THE BD-5 BULLETIN

A quarterly publication by and for BD-5 enthusiasts

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Inside this Issue

The BD-5 Bulletin
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Bulletin #23 Well Received!

It has now been two weeks since I completed the task of photocopying, stapling, tabbing, labeling and applying postage to some 857 issues of the Bulletin, including 49 mailed to Canada and 68 others to various countries around the world.

Judging from the comments I've received, I think it is safe to describe the rebirth of the Bulletin as an unqualified success.

As you can see, this issue is greatly expanded. Some of the material that you will see here is available on the web site, such as Les Berven's flight test report to the Society of Test Pilots. We have also included great news about the BD-5's main landing gear, and a complete transcript of the US Patent award to Jim Bede for the Truck-A-Plane design in 1976. Enjoy!

Call for Authors

Do you enjoy writing and passing on information for the enjoyment of others? Do you have a personal computer? If so, here's your chance to gain notoriety and fame in the BD-5 community.

The Bulletin needs authors to write articles about subjects related to the BD-5. Some ideas: construction tips, avionics, electrical systems, flight test reports, historical tidbits and just about anything else you can think of.

Interested? Email Juan Jimenez at flybd5@hotmail.com or mail your manuscript to the address listed on the left hand corner of this page. You do the writing and Juan will take care of the editing!

Nosegear Parts Located

Last month we talked about a problem that is common to Gerdes nosegear struts that are not cleaned on a regular basis.

Specifically, we talked about the degradation of the teflon disk, spring and ball bearing that make up the centering mechanism of the nosewheel castering system. We thought that parts could not be located. Well, we were wrong.

Paul Ross of Alturdyne wrote to us in March and deservedly chided us for not checking with him first. Sure enough, Paul has the necessary parts kit. The cost? A whopping three dollars and fifty cents. Call Paul at 619-449-1570, fax at 619-442-0841 or email him at any time at alturdyne@worldnet.att.net to get your kit.

On a personal note, as Editor and Director of the Bulletin I am thrilled to finally have a direct line of communication to Alturair. I have never really had a lot of contact with Paul, whose company has been around since 1976, supplying BD-5 owners and builders with parts and services. I am very happy that this situation has now changed,

There's more about Alturair in this edition of the Bulletin, including an important announcement about a new upgrade for the BD-5's landing gear design. Read on!

BD-5 Flight Test Program Report

By Lester H. Berven, Chief Test Pilot, Bede Aircraft Inc.

(Originally Published in the Journal of the Society Of Experimental Test Pilots)

Introduction

The BD-5 is an amateur-built general aviation aircraft which represents a new concept in sport aviation. The aircraft is purchased as a complete materials package and is assembled entirely by the owner/pilot.

Upon completion, the BD-5 is licensed by the FAA in the Experimental-Amateur Built Category. It is restricted to a local area defined in the aircraft operating limitations until it has flown 75 hours, at which time the local area restriction is removed, and it is operated in accordance with FAR 91 for homebuilts.

The BD-5 is basically a single-place, low wing monoplane pusher with several unique design characteristics. It has removable wings with a constant diameter tube spar which fits over the center section, a two cylinder, two cycle, dual ignition, internally mounted mid-engine which drives the wooden, fixed pitch prop through a Gilmore belt reduction drive system with a 1.6 ratio. It has manually retractable landing gear, and a combination push-rod/cable control system which is actuated with a side stick on the right console. Both a long wing (21.5 ft. span) and a short wing (14.3 ft. span) are available.

The BD-5 was first conceived in 1967 as an ultralight, self-launched glider, but in searching for an acceptable powerplant, it was found that the high power to weight ratio of the snowmobile type 2-cycle engine would allow a very efficient powered aircraft and development was channeled along these lines.

Development Flight Tests

The first prototype BD-5, N500BD was built in 1970. The fuselage was bolted aluminum angle framework covered with a molded fiberglass shell. The wing structure was an aluminum tube-spar with aluminum ribs and wing skins. This aircraft had the original V-tail and was powered by a 36 BHP Polaris snowmobile engine.

This fiberglass V-tailed prototype was first flown in September 1971 by Jim Bede. It made a total of 2 flights, both in ground effect just above the runway. These two flights showed a serious deficiency in both directional and longitudinal stability and control and a redesign of the tail was begun immediately.

The next configuration tried was a swept conventional vertical fin with a highly swept (60 degrees at the L.E.) stabilizer/elevator. High-speed taxi tests with this configuration showed very limited elevator power for rotation and a large trim change with power due to the induced flow from the propeller.

Because of the great interest in the BD-5 and the large number of orders he was receiving, Jim had previously decided to pay for the tooling necessary to produce a metal fuselage, and the first all-metal BD-5, N501BD, was being built at this time. Because of the limited manpower available and the difficulty of making modifications to the fiberglass BD-5, Jim decided to stop development and testing of the fiberglass prototype and concentrate on getting N501BD in the air. It was also at this time that he decided to add some more manpower, and he hired Burt Rutan as Director of Development and myself as Test Pilot in early 1972.

The first all metal prototype, N50lBD, differed from ship #1 not only in the fuselage design but it also had an all-flying stabilator, an American made Kiekhaefer 440cc snowmobile engine, electrically retractable landing gear, and a variable speed drive system.

The cooling system for this engine installation was two NACA flush scoops (one on each side of the fuselage) from which the cooling air was ducted down over the cylinder fins and out the rear of the fuselage in an exhaust/ejector duct.

The initial ground testing of this aircraft began in May 1972 with an evaluation of engine starting and cooling characteristics and with low speed taxi tests. These tests showed that the engine cooling was marginal on the ground and that the rudder was effective for taxiing above 25 mph IAS and that the ailerons were noticeable above 20 mph IAS.

High speed taxi tests were begun on 31 May and control effectiveness was evaluated in 5 mph increments up to 80 mph IAS. We found, as before, that the ailerons and rudder were very effective, but that the stabilator was not powerful enough to lift the nose, even at 80 mph (cg was 24% mac).

We then reballasted the aircraft to 27% cg and tried it again. This time I could rotate by accelerating to 70, pulling the power back to idle and applying full aft stick. Once the nose came up I could add full power and hold it there. By using this technique, I got the airspeed up to 80 mph IAS, made the first liftoff, flew down the runway at a height of about 5 feet and landed after about 10 second flight. Both trim and controllability seemed acceptable at 80 mph.

Before the next flight, the main gear was moved forward one inch and the cg was moved aft to 28% in an effort to lower the rotation speeds.

The next flight was made on 7 June 1972 at a gross weight of 690 lb. Some more high speed taxi tests showed that the power-off rotation speeds had been lowered to 65 mph but that it was still impossible to rotate power-on. Using the old "throttle back to rotate" trick I accelerated to 75 mph and lifted off for an intended flight around the pattern.

Acceleration to 80 mph was normal and I added a little back pressure to begin a gentle climb. The nose pitched up about twice as much as I wanted so I added forward pressure, with no effect. I pushed even harder, and the nose came back to where I wanted it. I was then at 95 mph IAS and about 20 feet above the runway.

At this point the nose began an uncommanded pitch down and it took considerable aft stick for recovery. This was followed immediately by a more violent pitch up to about 2g and a pitch down to slightly negative g. At this point I decided that this wasn't a very good day for the first flight around the pattern.

I pulled the power back to slow down to a previously flyable airspeed. As the airspeed decreased, the controllability improved and I made a reasonably normal landing in the remaining runway. After much discussion and more ground tests we decided the problem could have been caused by having the aerodynamic center of the stabilator forward of the pivot.

Calculation showed it to be right on, but with the highly swept stabilator the inflow from the prop would have moved the center of pressure inboard, and therefore forward. We then changed the stabilator geometry to increase the area 15% and moved the pivot one inch forward to eliminate the possibility of any instability.

With the new stabilator, the next taxi tests showed that the rotation speeds had not improved, and that with full aft stick, the stretch in the longitudinal control system would allow the stabilator to back off a full 10 degrees from its static maximum of 15 degrees. This control system deflection plus an aerodynamically unstable stabilator was undoubtedly the problem on the second flight.

Because of these problems and the fact that the stabilator with a sweep of 60 degrees was only giving us a CLmax of 0.6, we decided to completely redesign the longitudinal control system. We changed the stabilator to an unswept trapezoidal planform with a thicker airfoil section, 20% more area, and a larger anti-servo tab.

During this period of redesign, the Kiekhaefer 440 cc engine was replaced with a Hirth 650 cc and a series of airframe/engine integration tests were run.

The new stabilator was ready for test on 8 July 1972. To check the stick free stability of the stabilator, we disconnected and locked the anti-servo tab, and at 40 mph IAS measured the stick force at full aft stick. This technique indicated a very slightly stable tail, which was right where we wanted it. High speed taxi tests showed a power-on rotation speed of 50 mph IAS, and a power-off of 40 mph at a cg of 25% mac. Once the nose-wheel was off, I could hold it off down to 30 mph.

The next flight, on 11 July 1972, was the first real flight of the BD-5, when it flew away from the runway for the first time. Acceleration to 80 and lift-off were normal. I held the aircraft level and let it accelerate to 100 mph while I made some quick stability checks and leaned the mixture slightly.

Everything appeared normal, so I raised the nose to hold 100 mph. Initial rate of climb was about 600 fpm, with gear down and gw 700 lb. Cylinder head temperature at lift-off was about 380 degrees F (450 degrees F is redline). Passing the end of the runway at 500 feet, CHT was 440 degrees F and increasing, so I started a left turn back to key position, still climbing.

As I turned downwind, CHT was 550 degrees so I leveled off at 800 ft., throttled back and adjusted the mixture to cool down the engine. Half throttle gave about 100 mph IAS but the CHT stayed at 550 degrees so I decided to return for landing.

As I turned base, I pulled the throttle back to idle and set up a 500 fpm descent at 100 mph. About halfway across base leg just to keep it interesting, the cockpit started to fill with smoke, so I lowered the nose to increase R/D and turned final.

The smoke was getting worse and I wasn't coming down very fast, so at about 100 feet and just off the end of the runway, I shut the engine down and turned off the master switch, neither of which seemed to affect airspeed, R/D or the amount of smoke.

Touchdown was at about 80 mph and the smoke was really bad. As soon as I lowered the nosewheel at about 60 mph, I opened the canopy to clear out the cockpit and did our first high speed canopy opening tests. At 50-60 mph the canopy floated directly overhead and could be pushed back to full open with very little force on it.

I taxied up to the hangar and reported the smoke, but nothing could be found. It turned out that the smoke was exhaust recirculating into the cockpit which we fixed by installing a fresh air vent and sealing the firewall better. Ground tests showed that the cooling problem was a lack of adequate air exit at the exhaust ejector and we wound up an adjustable cowl flap on the bottom of the fuselage. With this fix we started flying the aircraft regularly and were able to get the first flying qualities data on the next several flights.

Instrumentation

Before I describe the results of the flying qualities tests, I'd like to show you our instrumentation system. For documentary shots, roll rate, and dynamic stability data we use an over-the-shoulder super-8 movie camera, some film from which you have already seen.

For stick force and position data we have a homebuilt force grip designed by Burt Rutan which is very simple and surprisingly accurate. Stick position is read off a flexible tape threaded through the top of the stick. Admittedly the system isn't very sophisticated, but it does allow us to see the variation in significant stability parameters with cg position, which is all we wanted anyway.

Flying Qualities

Both the looks and the performance of the BD-5 are excellent, but the thing that really makes this little airplane great is the flying qualities. Almost invariably the first question everyone asks is "Isn't that fast little short-coupled airplane going to be awful sensitive and hard to fly?"

The answer is absolutely not! It was recognized in the early design stages that very small airplanes are sometime overly sensitive and have low control forces, and that was the major factor in choosing a wrist controlled side-stick for the longitudinal and lateral control.

By decreasing the pilot's force capability to that available from his wrist, the aircraft and pilot forces are matched; and although the stick forces are very light, they feel absolutely normal. There is no tendency toward P10 or overcontrolling in any flight condition we've investigated so far, and we've been to 240 mph IAS and 5 g's, including most normal aerobatics.

I've found the same thing the Air Force studies on the side stick show; that compared to the center stick, the side stick offers more precise control, a more natural seated position, more useable instrument panel space and more natural control movements. With both forearms supported, turbulence or aerobatic accelerations do not feed back into the controls, and fatigue is reduced on long flights.

I really believe the side stick is the optimum system for very small aircraft, and I don't think the BD-5 would be a success without it.

Our early tests with N501BD did show that the stick force per G was too light -- only about 0.75 lb/G. On the next several flights we increased both the deflection and area of the stabilator anti-servo tab and arrived at our present optimum value of about 3 lb/g.

Now, that may sound a little light, but it fits perfectly from a control harmony standpoint, and it is purely wrist action. In fact, after about 30 minutes of aerobatics it feels like it may be too much. This does bring up an interesting point, however; if you raise your forearm off the armrest, the longitudinal control dynamics change considerably, and the stick force per G becomes too light for an inexperienced pilot, who would then be easily capable of overstressing the aircraft.

I'm not sure what the solution to that situation is, other than possibly some kind of forearm restraint. The results of our longitudinal static stability tests are shown in figure 1 for two CG positions. Stick forces and deflections are both stable as far back as 27.5% MAC. Maneuvering stick forces so far have set the aft CG limit at 28.5% which gives a 1.5 lb/G gradient.

At normal CG (25%) the longitudinal short period is deadbeat at all speeds. The phugoid, however, has a period of only 15 seconds and is neutral to very slightly damped. This is probably due to the fixed pitch prop/high thrust line combination, which causes an unstable pitching moment with speed changes.

This theory is supported by the jet BD-5 which has a much more well damped phugoid.

Lateral/Directional Stability

Lateral directional stability is good, with positive dihedral effect and light but well harmonized rudder forces. At 120 mph IAS a full rudder sideslip requires about 15 degrees of bank for straight flight. Full rudder sideslips are possible from 120 mph IAS down to stall with no adverse characteristics in either CR or PA configuration. Rudder fixed, the directional short period has a frequency of about 0.8 cps and a damping ratio of about 0.5.

There is no tendency toward dutch roll and spiral stability is neutral to very slightly stable. Adverse yaw is quite low at cruise speed, and at approach speed, a rudder fixed roll at about 30 degrees/sec will result in about a one-ball sideslip on the slip indicator.

As a result, rudder/aileron coordination is very easy and makes it a pleasant airplane to fly. Maximum roll rates are about 120 degrees/sec with the long wings, and 200 degrees/sec with the short wings. Rudder power is s6mewhat limited with the long wing and below 80 mph it takes full rudder for coordinating a full deflection aileron roll.

Stalls

Stall testing has uncovered two significant features-one good, and one bad. The good part is the stall characteristics. There is a very definite buffet 3 to 5 mph before the break, and no tendency to roll off until you have a moderate amount of sideslip. Up to a full ball sideslip, the aircraft will still break straight ahead, and recovery is immediate if you relax any back pressure.

The not-so-good part is that the stall speeds are significantly higher than we had expected. Data show a maximum lift coefficient of only 1.06 clean and 1.45 with full flaps. This works out to gross weight stall speeds of 72 mph clean and 61 with flaps for the long wing and 86 mph clean and 74 dirty with the short wings.

We feel this poor CLmax is due to a combination of low Reynolds number, laminar separation and a relatively large tail download (15% of gw).

Current Flight Tests

We managed to get 33 flights and 25 hours on N501BD and were able to complete most of our flying qualities optimization. Both systems and performance were non-representative, so the best we have there is preliminary data.

In those 33 flights we had two inflight engine seizures due to lack of adequate cooling and wound up cooling the engine from a scoop on the bottom of the fuselage. It seems that the airflow has to go from the exhaust side of the cylinders to the intake side, or you get hot spots around the exhaust ports.

The last flight of N501BD occurred on 8 Oct 1972 and was the fourth flight with the short wings. Take-off was normal up until I started leaning the mixture at about 50 feet. The engine didn't respond normally and sounded richer as speed increased and unloaded the prop.

I continued to lean until the mixture was full out, with no apparent effect. I was then about 300 feet over the end of the runway with no rate of climb. I made a left turn to line up on a convenient road and lost about 150 feet in the turn. Thinking I had possibly leaned the mixture too much, I tried richening it slightly, whereupon the engine quit completely.

I dumped the nose to maintain as much airspeed as possible and put the flaps down as I flared. It was at this point I discovered that the short wing BD-5 at 720 pounds and a rate of descent would not flare completely, even starting at best rate of climb speed (105 mph IAS).

I touched down on the road at about 85 mph and an 800 fpm descent, folded the main gear aft and ran off the left side of the road down into a 10 foot ditch, up the other side and came to a stop in a small cloud of dust.

The airplane was in surprisingly good shape. The major damage was to the leading edges of the wings, wrinkled fuselage bottom, and collapsed landing gear. The only injury sustained was to a field mouse I mashed at the bottom of the ditch.

Examination of the engine showed that the mixture control cable had broken on the take-off roll and I was unable to compensate for the richer condition of the engine at higher speed. It appeared that it would take about a month to fix the aircraft. Since we had all the aerodynamic data on ship 2 we needed, and all the systems were non-representative, it was decided to repair it only for looks as a display and press on with the next airplane, N502BD.

N502BD differs from N501BD in that it has manually retractable landing gear, plain flaps, longer gear struts, an integral blower fan to cool the engine. It also has a fixed ratio drive system with a toothed belt, and a new carburetor, calibrated for the prop load, so that there is no longer any requirement to change the mixture with throttle setting and airspeed. Finally, it has a dual ignition engine with a capacitor-discharge ignition system.

The first flight of ship #3 was made on 26 March 1973 and the flight program has proceeded with very few problems since then. The new manual landing gear works very well-gear up or gear down takes about half a second with very little pitch trim change.

The landing gear lever moves nine inches and it requires only 10 lb. to actuate it. We have a total of about 60 hours on N502BD now and have completed most of our systems and flying qualities testing.

Since N502BD's performance is more representative of the final configuration, we've attempted to get some more accurate performance estimates. However, we have yet to get our gear doors to work properly, and we're flying without a nose gear door and the main gear doors stuck open about an inch to an inch and a half above 140 mph IAS.

The maximum power available from our present 650 cc engine is 50 BHP at sea level and 6300 engine rpm because of our non-optimized exhaust system. With that configuration, the present long wing BD-5 will indicate 154 mph at full throttle and 7500 feet, (175 mph TAS) and about 180 mph at S.L.

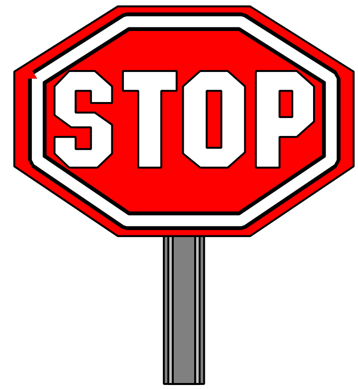
Rate of climb at S.L. and 660 lbs. is 900 fpm with a fixed pitch cruise prop at a best rate of climb speed of l00 mph. The short wing BD-5 with the same horsepower is about 15 mph faster and has 2/3 the climb rate. Take-off distance with the cruise prop is about 1800 feet for the long wing and 2500 feet for the short wing. These should be improved considerably when we get our CLmax up to a better value.

BD-5J

During our development program we came across a little turbojet engine that seemed to be just made for the BD-5, so we built another airframe and installed this Turbomecca Microturbo TRS-18 engine.

It has 200 lb. thrust, and electron-ic fuel control with automatic starting and was designed to operate from a plenum chamber inlet. To get enough fuel capacity (50 gallons) we increased the gross weight of the aircraft to 950 lbs. and made an intermediate length (17 feet) fully wet wing. To take the higher gross weight landing loads, we also went to oil/air struts all around which we've tested to a 10 fps touch-down at 900 lb.

First flight of the jet was made on 20 July 1973 and lasted 30 minutes. The jet has all the same outstanding flying qualities of the prop BD-5



Always triple-check all measurements. Better to triple check than double build.

with a very smooth reliable jet engine and I doubt if there has ever been an airplane that's more fun to fly.

Stall speeds at 800 lb. are 76 knots clean and 65 knots with flaps. Take-off and landing distances are 1200 and 800 feet, respectively. Initial rate of climb at 130 KIAS is 1600 fpm and in our present configuration the service ceiling is 26,000 feet.

Because the oleo gear struts are significantly different from the fiber-glass ones, we are unable so far to completely retract the gear. So we not only don't have gear doors, but the main gear hangs down a little over 3 inches. In this configuration maximum speed at S.L. is 200 KIAS, decreasing to 130 KIAS, (185 KTAS) at 20,000 feet.

Right now the performance is less than we'd hoped for but by cleaning up the gear and improving the engine thrust output we should have a pretty good performing airplane.

Conclusion

So far in our BD-5 test program we've opened up the airframe envelope to 220 KIAS and 5g and have completed our aerodynamic optimization except for cleaning up the landing gear and improving our CLmax. The remaining systems tests are engine power and cooling optimization and drive system development to decrease weight and improve the soaring capability.

The major flight tests remaining are the envelope expansion out to a Vdive of 300 mph and the spin tests. Our present schedule calls for completion of both of these during this fall, and well in advance of any of our customer's first flights.

Alturair to Offer Spun-Aluminum Main Gear Legs

As we mentioned at the beginning of the Bulletin, we have some very exciting news from Paul Ross, president of Alturair.

As you all know, the main gear legs of the BD-5 are made out of thick fiberglass sheets, which are cut and formed to become components LG-93, -94, -156 and -157. Two pieces make up each leg.

The way the raw fiberglass pieces that come with the kit is critical because of the stress that these pieces will take during landing. In fact, it is recommended that you send the raw fiberglass to an experienced shop in order for them to be cut correctly the first time.

Moreover, replacement fiberglass to make gear legs is extremely expensive.

What Alturair has done is to produce the first spun-aluminum gear legs for the BD-5! The kit replaces the fiberglass pieces, and also replaces the castings at the bottom of the legs, above the brakes, and we all know how these castings are prone to breaking.

The kit, according to Paul Ross of Alturair, is very easy to install. The result is a much sturdier main landing gear, no gear droop and better resistance to damage from hard landings. At press time, the kit was to be unveiled April 8 at the Sun-N-Fun show at a show special price of $300. Normal retail price had not yet been established.

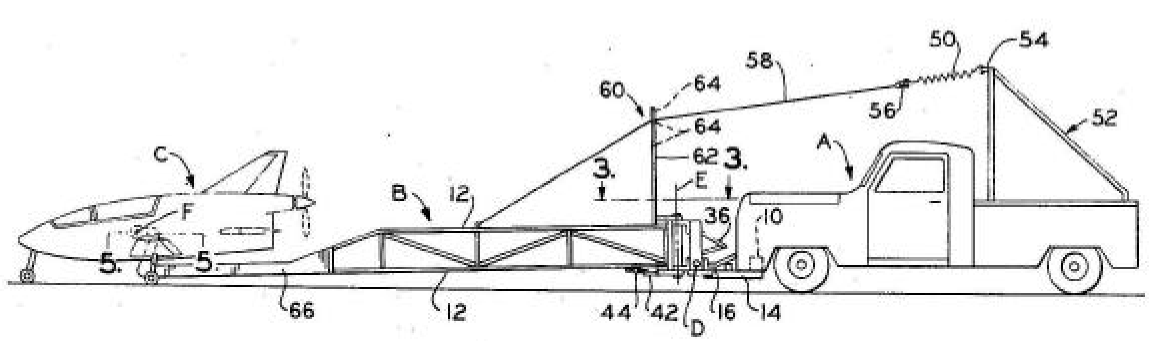
Bill Martin has been a busy beaver these past few months, racking up the hours on his **N501WM**. These photos were taken about three weeks before we went to print,"at about 2000 ft AGL, 125 mph indicated in formation with an H35 Bonanza," says Bill, whose test pilot was flying the BD-5. The photo with gear down is what it looked like when Bill first caught up with the BD after takeoff.

US Patent 3,991,487:

The Bede Truck-A-Plane

(Ed: I have received several requests in the past few months to run the complete text and drawings for James Bede's Truck-A-Plane, the only training device that has ever been available to teach a pilot how to "fly" a BD-5. With ranges of motion limited to 10 degrees or so, it was never very realistic, but pilots who have "flown" it tell me that it does a great job of teaching people how to land a BD-5. From the annals of history of the US Patent Office, I have located the full patent text and drawings. I have edited the headers slightly for publication - the actual text of the patent is presented intact. Enjoy!)

United States Patent 3,991,487 Bede November 16, 1976 Flight training assembly



Abstract

A flight training assembly is disclosed comprising an airplane having pilot operable flight controls, a truck for propelling the airplane at a speed sufficient to achieve lift of the airplane, and a boom structure interconnecting the airplane and truck. One end of the boom is interconnected with the truck for pivotal movement relative thereto about horizontal and vertical axes, and the other end of the boom is interconnected with the airplane at the center of gravity thereof by means of a spherical bearing assembly. Pivotal movements of the airplane relative to the boom and of the boom relative to the truck are limited.

Inventors: Bede; James R. (c/o Bede Aircraft, Inc., P.O. Box 706, Newton, KS 67114)

Appl. No.: 654984

Filed: February 3, 1976

Claims

1. A flight training assembly comprising a winged aircraft having pilot operable flight controls, a ground supported vehicle behind said aircraft with respect to the direction of flight thereof, said vehicle being movable along the ground at a speed to achieve lift of said aircraft, boom means, means mounting said boom means on said vehicle for pivotal movement relative to said vehicle about a horizontal boom axis extending laterally of said vehicle and about a vertical boom axis, universal joint means pivotally interconnecting said aircraft with said boom means substantially at the center of gravity of said aircraft, said universal joint means supporting said aircraft for pivotal movement relative to said boom means about a first horizontal aircraft axis extending laterally of said aircraft, a second horizontal aircraft axis extending longitudinally of said aircraft and a vertical aircraft axis, and means limiting pivotal movement of said boom means relative to said vehicle and pivotal movement of said aircraft relative to said boom means.

2. The training assembly according to claim 1, wherein said means limiting pivotal movement of said boom means includes means to control the rate of pivotal movement of said boom means about said vertical boom axis.

3. The training assembly according to claim 2, and means biasing said boom means to pivot about said horizontal boom axis in the direction to assist lift of said aircraft relative to ground.

4. The training assembly according to claim 3, wherein said biasing means includes spring means.

5. The training assembly according to claim 1, wherein said universal joint means is spherical bearing means including a spherical bearing member and spherical bearing support means, a shaft supporting said spherical bearing member at the center of gravity of said aircraft, said spherical bearing support means being fixed on said boom means, and said means to limit pivotal movement of said aircraft including resilient pad means on said shaft and engaged by said bearing support means in response to pivotal movements of said aircraft relative to said boom means about said second horizontal aircraft axis and about said vertical aircraft axis.

6. The training assembly according to claim 5, wherein said means to limit pivotal movement of said aircraft further includes means to limit pivotal movements of said aircraft relative to said boom means about said first horizontal aircraft axis.

7. The training assembly according to claim 6, and means releaseably connecting said resilient pad means on said shaft for adjusting the position of said pad means toward and away from said bearing support means.

8. The training assembly according to claim 7, wherein said means limiting pivotal movement of said boom means relative to said vehicle includes means to control the rate of pivotal movement of said boom means about said vertical boom axis, and means biasing said boom means to pivot about said horizontal boom axis in the direction to assist lift of said aircraft relative to ground.

9. A flight training assembly comprising, a winged aircraft having pilot operable flight controls, a wheeled motor driven vehicle including frame means and having operator controlled steering and speed control means, a boom having a first end, means interconnecting said first boom end and said frame means for pivotal movement of said boom relative to said vehicle about a horizontal boom axis extending laterally of said vehicle and about a vertical boom axis, said boom extending forwardly from said vehicle and beneath said aircraft in the direction from the tail of said aircraft toward the nose thereof, said boom having a second end extending upwardly into said aircraft, means interconnecting said second end of said boom with said aircraft at the center of gravity of said aircraft and supporting said aircraft for universal pivotal movement relative to said boom about a first horizontal aircraft axis extending laterally of said aircraft, a second horizontal aircraft axis extending longitudinally of said aircraft and a vertical aircraft axis, means to limit said pivotal movement of said boom relative to said vehicle about said horizontal and vertical boom axes, and means to limit said universal pivotal movement of said aircraft relative to said boom about said first and second horizontal aircraft axes and about said vertical aircraft axis.

10. The training assembly according to claim 9, and further including spring means biasing said boom laterally about said vertical boom axis toward a central position with respect to the laterally opposite sides of said vehicle.

11. The training assembly according to claim 9, and means including spring means biasing said boom to pivot about said horizontal boom axis in the direction to assist lift of said aircraft relative to ground.

12. The training assembly according to claim 9, wherein said means to limit pivotal movement about said horizontal and vertical boom axes includes bumper means mounted on said front end of said frame means and arm means mounted on said boom and pivotal therewith about said horizontal boom axis, said bumper means and arm means being cooperatively positioned to limit upward movement of said aircraft relative to ground.

13. The training assembly according to claim 12, wherein said means to limit pivotal movement about said horizontal and vertical boom axes further includes motion damping devices on laterally opposite sides of said vertical boom axis, each of said devices having a first end interconnected with said frame means and a second end interconnected with said boom, and each of said motion damping devices being operable to damp and limit pivotal movement of said boom about said vertical boom axis.

14. The training assembly according to claim 13, and spring means on laterally opposite sides of said vertical boom axis biasing said boom about said vertical boom axis toward a laterally central position with respect to said vehicle.

15. The training assembly according to claim 14, and means biasing said boom to pivot about said horizontal boom axis in the direction to assist lift of said aircraft relative to ground.

16. The training assembly according to claim 9, wherein said means interconnecting said second end of said boom with said aircraft includes a horizontal shaft fixed to and extending across said aircraft and through said center of gravity, a spherical bearing member on said shaft at said center of gravity, and bearing block means fixed on said second end of said boom and supporting said spherical bearing member.

17. The training assembly according to claim 16, wherein said means to limit said universal pivotal movement of said aircraft includes resilient pad means positioned on said shaft to engage said bearing block means in response to pivotal movements of said aircraft relative to said boom about said second horizontal aircraft axis and about said vertical aircraft axis.

18. The training assembly according to claim 17, wherein said pad means

is releaseably mounted on said shaft for adjustment towar and away from said bearing block means.

19. The training assembly according to claim 17, wherein said means to limit said universal pivotal movement of said aircraft further includes means to limit pivotal movements of said aircraft relative to said boom about said first horizontal aircraft axis.

Description

This invention relates to the art of educational devices and, more particularly, to airplane flight training aids.

The present invention finds particular utility in teaching a student pilot the techniques of taking-off and landing winged aircraft. Take-offs and landings are probably the most critical maneuvers in connection with flying, and proper judgment and coordination on the part of the pilot is required to minimize the likelihood of an accident during take-off and landing maneuvers. There are, of course, aircraft that are used primarily for training student pilots, and these trainers do teach the student all of the basic information required to pilot an airplane. However, due to the cost of operation only the minimum required time is devoted to the many maneuvers to be learned, including take-offs and landings. While it is recognized that more training in the techniques of taking-off and landing an airplane would be desirable, the cost of merely taking-off, circling the field and landing is prohibitive. Moreover, very little of the total time required to take-off, circle and land can be devoted to take-off and landing skills.

Another disadvantage in student training methods heretofore employed is that flying, and especially take-offs and landings, are restricted to good weather conditions. Accordingly, the student pilot is not likely to have any appreciable exposure during his training to adverse conditions such as a strong cross wind.

If such conditions exist at an airport, traffic is directed to the runway most favoring the direction of wind. Still further, the student pilot is not exposed to the effect of changing the center of gravity of a plane, such as by passenger and/or baggage loading. It is difficult, but possible, to put a payload on an aircraft which causes the center of gravity to shift beyond a specific boundary relative to the center of gravity when the aircraft is not loaded. Pilots are trained to be aware of this possibility, but very few have any idea of the consequence of such a shift in the center of gravity and the effects thereof on control of the aircraft.

In addition to actual in-flight training, there are of course electronic flight simulators that have been developed primarily for military and commercial airline use. These simulators are extremely expensive and, moreover, only simulate various effects on an aircraft. Accordingly, the student pilot is still aware that he is not actually flying, whereby the capabilities of such simulators is limited.

In accordance with the present invention, a training assembly is provided which overcomes the disadvantages referred to hereinabove, and others, and provides training capabilities heretofore unattainable in connection with pilot training techniques. The training assembly of the present invention is comprised of a winged aircraft having pilot operable flight controls, a ground supported vehicle for propelling the aircraft at a speed sufficient to achieve lift thereof, and a boom interconnecting the vehicle and aircraft. The boom has one end interconnected with the vehicle for pivotal movement about horizontal and vertical axes, and the other end of the boom is interconnected with the aircraft at the center of gravity thereof such that the aircraft is universally pivotal relative to the boom.

Preferably, the ground supported vehicle is a truck or the like positioned behind the aircraft, whereby the aircraft is pushed in the direction of flight thereof. In use, a person such as a student pilot sits in the cockpit of the aircraft, and the truck driver accelerates the truck to a speed sufficient to achieve lift of the aircraft. The student pilot operates the flight controls so as to achieve a take-off during acceleration of the truck and landing during deceleration thereof. The training assembly can be used on an airport runway or the like and, depending on the length thereof, the student pilot can also manipulate the flight controls in the aircraft to perform other maneuvers while the aircraft remains airborne. In this respect, the universal joint connection between the aircraft and boom allows the student pilot to exercise pitch, roll or banking, and yaw movements of the aircraft. Pivotal movement of the boom relative to the truck about the vertical pivot axis enables the student pilot to achieve movement of the plane laterally with respect to the path of movement of the truck, and pivotal movement of the boom about the horizontal axis allows the student pilot to maneuver in elevation.

Preferably, pitch movement of the boom upwardly relative to the truck about the horizontal pivotal axis is limited as is yaw movement of the boom laterally of the truck about the vertical pivot axis. Likewise, it is preferred to provide limits with regard to the pitch, roll and yaw movements of the aircraft relative

to the boom. Such limits avoid the possibility of the student pilot maneuvering the aircraft so as to cause damage thereto or to the boom and truck, and to avoid movement of the aircraft into a position which might cause lateral tilting of the drive vehicle or instability in the control thereof.

In accordance with another aspect of the present invention, pivotal movement of the aircraft relative to the boom can be limited so that certain flight maneuvers are locked out with respect to student pilot actuation of the flight controls. Accordingly, movement of the aircraft can be restricted, for example, to pitching movements until the student pilot gains experience with regard to controlling such movements. After the student becomes proficient in this control mode, the aircraft can be permitted to roll or bank and then, eventually, to yaw. Therefore, the student pilot gains experience with regard to the maneuvers one at a time. It is obvious that this provides a training capability which is impossible to achieve in flight training in a self-propelled aircraft.

In accordance with another aspect of the invention, the beam is biased to pivot upwardly relative to the truck about the horizontal pivot axis. This in effect reduces the weight of the aircraft on the forward end of the boom, whereby the aircraft can be made to fly at relatively low speeds. The ability to fly at low speed can be further increased by removing the power plant from the aircraft to reduce the weight thereof. The power plant is not employed during flight training and, accordingly, is preferably removed. The location of the universal joint is then at the center of gravity of the aircraft without the power plant.

The training assembly of the present invention also enables a student pilot to practice taxiing operations and lateral movement of the aircraft along the ground during taxiing. It will be appreciated too that the cost of operating the training assembly is considerably less than the cost of flying a plane and that, in a given period of operation, training time is maximized. Moreover, maneuvers including taking-off and landing can be practiced safely, and training under undesirable weather and load conditions can be achieved to give the student pilot experience with regard to the feel of such conditions. In this respect, for example, the training assembly can be operated on a runway where a strong cross wind condition exists, thus to enable the student to become proficient in maneuvering the aircraft under such conditions. As another example, weight can be added to the aircraft to reduce the stability thereof in the pitch direction, whereby the student pilot can experience the loss of stability under such conditions. Other destabilizing effects can also be introduced into the aircraft to expose the student pilot to flying conditions that could never be experienced on a normal training aircraft because of the danger that would exist. Under all of these normal and abnormal conditions, the student pilot can control maneuvering of the aircraft and, without exposure to dangerous circumstances, experience the feeling of actually flying the aircraft.

Accordingly, it is an outstanding object of the present invention to provide a flight training assembly including a pilotable winged aircraft attached to a ground supported drive vehicle and in which the aircraft is maneuverable relative to the ground and to the drive vehicle.

Another object is the provision of a flight training device of the foregoing character which enables a trainee to experience in-flight maneuvering of the aircraft under conditions of maximum safety.

Still another object is the provision of a flight training assembly of the foregoing character which enables a trainee to take-off and land the aircraft and to maneuver the aircraft in pitch, roll and yaw directions between a take-off and landing.

A further object is the provision of a flight training assembly of the foregoing character which enables a trainee to experience maneuverability of the aircraft under adverse weather and/or load conditions.

Still a further object is the provision of a flight training assembly of the foregoing character in which movement of the aircraft by the trainee is constrained within predetermined limits to avoid movement of the aircraft into an undesirable attitude relative to the ground and/or the drive vehicle.

Another object is the provision of a flight training assembly of the foregoing character which is economical to construct and operate and which maximizes the useful training time during a given period of operation.

The foregoing objects, and others, will in part be obvious and in part pointed out more fully hereinafter in conjunction with the description of a preferred embodiment of the invention illustrated in the accompanying drawings in which:

FIG. 1 is a side elevation view of a flight training assembly constructed in accordance with the present invention;

FIG. 2 is a plan view of the assembly illustrated in FIG. 1;

FIG. 3 is an enlarged plan view showing the joint structure between the boom and truck of the assembly;

FIG. 4 is a sectional elevation view of the joint assembly taken along line 4--4 in FIG. 3;

FIG. 5 is a plan view in section of the universal joint between the boom and aircraft taken along line 5--5 in FIG. 1;

FIG. 6 is a sectional elevation view of the universal joint taken along line 6--6 in FIG. 2; and,

FIG. 7 is a front elevation view of the universal joint.

Referring now in greater detail to the drawings wherein the showings are for the purpose of illustrating a preferred embodiment of the invention only and not for the purpose of limiting the invention, the flight training assembly, as seen in FIGS. 1 and 2, is comprised of a ground supported vehicle A, a boom B, and a winged aircraft C. As described more fully hereinafter, boom B is mounted on the front of vehicle A for pivotal movement about a horizontal axis D and a vertical axis E, and aircraft C is mounted on the outer end of a boom B for universal pivotal movement of the aircraft relative to the boom about the center of gravity F of the aircraft.

In the embodiment shown, vehicle A is a pick-up type truck which, as is well known, includes an under carriage or frame. Such a frame includes or may be provided with a cross member 10 to support the corresponding end of boom B. It will be appreciated that the truck has driver controlled steering and speed control mechanisms, not illustrated. Any suitable boom structure can be employed and, as shown, the preferred structure includes elongated metal tubes or rods 12 which are spaced apart and interconnected by tubular cross members welded thereto to provide a rigid, open and light weight boom structure.

Any suitable structure can be employed for mounting the boom on the front end of the truck for pivotal movement about horizontal and vertical axes. In the embodiment disclosed, as best seen in FIGS. 3 and 4, the mounting structure includes a pair of angle iron members 14 having inner ends secured to vehicle frame component 10 such as by welding and having outer ends spaced forwardly of the vehicle. An angle iron cross member 16 extends laterally between members 14 at the outer ends thereof and is welded thereto. A pair of support brackets 18 are welded to cross member 16, and a pair of vertical angle iron members 20 are pivotally interconnected at their lower ends with brackets 18 by means of a pivot pin component 22. Pin component 22 extends through aligned openings in brackets 18 and members 20 and through a sleeve 24 having its opposite ends welded to brackets 18.

A pair of L-shaped plate members 26 are welded to the upper and lower ends of vertical members 20 so that one of the legs of each of the plates 26 extends horizontally and forwardly from members 20. The latter legs are provided with vertically aligned openings therethrough, laterally centrally thereof, and a sleeve 28 is aligned with the openings through the legs and has its opposite ends welded to the legs. The corresponding end of boom B is provided with upper and lower cross plates 30 which are welded to the tubular members af the boom. Hinge arms 32 are welded to cross members 30 laterally centrally thereof and extend rearwardly therefrom into overlying relationship with the forwardly extending legs of members 26. Hing arms 32 are provided with openings aligned with the openings through members 26 and sleeve 28, and a pivot pin component 34 extends through the aligned openings as shown. It will be appreciated, therefore, that the axis of pivot pin 22 defines horizontal pivot axis D and the axis of pin 34 defines vertical pivot axis E.

Preferably, upward pitch movement of boom B about axis D is limited to control the extent to which the aircraft can be elevated relative to ground. For this purpose, upright members 20 are provided with stop members 36 which are welded thereto and extend rearwardly therefrom toward truck A. Further, a cross member 38 is welded to angle iron members 14 so as to be in the path of movement of stop members 36 in response to upward pitch movement of the boom. Preferably, a pad 40 of rubber or the like is provided between stop members 36 and cross member 38 to cushion the stopping movement of the boom when the desired limit of movement is reached.

It is also desirable to limit yaw movement of boom B in laterally opposite directions about axis E and relative to center line G of the truck. For this purpose, a pair of support arms 42 are welded to angle iron members 14 and 16 to extend laterally outwardly and forwardly thereof. The outer ends of arms 42 are interconnected with boom B by means of corresponding movement limiting and damping components 44 having opposite ends pivotally interconnected one with arm 42 and the other with a cross member 46 welded to the boom. The structure of devices 44 is not pertinent to the present invention, and any suitable device can be employed for limiting pivotal movement of boom B toward the corresponding arm 42 and, preferably, cushioning such movement. Pneumatic or hydraulic shock absorber type devices would be suitable for the intended purpose.

Further in accordance with the preferred embodiment, it is desirable to provide for boom B to be biased toward a center position with respect to center line G of the truck. As shown in FIG. 3, this is achieved by a tension spring 48 between each arm 42 and the corresponding side of boom B. Upon movement of boom B in either direction about axis E, one of the springs 48 is tensioned and thus tends to return the boom toward a position in alignment with center line G of the truck. It will be appreciated that many arrangements for achieving centering of the boom can be devised. For example, centering springs could be employed in conjunction with or as a component part of components 44.

With further regard to boom B, it is desirable to minimize the effective weight of the boom in order to reduce the effective load to be lifted by aircraft C during use of the assembly. In the embodiment shown, as best seen in FIGS. 1 and 2, the effective weight of the boom is reduced by means of a lift assisting arrangement including a plurality of spring components 50. Springs 50 have corresponding ends secured in a fixed position relative to truck A, and the opposite ends of the springs are interconnected with the boom and are displaceable relative to the fixed ends. More particularly, a suitable spring frame 52 is mounted on the truck in a fixed position relative thereto and includes a cross member 54 provided with a plurality of apertures to receive the ends of springs 50. The opposite ends of springs 50 are interengaged with apertures in a cross bar 56, and the latter cross bar is connected by a cable arrangement 58 with boom B at a location spaced forwardly of pivot axis D. Further, cable 58 is spaced above horizontal axis D by means of a support bridge 60 which, in the embodiment shown, includes a pair of legs 62 welded at their lower ends to boom B and interconnected by a plurality of cross members 64 which are vertically spaced apart from one another. Cable 58 extends across and rests on a given one of the cross members, and the forward ends of the cable are suitably attached to the boom. It will be appreciated that cable 58 is adapted to be associated with a selected one of the cross members 64, thus to vary the lifting effect of springs 50 on boom B. Any number of cross members can be provided for this purpose. Moreover, it will be appreciated that arrangements other than that shown can be employed to achieve a force to counteract the weight of the boom.

Any suitable winged aircraft can be employed in the training assembly of the present invention and, in the embodiment shown, the aircraft is a light weight, single seat plane of the pusher type having a power plant behind the cockpit and a propeller at the tail of the plane. In order to minimize the weight of the plane, the power plant is removed, whereby center of gravity F is the center of gravity for the plane without the power plant. Although not shown in detail, it will be appreciated that the plane includes pilot operable flight controls for operating wing, stabilizer and rudder flaps to achieve maneuvering of the plane in flight.

As mentioned hereinabove, the plane is mounted on the forward end of boom B by a universal joint assembly so that the plane is capable of pitch, roll and yaw movements relative to the boom. The structure of the forward end of the boom and a universal joint construction for the latter purpose is shown in FIGS. 5-7 of the drawing. In this respect, the forward end of the boom is provided with metal side plates 66 which are welded to boom tubes 12 and are laterally spaced apart to receive an inverted L-shaped metal arm 68 which is mounted between the plates such as by means of a plurality of nut and bolt assemblies 70. Arm 68 extends upwardly into the aircraft through a suitable opening in the bottom of the fuselage thereof. The free end of arm 68 extends forwardly and supports a spherical bearing block assembly comprised of bearing block members 72 and 74 which are interconnected by suitable nut and bolt assemblies 76. bearing block member 72 can be integral with arm 68 or can be a separate component welded or otherwise mounted on the free end of arm 68.

The inner surfaces of bearing block members 72 and 74 are provided with recesses cooperatively defining a spherical cavity 78 which receives and pivotally supports a spherical bearing member 80. Bearing member 80 is apertured to receive a rod 82, and the bearing member is securely mounted on the rod in any suitable manner to prevent both rotational and axial displacement of the bearing member relative to the rod. The ends of rod 82 are welded to support plates 84 which in turn are mounted on frame components 86 of the aircraft on laterally opposite sides thereof. Preferably, the rod and plates are removably mounted on the frame components such as by nut and bolt assemblies 88.

Rod 82 extends horizontally in the direction between the opposite sides of aircraft C, and the axis of the rod passes through the center of gravity F of the aircraft. Further, spherical bearing member 80 is centrally located in the direction between the opposite sides of the aircraft, whereby the center of the spherical bearing member coincides with center of gravity F. The laterally opposite sides of bearing block members 72 and 74 are provided with openings 90 coaxial with rod 82 and of a diameter sufficiently large to permit the desired pivotal movement of bearing member 80 relative to the boom.

As mentioned hereinabove, pivotal movement of the aircraft in the pitch, roll and yaw directions relative to boom B is limited. In the embodiment shown, pivotal movement in the yaw and roll directions is limited by means of a pair of resilient pad assemblies 92 mounted on rod 82 on laterally opposite sides of bearing block members 72 and 74. Each pad assembly 92 includes a circular disc 94 of resilient material such as rubber suitably secured to a metal backup plate 96 which is integral with or attached to a hub 98. Rod 82 extends through the pad assembly, and the latter is axially slidable relative to the rod to adjust the distance between the pad assembly and the adjacent side of bearing block members 72 and 74. A set screw 100 or the like can be employed to lock the pad assembly in a desired position. It will be seen, therefore, that by spacing each pad assembly from the corresponding side of bearing block members 72 and 74, aircraft C can pivot relative to boom B in the yaw and roll directions to the extent determined by such spacing. When the aircraft approaches the desired extent of movement in these directions, resilient discs 94 engage the corresponding side of the bearing block assembly to cushion and stop the movement.

Movement of aircraft C in the pitch direction relative to boom B is limited, in the embodiments shown, by a stop pin 102 mounted on spherical bearing member 80 and a window or opening 104 provided in bearing block member 74. The axis of pin 102 is on a radial line through the center of spherical member 80, and the pin is threaded into a recess in member 80 so as to be removable therefrom. Window 104 is of square or rectangular contour and has a width in the direction between the sides of bearing block member 74 sufficient to permit the desired movement of aircraft C in the yaw direction relative to boom B. The head of pin 102, in the embodiment shown, is circular and the diameter thereof and the height of window 104 are designed to permit the desired extent of pitch movement of aircraft C in opposite directions relative to center of gravity F. When the nose of the aircraft is pitched downwardly pin 102 engages the lower edge of window 104 to stop the pitch movement, and when the nose of the aircraft is pitched upwardly pin 102 engages the top edge of window 104 to stop the latter pitch motion.

It will be appreciated from the foregoing description that pivotal movement of aircraft C relative to boom B can be limited to just pitch movements by positioning pad assemblies 92 in abutment with the opposite sides of bearing block members 72 and 74. This locks out roll and yaw movements and thus enables the student pilot to experience and become familiarized with control of the aircraft in the pitch direction only. When the student becomes proficient in this control mode, the pad assemblies can be moved outwardly from the bearing block members to release the aircraft for movement in the roll and yaw directions. If desired, circular pin 102 can be replaced by a pin having a width corresponding to the distance between the sides of window 104 and a height less than the distance between the top and bottom edges of the window. The side edges of the latter pin would be rounded at a radius of curvature corresponding to the distance between the axis of pin 102 and the side edges of window 104. This pin and window configuration would permit movement of the aircraft in the pitch and roll directions, but would preclude movement in the yaw direction. Rolling movement would be limited by pad assemblies

92 in the manner described hereinabove. Accordingly, the student pilot can now experience and become familiar with control of the aircraft in two modes of movement. After the student becomes proficient in these control modes, pin 102 can be again employed in conjunction with bearing member 80, whereby the student pilot is now able to experience control of the aircraft in all three modes of movement.

The extent to which aircraft C is permitted to pivot in the pitch, roll and yaw directions relative to boom B can of course be varied as can the extent to which boom B is permitted to pivot in the yaw and pitch directions relative to truck A. Preferably, the limits are such as to enable the student pilot to practice take-offs and landings and other maneuvers of the aircraft with the degree of freedom he would have in a normal aircraft flight, but within limits of aircraft movement which make it virtually impossible to cause any uncontrolled situation which might result in damage to the aircraft, boom or truck. It has been found that these desirable results can be achieved with the following movement limitations: aircraft pitch up 15.degree. from horizontal and pitch down 10.degree. relative to horizontal; aircraft roll 10.degree. right and left and yaw 10.degree. right and left; boom yaw 10.degree. right or left of the center line of the truck and boom pitch upwardly approximately 25.degree. relative to horizontal. In the embodiment herein illustrated and described, the truck is a commercially available truck, the boom is approximately 18 feet long, and the aircraft is a BD-5 single seat aircraft manufactured by Bede Aircraft, Inc. of Newton, Kansas. The movement limitations refer to maximum degrees of movement in connection with the preferred embodiment.

In use, the truck driver operates the truck to move the aircraft into a desired position on a practice runway. During such movement, the student pilot controls movement of the aircraft along the ground and thus gains experience in taxiing the aircraft. When in position on the runway, the driver accelerates the truck and, when the ground speed is sufficient, the student pilot operates the flight controls of the aircraft to achieve a take-off. Following the take-off the student pilot can exercise those controls of movement of the aircraft which have been made available to him. When the truck approaches the end of the runway the driver decelerates the truck and the student pilot operates the flight controls to land the aircraft. Of considerable advantage in use of the training assembly is the fact that a flight instructor can ride in the truck and communicate instructions to the student pilot through a communication system between the truck and aircraft.

While considerable emphasis has been placed herein on certain structural components of the preferred flight training assembly, it will be appreciated that many modifications can be made in the preferred embodiment without departing from the principles of the present invention. In this respect, for example, a ground supported drive vehicle other than a pickup truck could readily be employed to propell the aircraft, and the aircraft could be other than the particular plane herein identified. Moreover, any suitable boom structure can be employed, and many structural arrangements other than that herein shown can be devised to achieve the desired mounting of the boom on the drive vehicle for pivotal movement about horizontal and vertical axes. Likewise, many arrangements other than that herein illustrated and described can be devised and employed for achieving universal pivotal movement of the aircraft relative to the forward end of the boom, and many arrangements can be devised for achieving limited pivotal movement of the aircraft relative to the boom and of the boom relative to the drive vehicle. The arrangements herein illustrated and described in this respect are merely illustrative of operable arrangements for the intended purpose. Accordingly, as many embodiments of the present invention can be made and as many changes can be made in the embodiment herein illustrated and described, it is to be distinctly understood that the foregoing descriptive matter is to be interpreted merely as illustrative of the present invention and not as a limitation.

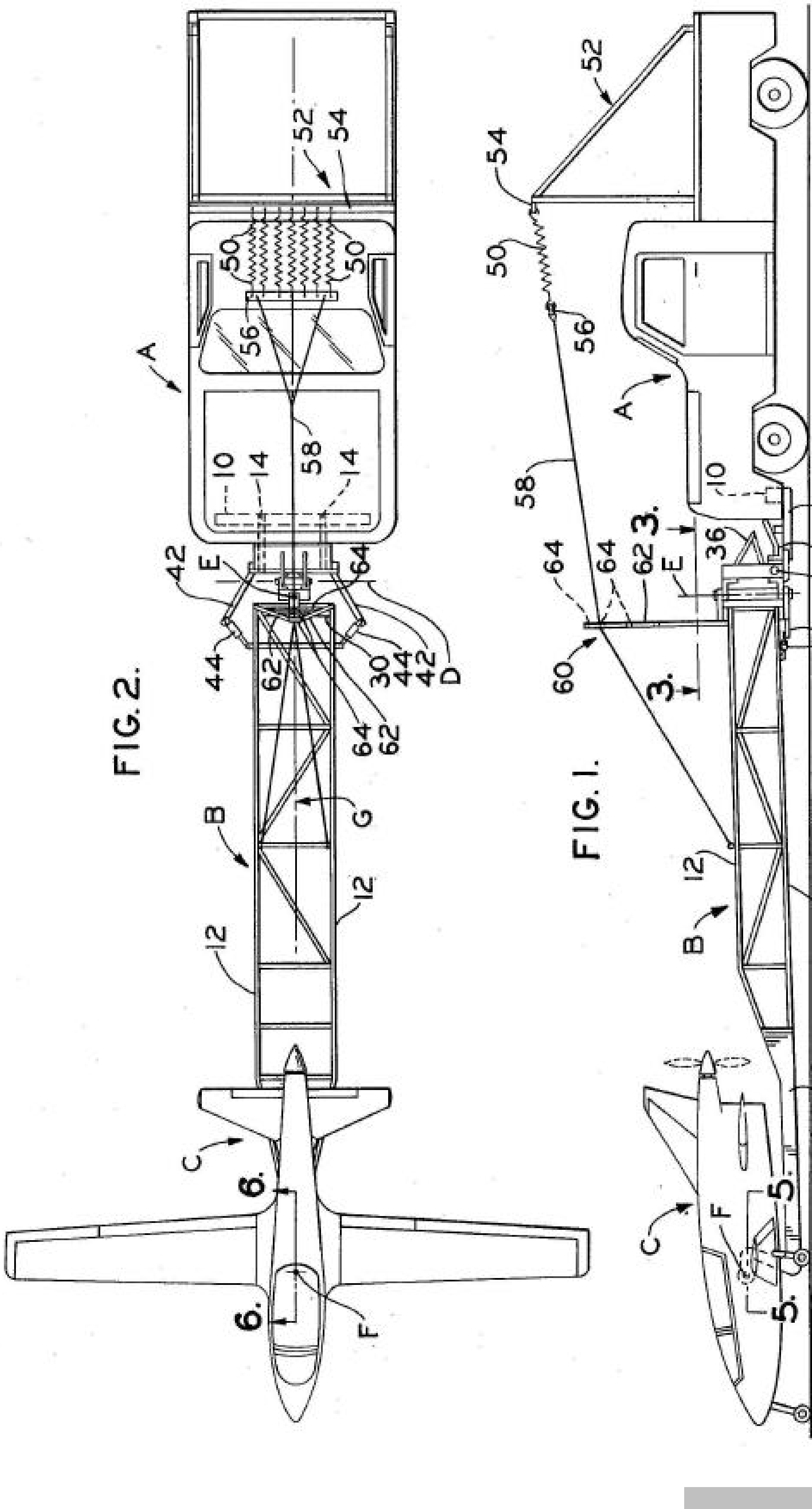
* * * * *

Very Last Minute News!
BD-5B Sets World Record!

We have just been told by Herwig Bielig of Austria that Horst Malligas has once again brought the FAI Class C1a/0 world speed record to the BD-5 community! His Rotax 618 UL-equipped BD-5B (apparently not using the A-wing this time) was clocked at 351.39 km/h or 189.735 knots with pilot Peter Schleichenberger (132.2 lbs) at the controls. The new record was set back in September but it took the FAI six months to issue the certification.

Congratulations, Horst!

U.S. Patent Nov. 16, 1976 Sheet 1 of 3 3,991,487



U.S. Patent Nov. 16, 1976 Sheet 2 of 3 3,991,487

FIG. 3.

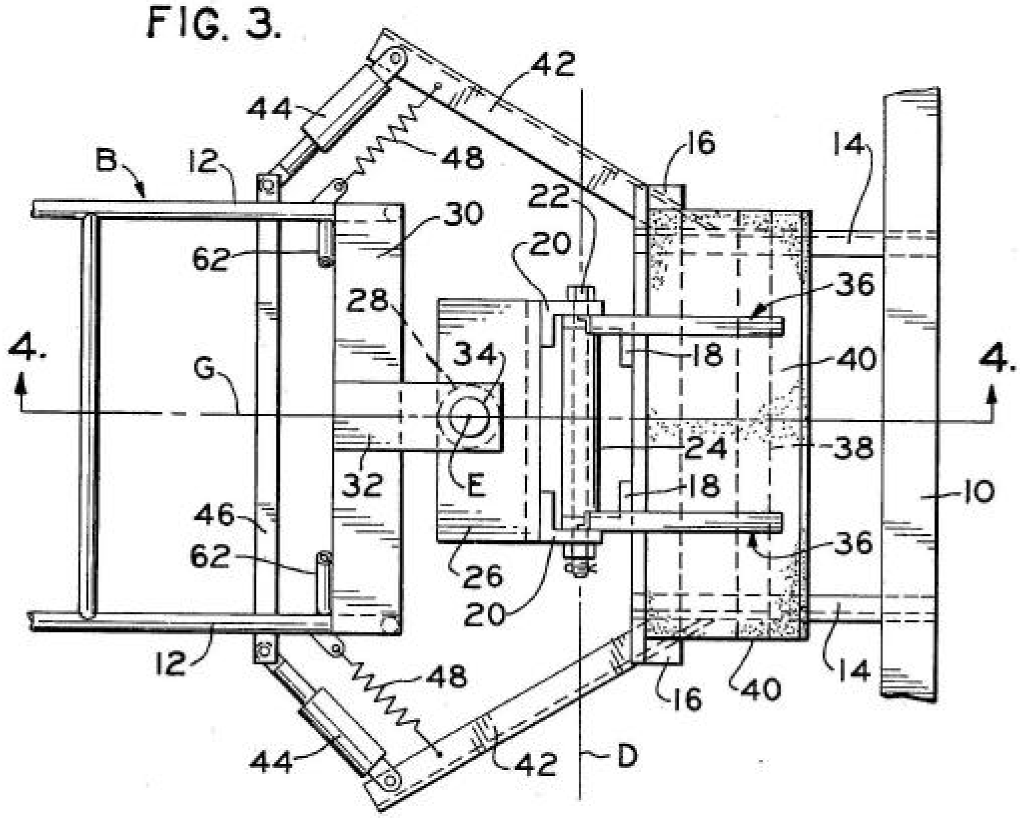
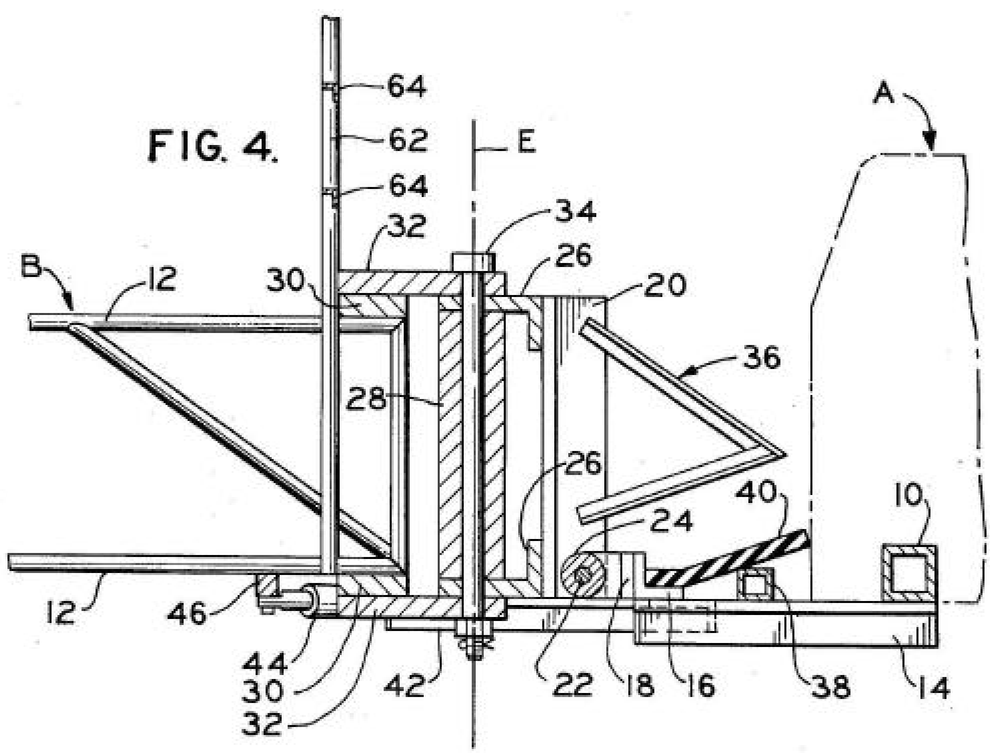


FIG. 4.



U.S. Patent Nov. 16, 1976 Sheet 3 of 3 **3,991,487**

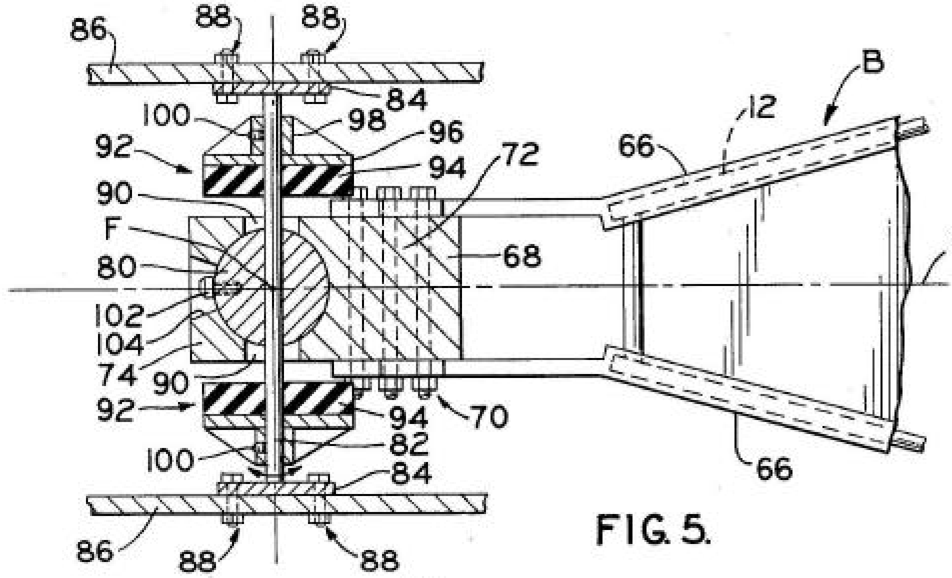


FIG. 5.

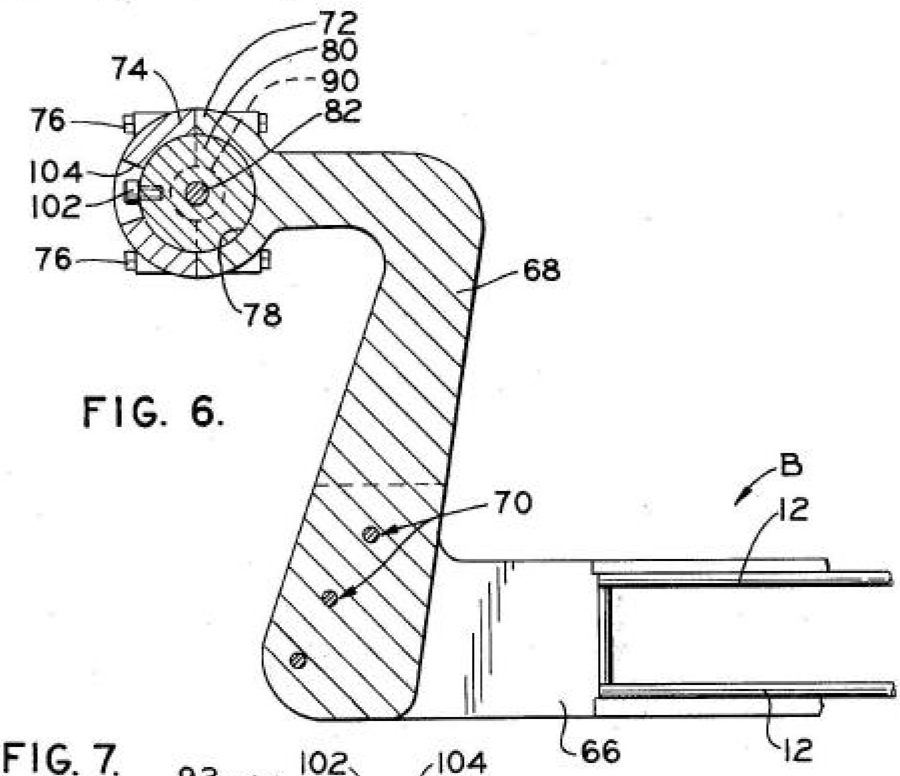
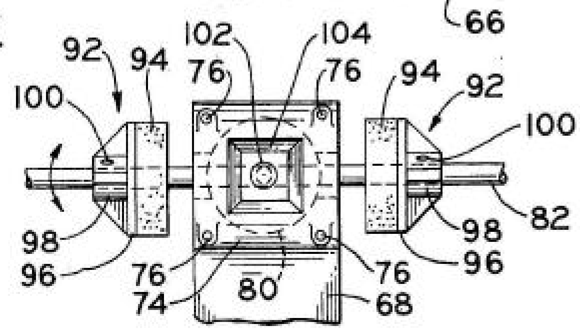


FIG. 6.

FIG. 7.



BD-5 Vendor List

The following vendors provide parts, services and kits for BD-5 builders. We list them here in alphabetical order, for your reference.

Alturair

1405 N Johnson Ave
El Cajon CA 92020-1630
Ph: 619-440-5531
Fax: 619-442-0481
Email: alturdyne@worldnet.att.net
Contact: Paul Ross
BD-5 kits, parts, builder services, engines (rotary engine in development).

BD-Micro Technologies

1260 Wade Rd
Siletz OR 97380
Ph & FAX: 541-444-1343
Email: sales@bd-micro.com
Contact: Edward "Skeeter" Karnes
FLS-5 kits (recip, turboprop, jet), parts, builder services, engines (2-stroke, turboprop).

Gerald "Jerry" Kauth

9810 State Ave #9
Marysville WA 98270
Ph: 360-435-8109
Drive system sales and upgrades, landing gear parts and assembly services.

Robenalt Engraving

1423 Broadway
Burlingame CA 94010-2082
Ph & FAX: 415-348-6262
Contact: Stanley Robenalt
Custom instrument panels, engraved placards.

Seneca Light Aircraft Systems

5479 E Cty Rd 38
Tiffin OH 44883
Ph: 419-585-7002
Fax: 419-585-6004
Contact: Matt Dandar
Hirth aircraft engine sales.

Miscellaneous Suppliers

The following vendors carry inventories of all types of aviation goods, tools and other items which you may need during your project to finish a BD-5.

Aircraft Spruce & Specialty East

900 S. Pine Hill Road
Griffin, Georgia 30223
Ph: 770-228-3901
Fax: 770-229-2329
Order Dept: 877-4-SPRUCE
Customer Service: 800-443-1448
Email: east@aircraft-spruce.com
web: http://www.aircraft-spruce.com
General aviation parts, supplies, tools.

Aircraft Spruce & Specialty West

225 Airport Circle
Corona, California 91720
Ph: 909-372-9555
Fax: 909-372-0555
Order Dept.: 877-4-SPRUCE
Customer Service: 800-861-3192
Email: info@aircraft-spruce.com
web: http://www.aircraft-spruce.com
General aviation parts, avionics, supplies, tools, instruments.

Aircraft Tool Supply Co.

P.O. Box 370
1000 Old U.S. 23
Oscoda MI 48750
Ph: 800-248-0638
Telephone: 517-739-1447
Fax: 517-739-1448
Email: info@aircraft-tool.com
Web: http://www.aircraft-tool.com
Aviation tools and supplies.

The Wag-Aero Group

1216 North Road
Lyons WI 53148
Ph: 262-763-9586
Fax: 262-763-7595
Order Line: 800-558-6868
wagaero-sales@wagaero.com
Web: http://www.wagaero.com
General aviation supplies, avionics, instruments, parts.

Is your company or service missing from this list?

Write or email us and let us know!

Have You Finished The R-8 Rudder Bracket Mod On Your BD-5?

This Modification Is A Mandatory Safety Of Flight Item!

Contact Your Favorite BD-5 Supplier For More Information.

The BD-5 Newsletter
Official Publication the BD-5 Network
PO Box 155293
Ft Worth TX 76155-0293
USA

Mailing label indicates remaining issues on subscription. If it says NONE, it's time to renew! Electronic subscriptions will note remaining issues in body of mail.

The BD-5 Bulletin is published quarterly. Domestic US and Canadian subscriptions are priced at $25/yr, international subscriptions are US$40/yr, and must be paid with US funds payable at a US bank or postal money order payable in US Dollars. Electronic subscriptions are US$15/year, and delivery is made in Adobe Acrobat format through Electronic Mail. All subscription funds must be made payable to **JUAN JIMENEZ**, PO Box 155293, Ft Worth TX 76155-0293, USA. To contact us by email, write to flybd5@hotmail.com or visit the BD-5 Web Site at **http://www.bd5.com**

Late Breaking News! US Govt Awards Free GPS Upgrades Worldwide!

As we went to print, we were advised of some great news for GPS owners. The U.S. government has decided to give the **entire planet** a free GPS upgrade by removing the *Selective Availability* (SA) block. This blocking prevented GPS units to pinpoint their locations up to ten times more accurately. The removal of SA became effective on May 1, 2000.

The Interagency GPS Executive Board has published the announcement, along with supporting documents and graphs, on its web site, located at **HTTP://WWW.IGEB.GOV.**

Dr. Dennis G. Milbert, Chief Geodesist at the National Geodetic Survey, explains in one of the documents available on the web site that to understand the implications of the removal of SA from the worldwide GPS network, you must "…consider a football stadium. With SA activated, you really only know if you are on the field or in the stands at that football stadium; with SA switched off, you know which yard marker you are standing on."

As part of the announcement, President Bill Clinton's statement reads: "The decision to discontinue SA is the latest measure in an on-going effort to make GPS more responsive to civil and commercial users worldwide. Last year, Vice President Gore announced our plans to modernize GPS by adding two new civilian signals to enhance the civil and commercial service. This initiative is on-track and the budget further advances modernization by incorporating some of the new features on up to eighteen additional satellites that are already awaiting launch or are in production. We will continue to provide all of these capabilities to worldwide users free of charge." Enjoy your free GPS upgrade, folks!