new line is added to the top of the display and the scene is shifted slowly downwards" (page 5-3, end of first full paragraph). In particular, Lyons contemplates using film to generate the moving map (Figure 5). The moving map is moved based on dead reckoned positions of the RPV.

As is well known in the art, dead reckoned positions have accumulating error. To correct for this error, Lyons describes two basic concepts: 1) "map matching" (Section 3); and 2) "terrain map correlation" (Section 4). The map matching concept requires that the RPV transmit some kind of image data to the control center. Thus, in addition to the moving map display, the control center shown in Figure 6 has a sensor display (i.e., a display generated from the image data transmitted by the RPV). Lyons contemplates the transmission of two kinds of image data generated by: 1) side looking radar (SLR)

images; and 2) real time forward-looking sensors. When using the SLR system, the SLR generated image data received by the control center allows it to make a downward-looking image. The pilot watches the sensor display (i.e., the display generated based on the transmitted image data) for "likely update features"—landmarks. When the pilot sees a landmark in the sensor display, the pilot presses a transfer button which causes the control center to superimpose the sensor display over the moving map (Figure 5). The pilot then adjusts the moving map so that it matches the overlaid sensor display image and presses an accept button. By adjusting the moving map in this manner, the dead reckoned position of the RPV is updated in an attempt to remove the error associated with the calculation of dead reckoned positions (Page 5-3, second, third, and fourth full paragraphs). The simulated SLR/map update system is illustrated in Figures 7A and 7B.

Having described the SLR-based map matching technique, the real time forward-looking sensor systems will now be described. Lyons describes basically two systems for updating dead reckoned RPV positions on a moving map using only real time forward-looking sensors: 1) an anamorphic projection system (page 5-3, fifth full paragraph; figure 8); and 2) a HUD based system (page 5-3, sixth full paragraph; figure 9). Similar to the SLR based system, the anamorphic projection system requires the pilot to watch the sensor display (i.e., the image generated from the transmitted data) for landmarks, press a button which superimposes the transmitted image on the moving map, adjust the moving map, and press an accept button. As described in Lyons, in order to superimpose the forward-looking transmitted image on the two-dimensional/top-down moving map image, the forward-looking image is transformed using anamorphic projection. Lyons goes on to describe various problems with the anamorphic projection technique, and then describes the HUD based system.

In the HUD based system, the pilot is presented with two images: 1) the moving map display (see left-hand image of Figure 9); and 2) the sensor display generated from the image data transmitted from the real time forward-looking sensor on the RPV. The HUD technology is used to allow the pilot to mark landmarks on the forward-looking sensor based image. These HUD markings are then superimposed on the moving map, and the pilot makes the necessary adjustments to the moving map (page 5-3, sixth full paragraph).

In summary, the map matching techniques use the following: 1) the transmission of image data from the RPV to the control center; 2) a display at the control center which shows an image based on the real time image data received from the RPV; 3) a moving map display that is moved based on the dead reckoned position of the RPV; and 4) some manner of superimposing the sensor image onto the moving map to allow the pilot to update the moving map in an effort to correct the error associated with the dead reckoned positions. Neither the sensor display's image nor the moving map can be equated to the generation of "a three-dimensional projected image" generated based upon "a digital database" stored in the control center. The sensor display's image is based on image data transmitted from the RPV, while the moving map contemplated by Lyons is a two-dimensional, top-down view displayed using film (see Figures 5 and 7).

Having described the map matching techniques from Lyons, Applicant will now describe the terrain map correlation technique of Lyons. The terrain map correlation technique described in Lyons is also used for correcting the error in dead reckoned positions shown to the pilot by a two-dimensional moving map. In particular, Lyons states at page 5-3, last paragraph:

> Reconisance or forward-looking sensors provide a convenient method of updating the navigation system. However, these sensors required large datalink bandwidth to transmit the video picture to the control center and

> hence are vulnerable to ECM... Hence, an alternative method of updating the navigation system is desirable. (emphasis added)

The phrase "updating the navigation system" is used throughout Lyons to refer to the adjustment of a two-dimensional moving map in an effort to correct for error due to dead reckoning.

Rather than requiring the user to actively update the moving map display (i.e., push a button which causes the images to be superimposed, adjusting the moving map, and pushing an accept button), the terrain map correlation technique attempts to adjust the moving map (i.e., correct for the dead reckoned error) without pilot intervention using a laser range measurements and a digital elevation database. In operation, the RPV transmits to the control center a set of laser range measurements (including an altimeter reading). The control center uses dead reckoned positions to both adjust the two-dimensional moving map and to estimate the location of the RPV over a digital database map of elevation points stored in the control center (Figure 10). Based on a calculation of the possible error associated with the dead reckoned positions, a search area is identified in the digital database (Figure 12). A search is then performed within this search area to identify the position that most closely matches the transmitted laser range data. The RPV's position is then updated to the location that best matches the transmitted laser ranges in an attempt to correct the error associated with the dead reckoned positions. The moving map is then automatically adjusted (without pilot intervention) to reflect the updated RPV position.

Thus, the digital database of Lyons (conceptually illustrated in Figure 10) is not used to generate a three-dimensional projected image, but is used to update the two-dimensional moving map in an effort to correct for the error in the dead reckoned positions. In addition to the description in Lyons, further support for the fact that the digital database of Lyons is not used to generate a three-dimensional projected image is

that the image of Figure 10 is generated using square polygons. Square polygons are not plainer, and therefore, typically are not used for generating images. In contrast, triangular polygons are plainer and are typically used for displaying three-dimensional projected images.

2. Lyons Does Not Teach or Make Obvious the Claimed Inventions

In contrast to the teachings of Lyons, claim 1 requires the use of a digital database stored in the control center, and a computer that transforms the database "to provide three-dimensional projected" images based on the position and orientation data received from the RPV. Thus, the digital database of claim 1 is used to generate a three-dimensional projected image for the pilot, whereas: 1) the moving map of Lyons is a two-dimensional image generated using film; and 2) the digital database of Lyons is used for updating the two-dimensional moving map to correct for error associated with the dead reckoned positions, not for display.

Similarly, independent claim 14 requires a database comprising terrain data and a computer "configured to access said terrain data according to "information identifying the remotely piloted craft's position and orientation in three-dimensional space" and configured to transform said terrain data to provide three-dimensional projected image data representing said remotely piloted aircraft's environment." Furthermore, claim 14 requires a display to display the three-dimensional image data.

Independent claim 24 covers a remotely piloted aircraft having a communication system for transmitting the remotely piloted aircraft's position and orientation to a pilot station "for transformation into a three-dimensional projected image of said remotely piloted aircraft's environment according to a database representing real terrestrial terrain using polygons."

Finally, independent method claim 32 requires: 1) "communicating said current position and orientation from said remotely piloted craft to a pilot station;" 2) "accessing a database comprising terrain data that represents real terrestrial terrain as a set of polygons;" 3) "transforming said terrain data into image data representing a simulated three-dimensional view according to the current position and orientation of said remotely piloted aircraft;" and 4) "displaying said three-dimensional view using said image data."

The remaining pending claims are each dependent on one of the allowable base claims 1, 14, 24, and 32. For at least these reasons, Applicant respectfully submits that this rejection has been overcome.

35 U.S.C. §103 rejection, over Lyons, et al. in view of Kanaly (US Patent 4,405,943)

The Examiner has rejected Claims 10, 11, 19, 20, 33, 46-47 under 35 U.S.C. §103 as being obvious over Lyons, et al. ("Lyons") in view of Kanaly (US Patent 4,405,943). Claims 10, 11, 19, 20 and 33 are each dependent on one of the allowable base claims 1, 14, 24, and 32. Claims 46 and 47 have been canceled (without prejudice). For at least this reason, Applicant respectfully submits that this rejection has been overcome with respect to claims 10, 11, 19, 20 and 33.

35 U.S.C. §103 rejection, over Lyons, et al. in view of Thornberg, et al. (US Patent 5,552,983)

The Examiner has rejected Claims 12-13, 21-22, and 48-49 under 35 U.S.C. §103 as being obvious over Lyons, et al. ("Lyons") in view of Thornberg, et al. (US Patent 5,552,983) Claims 12, 13, 21-22 are each dependent on one of the allowable base claims 1 and 14. Claims 48 and 49 have been canceled (without prejudice). For at least this

reason, Applicant respectfully submits that this rejection has been overcome with respect to claims 12, 13, 21, and 22.

Conclusion

Applicant respectfully submits that the rejections have been overcome by the amendments and remarks, and that the Claims are now in condition for allowance. Accordingly, Applicant respectfully requests the rejections be withdrawn and the Claims as amended be allowed.

Drawing Corrections

The drawings have been objected to by the draftsman. The Applicant will file amended drawings at the time of allowance of the present application.

Invitation for a telephone interview

The Examiner is invited to call the undersigned at 408-720-8598 if there remains any issue with allowance of this case.

Charge our Deposit Account

Please charge any shortage to our Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: 10/21, 1997

Daniel M. De Vos
Reg. No. 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025-1026
(408) 720-8598

BLAKELY SOKOLOFF TAYLOR & ZAFMAN
A Limited Liability Partnership Including Law Corporations

1279 Oakmead Pa y
Sunnyvale, California 94086
(408) 720-8598 Telephone
(408) 720-9397 Facsimile

Facsimile Transmittal Sheet

#7

RECEIVED
OCT 21 1997
GROUP 2300

Date: 10/21/97

URGENT

Deliver to: Tan Nguyen

Fax No. (703) 308-5358

FROM BSTZ:

From: Daniel De Vos
Operator: Dawn Roberts
Page 1 of 14

To Firm: U.S. PATENT AND TRADEMARK OFFICE
Phone:
Your Ref: Applic. No.: 08/587,731
Our Ref: 002055.P004
Title: A METHOD AND APPARATUS FOR REMOTELY PILOTING AN AIRCRAFT

Message:

As agreed, Applicant is resubmitting the response previously faxed on September 11, 1997. To complete the record, following is a brief summary of the reasons (as understood by the Applicant) for resubmitting the response:

On September 11, 1997 applicant faxed 14 pages to the Patent and Trademark Office. These 14 pages included a fax cover page, two copies of a two page Transmittal letter, and a nine page response. In response, Applicant received a paper mailed on September 12, 1997 indicating that applicants response was non-responsive. In a telephone discussion, it was determined that only one page of applicants nine page response was actually received.

Sincerely,

Daniel M. De Vos

RECEIVED
OCT 2 1 1997
GROUP 2300

Attorney's Docket No.: 002055.P004 Patent

In re the Application of: Jed Margolin
(inventor(s))

Application No.: 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft

(title)

ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

SIR: Transmitted herewith is an Amendment for the above application.

_____ Small entity status of this application under 37 C.F.R. §§ 1.9 and 1.27 has been established by a verified statement previously submitted.

_____ A verified statement to establish small entity status under 37 C.F.R. §§ 1.9 and 1.27 is enclosed.

__X__ No additional fee is required.

The fee has been calculated as shown below:

	(Col. 1) Claims Remaining After Amd.		(Col. 2) Highest No. Previously Paid For	(Col. 3) Present Extra
Total Claims	* 38	Minus	** 49	0
Indep. Claims	* 4	Minus	*** 5	0
____	First Presentation of Multiple Dependent Claim(s)			

	SMALL ENTITY Rate	Additional Fee	OTHER THAN A SMALL ENTITY Rate	Additional Fee
	x11	$	x22	$ 0
	x40	$	x80	$ 0
	+130	$	+260	$
	Total Add. Fee	$	Total Add. Fee	$ 0

* If the entry in Col. 1 is less than the entry in Col. 2, write "0" in Col. 3.

** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.

*** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space. The "Highest No. Previously Paid For" (Total or Independent) is the highest number found from the equivalent box in Col. 1 of a prior amendment or the number of claims originally filed.

I hereby certify that this correspondence is being transmitted by facsimile to the United States Patent and Trademark Office in accordance with 37 CFR § 1.6(d), on the date shown below.

Name: Dawn Roberts

Signature: Dawn Roberts

Date: 10/21/97

(LJV/cak 10/25/96)

_____ A check in the amount of $_____ is attached for presentation of additional claim(s).
_____ Applicant(s) hereby Petition(s) for an Extension of Time of _____ month(s) pursuant to 37 C.F.R. § 1.136(a).
_____ A check for $_____ is attached for processing fees under 37 C.F.R. § 1.17.
_____ Please charge my Deposit Account No. 02-2666 the amount of $_____.
A duplicate copy of this sheet is enclosed.
__X__ The Commissioner of Patents and Trademarks is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 02-2666 **(a duplicate copy of this sheet is enclosed)**:
__X__ Any additional filing fees required under 37 C.F.R. § 1.16 for presentation of extra claims.
__X__ Any extension or petition fees under 37 C.F.R. § 1.17.

BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP

Date: 10/21, 1997

Daniel M. De Vos

Reg. No. 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025
(408) 720-8598

(LJV/cak 10/25/96)

Attorney's Docket No.: 002055.P004 Patent

In re the Application of: Jad Margolin
(inventor(s))

Application No.: 08/587,731

Filed: January 19, 1996

For: A Method and Apparatus for Remotely Piloting an Aircraft
(title)

ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

SIR: Transmitted herewith is an Amendment for the above application.

_____ Small entity status of this application under 37 C.F.R. §§ 1.9 and 1.27 has been established by a verified statement previously submitted.

_____ A verified statement to establish small entity status under 37 C.F.R. §§ 1.9 and 1.27 is enclosed.

__X__ No additional fee is required.

The fee has been calculated as shown below:

	(Col. 1) Claims Remaining After Amd.		(Col. 2) Highest No. Previously Paid For	(Col. 3) Present Extra	SMALL ENTITY Rate	SMALL ENTITY Additional Fee	OTHER THAN A SMALL ENTITY Rate	OTHER THAN A SMALL ENTITY Additional Fee
Total Claims	* 38	Minus	** 49	0	x11	$	x22	$ 0
Indep. Claims	* 4	Minus	*** 5	0	x40	$	x80	$ 0
____ First Presentation of Multiple Dependent Claim(s)					+130	$	+260	$
					Total Add. Fee	$	Total Add. Fee	$ 0

* If the entry in Col. 1 is less than the entry in Col. 2, write "0" in Col. 3.

** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.

*** If the "Highest No. Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space. The "Highest No. Previously Paid For" (Total or Independent) is the highest number found from the equivalent box in Col. 1 of a prior amendment or the number of claims originally filed.

I hereby certify that this correspondence is being transmitted by facsimile to the United States Patent and Trademark Office in accordance with 37 CFR § 1.6(d), on the date shown below.

Name: Dawn Roberts

Signature: Dawn Roberts

Date: 10/21/97

(LJV/cak 10/25/96)

_____ A check in the amount of $_____ is attached for presentation of additional claim(s).
_____ Applicant(s) hereby Petition(s) for an Extension of Time of _____ month(s) pursuant to 37 C.F.R. § 1.136(a).
_____ A check for $_____ is attached for processing fees under 37 C.F.R. § 1.17.
_____ Please charge my Deposit Account No. 02-2666 the amount of $_____.
A duplicate copy of this sheet is enclosed.
__X__ The Commissioner of Patents and Trademarks is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 02-2666 **(a duplicate copy of this sheet is enclosed)**:
__X__ Any additional filing fees required under 37 C.F.R. § 1.16 for presentation of extra claims.
__X__ Any extension or petition fees under 37 C.F.R. § 1.17.

BLAKE, CASSELS & GRAYDON LLP / TAYLOR & ZAFMAN LLP

ORIGINAL SIGNED BY

Date: 10/21, 1997

Daniel M. De Vos

Reg. No. 37,813

12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025
(408) 720-8598

(LJV/cak 10/25/96)

08/587,731

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/587,731	01/19/96	MARGOLIN J	002055.P004

LM21/1128
BLAKELY SOKOLOFF TAYLOR AND ZAFMAN
12400 WILSHIRE BOULEVARD
7TH FLOOR
LOS ANGELES CA 90025

EXAMINER	
NGUYEN, T	
ART UNIT	PAPER NUMBER
2763	8

DATE MAILED: 11/28/97

This is a communication from the examiner in charge of your application.
COMMISSIONER OF PATENTS AND TRADEMARKS

OFFICE ACTION SUMMARY

☒ Responsive to communication(s) filed on 10/21/1997

☐ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle*, 1935 D.C. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire 3 month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. §.133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claims

☒ Claim(s) 1-38 ☒ are pending in the application.

Of the above, claim(s) _____ is/are withdrawn from consideration.

☐ Claim(s) _____ is/are allowed.

☒ Claim(s) 1-38 is/are rejected.

☐ Claim(s) _____ is/are objected to.

☐ Claims _____ are subject to restriction or election requirement.

Application Papers

☐ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The drawing(s) filed on _____ is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on _____ is ☐ approved ☐ disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) _____.

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: _____

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☒ Notice of Reference Cited, PTO-892

☐ Information Disclosure Statement(s), PTO-1449, Paper No(s). _____

☐ Interview Summary, PTO-413

☐ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

-- SEE OFFICE ACTION ON THE FOLLOWING PAGES --

DETAILED ACTION

Notice to Applicant(s)

1. This office action is responsive to the amendment filed on October 21, 1997. As per request, claims 39-49 have been canceled. Thus, claims 1-38 are pending.

Drawings

2. The drawings are objected to under 37 CFR § 1.84 for the reasons set forth by the draftsman. See attached PTO-948 form for details. Correction is required. However, correction of the noted defect can be deferred until the application is allowed by the examiner.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made

to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1-9, 14-18, 23-32, and 34-38 rejected under 35 U.S.C. § 103(a) as being unpatentable over Lyons et al. (an article entitled "Some Navigation Concepts For Remotely Piloted Vehicles", AGUARD Conference Proceedings No. 176 on Medium Accuracy Low Cost Navigation, September 1975, pages 5-1 to 5-15) in view of Wysocki et al. (5,381,338) or Fant (4,835,532) or Beckwith et al. (4,660,157).

a. With respect to claims 1, 2, and 14, Lyons et al. disclose the invention as claimed (see at least the abstract) including a remotely piloted aircraft (see figure 8, RPV), a communications system for communicating flight data between a computer and said remotely piloted aircraft, said flight data including said remotely piloted aircraft's position and orientation, said flight data also including flight control information for controlling said remotely piloted aircraft (see page 5-2, section Radio Navigation Using a Data Link, and figure 6 and the related text), a digital database comprising terrain data (see pages 5-3 and 5-4, section Terrain Map Correlation; and figure 8). Lyons et al. further disclose that the computer accesses said terrain data according to said remotely piloted aircraft's position and to transform said terrain data to provide a projected image data according to said remotely piloted aircraft's orientation; a display

for displaying said projected image data (see page 5-4, third paragraph, and figure 8), and a remote flight control coupled to said computer for inputting said flight control information (see figure 6).

Lyon et al. do not explicitly disclose that the computer produce a three dimensional image data from the digital database and the navigation information. However such feature is well known at the time the invention was made (for examples, see figure 1 and the related text in Wysocki et al.; see figures 1, 3 and the related text in Fant; or see figures 1, 4 and the related text in Beckwith et al.)." It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of either Wysocki et al., Fant, or Beckwith et al. into the system of Lyon et al. in order to improve the system with the enhanced capability of displaying three-dimensional image of the remoted aircraft over the terrain data.

b. With respect to claim 3, Lyons et al. disclose that the flight data communicated between said remotely piloted aircraft and said computer is secured (see page 5-2, first paragraph of the Radio Navigation Using Data Link section).

c. With respect to claims 4, 5, 7, and 15, Lyons et al. disclose that said remotely piloted aircraft further comprises a infra red sensor image (video camera) and means for communicating and displaying video data representing images captured by the sensor image (see page 5-3, section Map Matching, and figure 8).

d. With respect to claims 6 and 16, Lyons et al. disclose that the video data is transmitted on a different communication link (wideband transmission of video signals) than said flight data (see page 5-2, first paragraph of section Radio Navigation Using a Data Link).

e. With respect to claims 8 and 17, Lyons et al. disclose that the display is a head mounted display (see figures 5 and 6).

f. With respect to claims 9 and 18, Lyons et al. also disclose that the remote flight control is responsive to manual manipulations (see figure 6).

g. With respect to claim 23, Lyons et al. disclose that the communications unit includes at least one of a communications transceiver and a simulation port (see page 5-4 and figure 6).

h. With respect to claim 24, Lyons et al. further disclose that the database representing terrain using polygons (see figure 10).

i. With respect to claims 25-28 and 30-31, the limitations of these claims have been noted in the rejection above. They are therefore considered rejected as set forth above.

j. With respect to claim 29, wherein said video data is transmitted real-time (see page 5-3, first paragraph of the section Map Matching).

k. Claims 32 and 34-38 are method claims corresponding to apparatus claims

24-31. Therefore, claims 32 and 34-38 are rejected for the same rationales set forth for claims 24-31.

5. Claims 10, 11, 19, 20, and 33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lyons et al., Wysocki et al. or Fant or Beckwith et al. as applied to claims 1-9, 14-18, 23-32, and 34-38, and further in view of Kanaly (4,405,943).

Lyons et al. disclose the claimed invention as discussed above except for the determination of a delay time for communicating said flight data between said computer and said remotely piloted aircraft, and adjusting the sensitivity of said set of one or more remote flight controls based on said delay time. However, Kanaly does suggest delay time for communicating between the ground station and the remote airborne into account of controlling the remote airborne (see at least column 3, lines 15-24, and column 8, line 54 to column 9, line 6). It would have been obvious to incorporate the teaching of Kanaly into the system of Lyons et al. in order to improve the system with the enhanced capability of providing more accurate the remote flight controls to the remoted vehicle and receiving the accurate position and heading data of the vehicle from the remoted vehicle.

6. Claims 12-13, and 21-22 are rejected under 35 U.S.C. 103(a) as being

unpatentable over Lyons et al., Wysocki et al. or Fant or Beckwith et al. as applied to claims 1-9, 14-18, 23-32, and 34-38 above, and further in view of Thornberg et al. (5,552,983).

Lyons et al. disclose the claimed invention as discussed above except that the remote flight controls allows for inputting absolute pitch and roll angles. However, such feature is well known in the art at the time the invention was made. For example, Thornberg et al. suggest a variable referenced control system for remotely operated vehicles which includes means for inputting absolute pitch and roll angles for remotely control the unmanned aerial vehicle (see at least figures 5 and 6). It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the teaching of Thornberg et al. into the system of Lyons et al. in order to input the pitch and roll control signals as the flight control signals for remotely control the vehicle.

7. All claims are rejected.

Remarks

8. Applicant's arguments filed on October 27, 1997 have been fully considered and they are deemed to be persuasive. However, upon the updated search, the new ground of rejections has been set forth as above.