



The First Johnson Airplane

By: Al Kelch, Editor

The first attempt of the Johnsons to fly was a long hard struggle that terminated with little success. It is obvious that these attempts, like the Wright Brothers' early failures, proved to be the training ground for the second attempt, which was culminated in a complete success. The Johnsons proved their mettle in this long struggle, remaining hopeful and cheerful to the bitter end. They so thoroughly abandoned the first attempt that little trace is left. This picture is the only one found in their collection, and it was not labeled. I am making the assumption from the familiar up exhausts that appeared on all Johnson engines. There is little resemblance in this plane and the second one with its sleek construction and sophisticated engineering. The Johnsons learn fast! The following is a complete account of the first attempt, as published in the Terre Haute Tribune. The tedious research for this article was furnished by David Moulton.

Wednesday, August 3, 1910

JOHNSONS' PREPARE TEST AIRPLANE - machine stands ready after more than a year's work for its initial flight - brothers guard secret of place of first trial. Airship has as original feature, V type 2 cycle engine, built for strength and lightness.

Harry, Louis, and Julius Johnson, the Johnson Brothers, who have been at work for more than a year manufacturing an aeroplane at their shop, 717 N. 10th St., have at last completed the machine and will leave Friday for a place in the open country near Terre Haute,

to make the first attempt at flying it.

Thus far, the Johnson Brothers have kept the location of the place where they will try to fly the machine, an entire secret. It is desired to have no crowd about to bother while the machine is being tried.

Everything was completed Wednesday with the exception of putting the parts together. The machine, which weighs 650 pounds complete, will be shipped knocked down to the scene of the first attempted flight. The propeller, which is over 10' in length, the wings, seat and balances will not be attached until the scene of

try-out has been reached.

Wednesday morning the airplane stood in the big building erected especially for the purpose of building it, at the rear of the Johnson home, on North 10th St. It is 36' in length and measures the same exactly from tip to tip in width. Every part of it has been manufactured by the three young men while they at the same time carried on their occupation of gasoline and marine engine manufacturing. It was begun just a little less than a year ago.

The wings, which are to extend on either side from

the front of the machine, measure 16½ x 8' and are made of light waterproof canvas, stretched over stout framework. The engine is a V type 2 cycle engine, the only one of its kind to have ever been made.

"There are V type engines" said Mr. Johnson, "but they are 4 cycle. The 2 cycle engines have previously been built straight, causing increased weight. Everything about the machine has been built for speed and lightness."

Two 7½ gallon gasoline tanks will furnish the propelling power for the machine. It is expected it will take a day and a half to set the machine up after it's been shipped to the place where it will be tested.



Saturday, August 6, 1910

LOCAL AVIATORS MAKE READY FOR FIRST TRIAL. JOHNSON BROTHERS MOVE AIRPLANE TO FIELD NEAR BLACKHAWK AND SET UP MACHINE FOR TEST - everything was hustle and bustle at the Johnson brothers aero camp, a few miles from Blackhawk, Saturday, where the three young men, manufacturers of engines and incidentally builders of an airplane, were engaged in putting together their airplane preparatory for a trial flight. One of the busiest of the workers was Clarence Johnson, a 12 year old brother, who showed himself a handy man about the place. Owing to the fact that due to their hurried move from Terre Haute with their machine Friday, the Johnson brothers left behind some necessary blocks and braces, and the flight that was scheduled for Saturday, will be postponed until some time Sunday. The strange man by the name of Zakarius, supposed to be from Indianapolis and well versed in aviation, was with the three brothers Saturday as they worked on their machine, which was enclosed in a 40' tent, to shut out the view from the spectators. Another important personage at the scene was Dr. Dupui, of Riley, who was on hand in case a flight should be made, to see to the injuries of the aviator in case he should meet with an accident.

The try out grounds are admirably situated in the center of a 100 acre farm in the reservoir of the old Wabash and Erie Canal. There is a wide stretch of clear country, without any woodland within its radius of two miles. It is believed the airplane will be assembled and ready for a trial late Saturday afternoon, but it is not thought a flight will be attempted before Sunday.



Sunday, August 7, 1910

JOHNSON BROTHERS PREPARE FOR INITIAL TEST OF BIG AIRPLANE. CONFIDENCE PERMEATES CAMP AS TIME FOR TRY-OUT NEARS - the first flight, if flight is to be, of the Johnson airship, now resting in all readiness for its try-out at its camp at southeast of Terre Haute, will come at about noon today, and the result of a year's work and effort to build a successful airplane will be determined.

In spite of the Johnson effort at secrecy, spectators began to throng to the camp in the old reservoir bed early Saturday afternoon, and later in the evening automobiles could be seen on every road leading to the hiding place. The farmers also took Saturday evening off to take advantage of the opportunity to see the machine and the men.

A heavy steel roller was brought to the scene Saturday evening and the Johnsons will lay out the course early Sunday morning on which the aviators who drive the machine in the preliminary try-outs will score down for a start. The meadow as it stands, is rough, and trouble was feared when the wheels of the flyer were started over the ground before the machine raised into the air.

Just who would be the first man to steer the machine on its initial effort, the Johnsons refused to state, but the crowd of sightseers who have been watching the progress of the work at the camp picked the man who they believe will be in the seat when the airplane raises first. It is William Zachow, the stranger from Racine, Wisconsin who arrived in this city just in time to take an active part in completing preparations for the try-out. Zachow refused to give out his name, but the above is the name he registered under at the Philbeck Hotel. Gossip has it that the Wisconsin man is an experienced aviator, and it is on this fact that the spectators base their belief that he will be the one to drive the machine when it is tried out.

There is no spirit of speculation in the air about the Johnson camp, but in plain, businesslike manner, the men are carrying forth the work which is to determine whether or not Terre Haute has produced a parallel to the Wright Brothers. There were several men on the ground Saturday afternoon who professed some knowledge of mechanics. All the men who have seen the machine since it has been brought near enough to completion for an idea to be formed as to its efficiency, has had nothing but praise for the thoroughness with which it has been finished, and experienced mechanics say that from a mechanical standpoint, the machine looks good.

An experienced mechanic who examined the machine Saturday, stated that the V type, 2 cycle engine, a

distinctive feature of the new machine, is especially adapted for the use on airplanes. The Johnson brothers claim the distinction of having made the first engine of this type, and mechanics say that it is the coming engine for use on aerial machines.

The Johnsons, themselves, though they do not talk much, have all confidence in their creation. The men have had years of experience in the manufacture of all kinds of engines, and in addition have put in considerable time in research work on the subject of airplanes and other flying machines. They have been close students to the methods of the Wright Brothers.



Monday, August 8, 1910

MAKER LAYS PLANS TO PILOT AIRPLANE ON INITIAL FLIGHT - with the airplane removed from the tent in which it has been housed, and the engine of the plane in perfect running order, the Johnson brothers were expected Monday at noon to make an attempted flight at any time.

The field, located near Blackhawk, south of the city, where the first trial will take place, is in perfect condition for the flight. The only thing that may cause a delay of the flight is the lightness of the wheels which support the airplane on the ground at the start. It was feared Monday that heavier wheels would be necessary. In case this is decided on, the trial of the machine will not take place for a day or so. One of the Johnson boys will pilot the machine on its initial attempted flight. This was definitely announced Monday. It was thought at first that William Zachow, who was present at the aviation camp would pilot the machine, but it has developed that the stranger is a salesman for an airplane supply company. He is said to be thoroughly familiar with the mechanism of airplanes, however, and has been of great value in getting the machine ready for flight.

A test of the engine was made Monday morning, it developed 40 HP. Confidence was expressed by the Johnsons that the engine could develop 20 HP additional if necessary.



Saturday, August 13, 1910

WEAK SPRINGS POSTPONE JOHNSONS' TRIAL OF FLIGHT. CROWDS GATHERED AT AVIATION

FIELD TO AGAIN LEARN THAT MACHINE'S TEST MUST AGAIN BE DELAYED - the Johnson brothers made no attempt to fly this afternoon. It is reported that they would make their initial attempt to scale the clouds today. A crowd followed in the wake of the rumor, and by 2:00 this afternoon many people swarmed down from the meadow.

When the Johnson machine was wheeled out at 2:00 it was found by the inventors that an important set of springs were too weak. These will be strengthened and it is probable that the apparatus will not be taken out of the tent again until Tuesday of the coming week.

Two of the brothers hurried to Terre Haute this afternoon as soon as the defect in the machine was discovered. They will return to the camp Sunday and begin adjustment.



Sunday, August 14, 1910

BROTHER AVIATORS DELAY DEMONSTRATION AGAIN. PART OF MACHINE USED IN MAKING LANDING GETS OUT OF ORDER SECOND TIME - though delayed again in their preparation for the initial flight of the first airplane ever manufactured in Terre Haute, the Johnson boys, Louis, Julius and Harry, went to work to remedy the defect which made necessary the postponement of their flight for the second time. The defects which they are now forced to repair causes no despair in the Johnson boys, or lessens their faith that the machine will fly after they are completed.

"We have encountered no difficulty whatever as yet which would in any way interfere with the successful flight of the machine," said one of the boys Saturday. "The trouble is only in the wheels and supporting spring, those parts of the machine which are used to make a landing on, and the defect is not curious in any way, though it does take some time to make the necessary changes."

The intention of the trio was to fly Saturday, and the day was ideal, but it was decided at the last minute that the chances of flying and making a safe landing would involve too great a risk.

Louis, the eldest of the Johnson brothers, said to a Tribune representative Saturday, "I am sorry that we could not fly today. In the first place the weather is ideal, and in the second place when the statement that we have been halted again appears in print, a great many people will believe that the machine is a failure. As for us, we are certain, as we have been all along, that the airplane will fly."



Monday, August 15, 1910

JOHNSON PROMISES TO MAKE AIRPLANE TRIP WEDNESDAY. BROTHERS OCCUPY ENTIRE DAY REPAIRING CARRYING TRUCK OF HEAVIER THAN AIR MACHINE - the work of getting ready the remodeled parts of the carrying truck for the airplane, occupied the day of the Johnson boys at their work shop on 10th Street on Monday. The men expect to have their work completed and will take their remodeled parts to the camp near Blackhawk, Tuesday evening.

Louis Johnson said Monday that they expect to have everything in readiness for the trial by Wednesday. One man has been left at the camp, while the others came to their home in Terre Haute over Sunday.



Friday, August 19, 1910

JOHNSONS WAIT WEATHER FOR FIRST TEST OF FLYER. HUGE MONOPLANE GIVES EVERY EVIDENCE OF BEING FULLY CAPABLE OF NAVIGATING THE AIR - the initial flight of the Johnson monoplane was scheduled to take place Friday afternoon, but a strong wind swept over the field here, and made the test impossible. The huge flyer waits serenely for the first chance to take to the air, having been thoroughly tested on the ground.

Friday afternoon the monoplane was staked to the ground headed into the wind, and the engine turned on for the purpose of determining her power. Under full speed the flyer acquired the full strength of the helpers to keep her from leaping upward. At half speed the power developed was not sufficient to convince the builders that the test would be a success in the wind, as it is their desire to fly first under half power, leaving the remainder for reserve while in the air.

After the test of the engine, Louis Johnson expressed himself as being unsatisfied with the condition of the engine and propeller.



Saturday, August 20, 1910

JOHNSON SHIP REFUSES TO QUIT TERRA FIRMA. ENGINE FAILS TO DEVELOP SUFFICIENT SPEED

TO LIFT MACHINE INTO AIR - the Johnson brothers have made half a dozen attempts to fly the monoplane upon which they have worked for so many months, and in none have they succeeded in getting the big machine into the air.

Three times Friday they turned the big propeller under high speed and freed the machine from all restraints. At a rate of about 12 mph it tore down a rough field, only to be stopped at the limit of the course without having raised from the ground. Three of these efforts were made before, and three after alterations had been made to the propeller. Saturday morning the Johnsons were not disheartened or discouraged, they had come to the realization that they were not as far advanced in the building of the machine as they had thought. Their attention was turned to alterations that were expected to have a decided affect on the plane and also to the grounds upon which they were flying. The aviation camp is located on exceedingly poor grounds. It is rough and full of ruts, and so soft that the tired wheels sink to 1" to 3" in it when the machine is started. Those who have watched the attempts to fly are of the opinion that the nature of the grounds is largely responsible for the failures, as it is impossible to start the machine at a pace that will make it rise. Whether the Johnsons will move or prepare a smoother runway is a question that has not yet been determined. The three efforts to fly Saturday morning were made early, while the sun was rising and the wind was low. A fairly steady breeze from the south made it necessary to drive the machine up a slight grade into the wind, but this was not sufficiently a factor to which to attribute a failure to rise. The monoplane failed to fly simply because it did not have enough power to raise it from the ground. There is no speed indicator in the camp and it is impossible to tell at what rate the propeller is revolved, but several have estimated it at about 900 rpm. 1500 rpm is considered necessary for success, and the Johnsons may have to make radical changes in the propeller before making the desired speed.

Saturday evening, before a large crowd, they started the engine three times and raced down the field with Louis Johnson in the machine. The first was probably the best of all the trials. The monoplane attained a good rate of speed, but it did not leave the ground. The builders decided the trouble was due to the size of the propeller, and they cut it down several inches. The result was the engine operated faster and more smoothly, but it was by no means as speedy as necessary and the test made established that more alterations were necessary, especially if attempts to fly are from the present locations.



Sunday, August 21, 1910

FOUR DEVOTEES OF AERONAUTICS MAINTAIN CHEERFULNESS IN FACE OF PARTIAL DISAPPOINTMENT. WAITING FOR CALM. JOHNSONS ADVANCE IN CONQUERING AIR. SIX TRIALS OF MONOPLANE PROVE MANY THEORIES CORRECT BUT BRING PARTIAL DISAPPOINTMENT. LOW SPEED PROPELLER PROVES TOO WEAK TO RAISE WEIGHT. DIFFICULTIES AT FIELD AND APPLICATION OF MOTOR'S ENERGY PRESENT PROBLEMS THAT MUST YIELD BEFORE PERSEVERENCE - Sunday, the Johnson brothers, who are now so earnestly engaged in the attempt to fly a monoplane in the old canal basin near Blackhawk, are going to demonstrate that they can build a high power, low speed motor fully adapted to the needs of the aviator.

Just now they are encountering difficulties that would discourage many, with a patience that means success, they are working under handicaps that appear as insurmountable, but must give way before their determination.

Saturday morning, the last of six attempts to make their machine leave terra firma failed and they went back to their tent disappointed after two weeks of the hardest kind of labor. In spite of the cheerful attitude they assumed, there was an air of disappointment all around the camp and even the jokes of the jolly party did not dispel it.

The disappointment lay not so much in the fact that the machine failed to leave the ground in its trials, as in the evidence that higher speed would be necessary for the proper operation of the motor. It is the object of the Johnsons to develop a motor that will run a monoplane without the terrific speed common to those in use. If they succeed in securing one of this type, they have a fortune at their command. They do not desire to construct an airplane merely for the purpose of flying. If they did, they could easily obtain the pattern of the Wright brothers' machine or other machines and build accordingly, or they could purchase a machine at less cost and trouble than they have encountered. But, having as their object the development of a low speed motor, the failure of the one now in use to do the work expected, was disappointing. Although it whirled the propeller at a speed that astonished the spectators, it was not operated at a rate of which it is capable, but at a rate very much lower, and which the builders hope would be sufficient for its purpose.

Consequently, when the speed attained by the motor in the first trials Friday proved insufficient, one of the hopes of the Johnsons was dashed.

Reluctantly they cut down the size of the propeller, knowing that every inch shaved from it would increase the speed of the engine. Two inches all around were sacrificed in the desire to raise the skybird, and the result was a perceptible increase in the number of revolutions and consequently a steadier engine. Some consolation was offered by the fact that even with the reduced propeller there was little vibration noticeable about the machine.

Late Friday night the airplane was run out of its tent, and the motor started. The effect was extraordinary and the hopes of the Johnsons that they had accomplished their purpose ran high. Saturday morning, early, the fourth attempt to fly, and the first with the reduced propeller, was made.

Whether the alterations had any effect on the raising power of the motor was difficult to determine, because of the conditions under which the trial was made. A steady breeze from the south, made it necessary to start the machine from the north end of the field at the foot of the small incline, and on ground that was wet and soft. The machine behaved no better than before, but whether it was due to the propeller, the grade or the soft ground, was a question the Johnsons were not ready to answer. To eliminate the grade is almost impossible. To wait for a more favorable wind is nerve racking, yet the Johnsons will have to do all of these things before making sure that they have the propeller rightly proportioned for the task.

Whatever may be determined regarding the propeller, it remains that the Johnsons have demonstrated an engine that is remarkable for its power and speed combined with its steadiness and construction. The motor is of the 2 cycle type, 4 cylinders. This means that an explosion occurs in each cylinder just twice as often as in the more common 4 cycle 4 cylinder type. More power is the result and 75 hp is the indication. This is accomplished by combining the Johnson patent valve with cylinders set at an angle of 180° and big carburetors. The patent valve is one on which the men have worked for a long time and they have shown by it a method of allowing more gas to enter the cylinders without increasing the size of the valve, a point, of considerable value in construction. Then, they have obtained a motor that will run at great speed and create so little vibration that it scarcely causes a tremor in the light wooden frame of the airship. All in all, the motor has conducted itself in a manner that is deemed most satisfactory. It is applying it to the airplane that has

proven the puzzle and that is the very point the Johnsons are seeking.

The Johnson monoplane will fly because it is constructed on the proper principles for flight. That it has not been successfully launched as yet is due to two things - the experience in designing and operating of the men in control of it and the unfavorable conditions under which the trials have been made. Both of these points will be overcome in time. While they are eliminating the unfavorable conditions, they are learning from experience the points they have overlooked in designing, and they are learning rapidly how to operate it.

The story of the construction of the Johnson monoplane is one of hard work and persistent effort. The Johnsons have had no teacher in the art. They have studied much, observed a great deal, and gathered from experience a great deal more than the average man will ever know about airplanes. No one realizes more than they that there is a great deal more to be learned. That is why, after months of work they took their machine to the Blackhawk basin. It was two weeks ago today that they arrived there, and since that time they have fought mosquitos, malaria and rain in a most credible effort to work out the theories they have formed. It is not a pleasant task, but one that requires thought, constant experiment and careful reasoning. They are not particularly interested in what the public thinks about their work. They want to apply the Johnson motor to aeronautics.

As one enters the aviation field, he is greeted by a sign that reads "Welcome - Outside the Tent". The sign is expressive of the attitude of the Johnson boys. They are willing that anyone watch them at work, free about giving information when asked, but they promise nothing, and consequently are not responsible for the disappointment of the many who have come to see them fly, and have left without that satisfaction.

Julius Johnson expressed their attitude well when he said, while waiting for a wind to subside, "we have waited a year to get to this point with the machine, and we can afford to wait another day rather than run the chances of breaking up the airplane".

Last week's activity at the camp became intensive. Thursday morning, when the machine was run out of its protection for the first time, the frame buckled. This was immediately repaired and trials of the engine and frame made that evening. Friday, three unsuccessful attempts to raise the machine were made, and Saturday, with an altered propeller, three more efforts brought no better success.

When the last visitor departed from the aviation field Thursday night, the Johnsons rested content with their

preparations for a flight on the early morning air. Time and again the builders had been disappointed in not having it ready for flight at the time agreed upon. Little weaknesses that could not be foreseen became apparent when the machine was started across the rough field, had yielded one by one to careful attention and ingenuity. Every nut and bolt on the unwieldy looking skybird had been inspected and found in first class condition. The alterations made necessary by faulty calculations as to weight and pressure on the running gear were completed and the new woodwork covered with a preserving paint. In the center of the structure the light, but powerful engine, shown in polished brilliancy. Just in front of it the big propeller, built of many pieces and smoothed to a surface like glass, was perfect to the last detail. A sliver that had been knocked from it was replaced with cement, and its bearing was as true as science could make it. Stretching away on each side for 16', were ribbed wings on which so much depends, each without a flaw or scratch. At their tips hung the balancing planes, so delicately fitted that the slightest movement of the operator was reflected by a changed position. To the eye the machine was perfect and the builders who worked so patiently, at last were satisfied it was ready for its initial trip.

It now appeared that nothing stood in the way of a thorough demonstration, but the Johnson brothers were doomed to meet another disappointment. Under its power for the first time, Louis Johnson drove the airship down the field from the tent in which it had been housed. Three of the four cylinders were in operation, yet it was evident that the Johnson motor was sufficiently powerful for the purposes of the craft. At speed that hurried those who accompanied it, the aircraft ran along over the rough ground with little or no vibration from the motor and a steadiness that spelled success. Four men hung to it with their weight keeping it from mounting the air, while the driver accustomed himself to the situation and watched the engine and the plane.

This was the final test of the monoplane before it was entrusted to the element for which it was constructed. This test fully demonstrated that the care bestowed upon its construction was not misplaced. There was not a flaw noticeable in any of its moving parts. There was nothing about its action that indicated a single weakness. But one thing marred the success of this test, and Thursday night saw that one point corrected. The long body or frame that extends from the plane to the rudder on the tail, was not sufficiently strong to stand the strain of alighting from a height as was shown in its action during this test. Immediately the builders prepared to strengthen it, and all day Thursday they worked on this one part, rebracing and adding to the solidity of this frame

work, until, as the crowd left the field Thursday night, they saw the end of the last bit of preparation for an air test.

While it has been disappointing to visit the aviation field and fail to witness an attempt to fly, the chagrin of the Johnson brothers and Pearl Conover has been greater. Living in a single big tent pitched in a malaria breeding district, pestered by insects and blistered with the heat, they have put up with all kinds of inconveniences since leaving Terre Haute, and every hour's delay has been bitter to them. Malaria sent Clarence Johnson, the youngest of the camp, back to the city unfit to be about. Mr. Conover succumbed to it one day, but was able to throw off the attack. The Johnson brothers have all felt the effect of life in the camp and as Louis Johnson expressed it, "Are dead anxious to get to doing something".



Monday, October 10, 1910

MONOPLANE JUSTIFIES EFFORTS OF JOHNSONS. AIRCRAFT GOES INTO AIR SEVERAL TIMES AT TESTS MADE SUNDAY - after many weeks of quite work at their camp on the old reservoir prairie 3 miles east of Blackhawk, in an effort to perfect the airplane, which, when first tried out, was found to be lacking in a few particulars, Louis, Harry and Julius Johnson, the inventors and builders of the Johnson Bros. airplane, succeeded in making several lifts with the aircraft at tests made Sunday evening. Three tests were made, and it was on the third one that the machine lifted from the ground. Several times the craft raised for distances of from 15 to 20'. Though the height attained was not more than a foot from the ground at any time, this fact was rather to lack in certain details than because the airplane could not raise higher.

The craft exhibited a wonderful buoyancy for the test and tended to leave the ground at all times higher than it was allowed to. However, necessity for certain corrections was manifested before a flight could be safely made and to avoid possible wrecking of the machine, it was held down at all times.

An assistant of the Johnson boys, in their efforts toward perfecting the machine, stated Monday that an idea of buoyancy of the machine could be gained from the fact that when starting on the soft dirt just previous to the test, that it would leave no track in the soft dirt, but that when being brought back for a second test it would plow back into the soil for a depth of 6".

Preparations were almost completed Monday after-

noon for further tests to be made solely on the ability of the machine to lift. It is expected that the trial will take place about an hour before sunset. No effort at flight will be made at this time, the test being confined to determining the buoyancy of the machine, its balance and general fitness for flight.



Tuesday, October 11, 1910

JOHNSON GIVES EXPRESSION TO SATISFACTION WITH PLANE. TEST CONTINUED TO OCCUPY TIME OF BROTHERS AT AVIATION FIELD - Louis Johnson, the elder of the Johnson brothers, builders of the Johnson Monoplane, spent Tuesday in Terre Haute looking after business matters. The other two brothers, Julius and Harry are at the aviation field, making a few required minor changes in the mechanism, preparatory to attempting a flight Wednesday or Thursday.

Louis will return to the field Tuesday evening to be ready to sit at the wheel of the machine in the initial attempt at flight.

"We have gone far enough now, to see through to the end, and we now know that the theory which we have been working, is the right one. We will fly within a few days, possible Wednesday or Thursday. The changes now being made are only minor adjustments, which were seen to be necessary in our tests as to the lifting power of the machine".



Editor's Note:

The brothers apparently abandoned the attempts to make the 1910 airplane fly shortly after this, in October 1910, and started work on an improved design, which was successful in the summer of 1911. Between the end of October and the middle of July 1911, they built an entirely new airplane but used the same power plant that had been used in the 1910 version. The new airplane was radically different in design using basically a metal framework, cloth covered wings and cloth covered tail surfaces, which were supported on a single aluminum boom. It had a tricycle gear as contrasted with the conventional gear in the 1910 plane. It had wing-warping in place of the moveable surfaces at the tips of the wings, steerable nose wheel and brakes and many other engineering refinements. 