No. 289 JULY 2010

T.W.I.T.T. NEWSLETTER

This appears to be a rare photo of a Horten IV on the trailer with the rear protective shell removed, the nose cover taken off to get to the center section and the root section cover opened up. This is what Bob Fronius was working on for the scale Horten on display in the hanger.

T.W.I.T.T.
The Wing Is The Thing
P.O. Box 20430
El Cajon, CA 92021

The number after your name indicates the ending year and month of your current subscription, i.e., **1007** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, July 17, 2010, beginning at 1:30 pm at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive - Southeast side of Gillespie).

THE WING IS THE THING (T.W.I.T.T.)

T.W.I.T.T. is a non-profit organization whose membership seeks to promote the research and development of flying wings and other tailless aircraft by providing a forum for the exchange of ideas and experiences on an international basis. T.W.I.T.T. is affiliated with The Hunsaker Foundation, which is dedicated to furthering education and research in a variety of disciplines.

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Meetings are held on the third Saturday of every other month (beginning with January), at 1:30 PM, at Hanger A-4, Gillespie Field, El Cajon, California (first row of hangers on the south end of Joe Crosson Drive (#1720), east side of Gillespie or Skid Row for those flying in).

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PRESIDENT'S CORNER

I have taken the very optimistic approach for this organization by renewing our license for the web site out to August of 2019. This resulted in getting the license for almost half price over a yearly renewal so I couldn't pass it up. This ensures there will be something for the flying wing community for a long time to come, even if for some reason the newsletter should stop production or go into few issues per year.

Most of you Internet users probably already know this but I just discovered it while looking for pictures to put in the Northrop article. If you type in flying wings in Google there is a line that is labeled "images for flying wings". When you click on the link it comes up with over 5 million results and shows thumbnails of images. Some of the images are always of fling wings probably due to the way the webmaster has them coded to try and get more hits. I used this newly found treasure trove to come up with the cover shot since there were many new images I had never seen before.

I have included another installment of the Northrop article started in May. In many instances I was able to find the exact pictures included in the original paper, but as you will see not everything has found its way onto the Internet. I found this somewhat surprising, but it may have to do with Northrop Grumman having more control over some historical images than other that became pretty much public fare over the years.

I am still looking for more letters from all of you. I would sure like to share your projects and/or stories with the rest of the group, but I can't do that if you don't send them in.

Andy

LETTERS TO THE EDITOR

May 19, 2010

I am enjoying my browse through the newsletters and found an interesting project near the end of November 1987 issue. The 3 view on graph paper page 7 illustrated by what appears to be Gerald Butler, Box 635, Santee, CA 92071.

I checked the roster of Jan. 2003 and didn't see him there. Can you please see if this address matches the supposed name and if He is still a member? I wanted to talk to that designer about center section lift of the Horten style wing, and engine, prop assembly.

Please see if this member can be contacted.
Thanks again,

Stephen Sawyer
Lincoln, CA
<s-sawyer@sbcglobal.net>

(ed. – This came in right after the last issue went to print and I couldn't find any information about Gerald in our back membership records. If any of you happen to know him, please drop Stephen a line and help him make contact. Thanks.)

May 21, 2010

Aloha:

Pardon my belated response. I previously flew an Icarus V hang glider (built by Larry Mauro) but crashed it back in 1976 when I clipped a tree coming into a tight landing spot; I got out of the hospital three months later. I also flew and still have an Easy Riser that we may convert to electric power; we flew it with various two strokes, both direct drive and reduced.

I have a 1952 Cessna 170B that I use for inter-island flights and movie work ("The Rundown" and "You, Me & Dupree") and a small open cockpit flying boat similar to an Osprey 1.

I have followed electric flight since 1973 when Larry Mauro (Ultralight Flying Machines) started working with electric power that resulted in the Solar Riser that is now in the EAA museum. More later, I'm taking my grandkids surfing today.

David Bettencourt
<airlaw@pixi.com>

(ed. – When we get a new member I always ask them how they heard about TWITT and what their interests are. This was David's response. Sounds like he has done some unique flying and still is since he island hops. Welcome to TWITT.)

May 24, 2010

I am very interested in schematics and information about BKB's and BEKAS planes. I want to know if I could get it somehow (I live in Argentina, Buenos Aires), and how can I pay this.

Thank you a lot.

Mikhail Grebnev
<mikgrebnev@gmail.com>

(ed. – I wrote back to Mikhail that as far as I knew there were no plans for the BKB, but I wasn't sure about whether plans were ever produced for the BEKAS. If anyone knows of a museum or individual that might have access to plans for either aircraft, please drop Mikhail a note with the information.)

June 17, 2010

I know this is off-topic, but I have a brand new Spirit Elite ARF, new in box, FOR SALE, for the great price of $100, obo, plus $15 S&H. I bought the kit about a year ago for the list price of $129.

Unfortunately, due to my work schedule (I fly for the Army), I just don't have the time to get this great bird built and flying, and it is an outright shame that its not tearing up the skies right now (private message/e-mail)!

I also have an Airtronics RD 6000 computer radio kit for sale for $75.

You are more than welcome to pass this on to anyone you know as well! Any questions? Let me know!

Serious Inquiries Only

Brian
<cbl2799@yahoo.com>

(ed. – This came from the Nurflugel bulletin board and was the only thing all month that was worth printing. You can see an image of the glider below and check out the pricing at: http://www.greatplanes.com/airplanes/gpma1047.html)

Items from the Mitchell U-2 Bulletin Board

I have an A10 for sale it is like new condition with very low times. It has the KFM 30 hp engine with re-drive, electric start, power fin adjustable prop, BSR soft pack chute, trailer all manuals for the engine and plane. It flies great. $7500 OBO

Tim
<tmpilot84@yahoo.com>
home 307-358-3821
cell 307-351-5362

(ed. – This came from on the board today (6/30/10) so by the time you get this it might still be available if you think it is a good price.)

I came across a very nice purpose built engine that has just came onto the market. It's worth looking at all the videos on their website. Yes it will certainly do for my U2 project it's name is ""Redhead 180"" it's a copied and modified ""Black Devil"" paramotor engine. It is 180cc's, very easy pull start, around 34lb's weight, a whopping 150 lb's thrust [sustained over 2 hours] and all for US$1699.99. Parts are made in China [the same as Peugeot, BMW, solo,etc.] but I think it is all supervised by Americans??? [I am looking into that at the moment.] It is certainly well worth a peek-boo, just to see the size of the factory. Here's the address http://www.aerothrustppg.com/videos/engines/index.shtml

I think we are moving in the right direction but it all happens sooo slloooowwwley doesn't it. An option I am looking at is a folding prop and guess what a company here in "the land down under" makes them. Look up "Bolly Aviation" then click on their series 4 props and there you have it. Tthey work out at around US$620 which is not too bad. So all up for an engine and prop I'm looking at around AUS$3000. I will be contacting the engine makers to see if I can get the motor out from the Chinese factory [closer to Perth Western Australia therefore less freight]. I'll let you all know how it goes,

Cheers for now.

Alex Patrick
<a.pat@bigpond.com>

(ed. – The following is the next installment of the technical paper from the 1940's that were sent to us by Steve Torpey in Bakersfield. My thanks to Steve.)

"The Development of All-Wing Aircraft"
by J. K. Northrop

Royal Aeronautical Society Journal (Vol. 51, #438)
June 1947 (RFD# 117122)

OTHER MAJOR ADVANTAGES

There are other major advantages of the all-wing, type which cannot be so definitely evaluated but which can and do contribute appreciably to improvement in efficiency and range. Two of these, namely the elimination of jet-tail surface interference, and the possible elimination of wing-tail surface shock wave interference, have already been mentioned. The third, and the most immediately applicable to designs of the near future, is the improved adaptability of all-wing types to the distribution of major items of weight empty and useful load over the span of the wing. While such distribution can be made to a limited extent in conventional aeroplanes, it can be much more fully accomplished in the all-wing type. Such weight distribution results in substantial savings in structural weight, which have important effects on the ratio of gross weight at take-off and landing weight. An analysis of the range formula indicates that this ratio is one of the most important range parameters. Competent authority has shown that distribution of fuel in the wings instead of the fuselage of a large conventional modern transport would allow an increase in gross weight of 16 percent without increase to empty, with a corresponding increase in range up to 30 percent.

It is fairly obvious that the all-wing aeroplane provides comparative structural simplicity, plus the possibility of structural material distribution in a most effective way at maximum distances from the neutral axis, plus an opportunity to stow power plant, fuel, and payload at desirable intervals along the span of the wing, which cannot be equaled in conventional types. These matters are rather intangible and difficult to illustrate by numerical relationships. They depend to a large extent on the type and size of the aeroplane, what it is designed to carry, and what the desired high, speed may be.

PROBLEMS INVOLVED IN ALL-WING DESIGN

Having demonstrated, perhaps, that the advantages of the all-wing type are fully worth striving for, let us consider the problems involved and their solution. Based on our present experience these difficulties do not appear now of surpassing magnitude, but in 1939 several of them seemed so serious as to discourage the most hardy optimist.

To one testing a swept-back aerofoil having a desirable root thickness, taper ratio and symmetrical section, together with reasonable washout at the tips such as might be designed from the then available data, the first results were a bit terrifying. Fig 5 shows the pitching moment curves obtained from the first wind tunnel tests of a model built to the above description. It may be seen that the elevator effect is erratic, changes in sign with varying deflections, and would be entirely unsuitable for the control of an aeroplane. It may also be seen that the degree of static longitudinal stability indicated by the average slope of the pitching moment curves is less than that considered desirable in a conventional aeroplane. Experiments involving visual observation of tufts on the model indicated a separation along the trailing edge of the aerofoil which was apparently due to the planform configuration, and which was responsible for the erratic curves. In early experiments a simple addition of 10 percent to the chord length with a straight-line contour from approximately the 70 percent chord point to the new 110 percent chord point, almost completely eliminated the difficulty and pitching moment curves for the revised model are shown in Fig. 6.

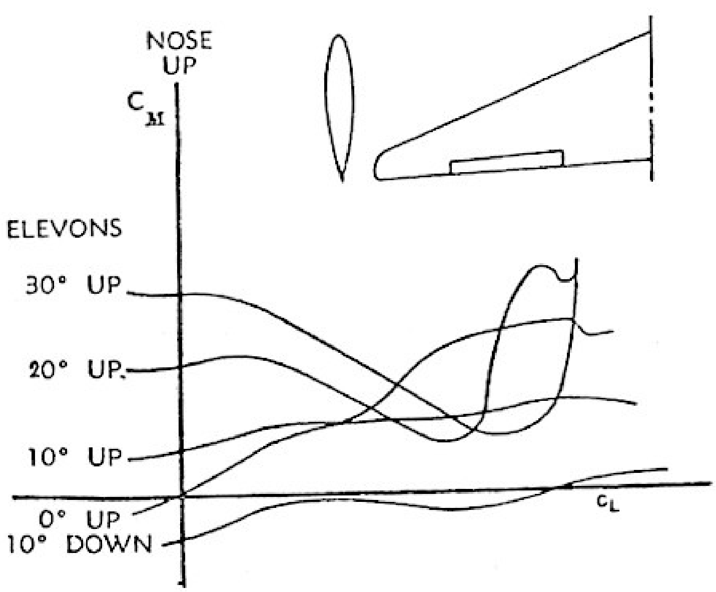

Fig. 5.
Elevon effectiveness without trailing edge extension.

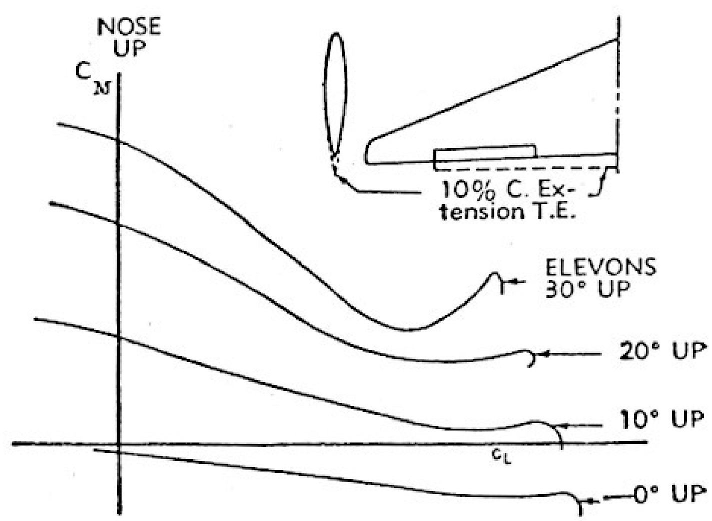

Fig. 6.
Elevon effectiveness with trailing edge extension.

N1M, FIRST FULL-SCALE AEROPLANE

It was soon determined that data applicable to conventional wings with little or no sweep were completely unreliable for the degree of sweepback required in practical all-wing designs, and that a whole new technique had to be developed to determine the limits within which taper ratio, sweep-back and thickness ratio could be combined for satisfactory results. All these variables were explored in a series of wind tunnel models, and when a reasonably satisfactory group of configurations had been determined it was decided to build our first piloted flying wing, the NIM (Northrop Model 1 Mockup).

Because of the many erratic answers and unpredictable flow patterns which seemed to be associated with the use of sweepback, it was decided to try to explore most of these variables full scale, and the NIM provided for changes in planform, sweepback, dihedral, tip configuration, C.G. location, and control-surface arrangement. Most of these adjustments were made on the ground between flights; some, such as C.G. location, were undertaken by the shift of ballast during flight. The variations to which this first aeroplane was subjected are indicated in Fig. 7, which shows two extremes of arrangement in which the aeroplane was found to be quite satisfactory in flight.

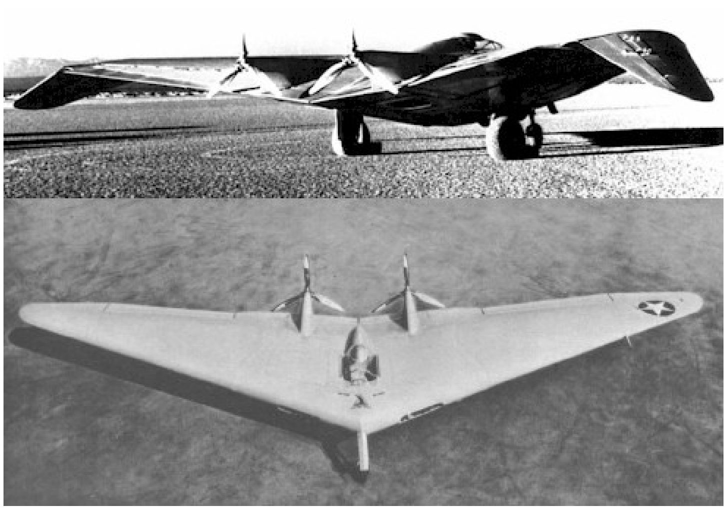

Fig. 7
Variations on the Northrop N1M.

It is an interesting commentary on the comparative ease with which the basic problems of controlled flight were solved to note that no serious difficulties were experienced in any flight attempt, or with any of the various configurations used. Some "felt" better to the pilot than others, but at no time was the aeroplane uncontrollable or unduly difficult to fly. The principal early troubles were related to the cooling of the small “pancake"-type air-cooled engines which were buried completely within the wing, and because of the pusher arrangement did not have the benefit of slipstream cooling in taxiing, take-off and climb. Engine-cooling problems seriously handicapped the early flights but later, somewhat larger engines were installed and the design of the cooling baffles was sufficiently improved so that repetitive sustained flights were accomplished easily.

The first flight was more or less an accident in that, while taxiing at comparatively high speed over the normally smooth surface of the dry desert lakebed used as a testing field, the pilot struck an uneven spot. He was bounced into the air and made a good controlled flight of several hundred yards before returning to earth. Altogether, this first aeroplane was used in over 200 flights of substantial duration, during which numerous configurations were tested and a great deal of work was done in the determination of the best types of control surface and surface control mechanism.

ELEVONS AND RUDDERS

From the inception of the work, longitudinal and lateral controls were combined in the "elevon," which word was coined to designate the trailing edge control surface members, which operate together for pitch control and differentially for roll control. At no time during early tests did control about the pitch or roll axes give any appreciable difficulty. The control which was least expected to cause difficulty gave the most, namely the rudder.

Early in the test program it was found that the aeroplane had quite satisfactory two control characteristics that is, a normal turn resulted from a normal bank without the use of rudder controls and as a result, throughout the program we have often considered the elimination of rudder controls entirely. It was indeed fortunate that the first aeroplane developed such docile characteristics, for many of the rudder configurations tried proved to be ineffective—or worse, affected the flight characteristics of the aeroplane adversely.

From the start it was determined to eliminate to the greatest extent possible, vertical fin and rudder surfaces; first, because they violated the all-wing principle and added drag to the basic aerofoil; second, because with the moderate sweepback employed in our early designs the moment arm of a conventional rudder about the C.G. was small, and an excessively large vertical surface would have resulted had we tried to achieve conventional yaw control moments. The rudder development was therefore concentrated on finding a type of drag-producing device at the wing tips, which would give adequate yawing forces without affecting pitch or roll. To this end we tried 25 or 30 different configurations in flight, which were first tested in the wind tunnel. As a result of this experience it was concluded that dynamic reactions were likely to be very different from static reactions; some of the configurations, which looked best in the wind tunnel proved to be quite unsatisfactory in flight.

The best and most practical rudder found was one of the simplest in concept and one of the first to be flown, namely a plain split flap at the wing tip which could be opened to produce the desired drag. This flap was later combined with the trimming surface needed to counteract the diving moment of the landing flaps, forming the movable control surfaces at the wing tip of the XB-35, as shown in Fig. 8 *(ed. – there was no equivalent picture available – the image showed the clam shell aileron/dive brake arrangement)*.

Among the many flights accomplished with the first experimental aeroplane were several in tow of other aircraft where the distance to be covered, or the altitude to be gained, made it impractical to depend solely on the aeroplane's own engines. After a few minutes of acquaintanceship with the slight differences brought about by the presence of the tow cable, the aeroplane behaved well in tow and several comparatively high altitude flights were made to investigate the spin characteristics. These appeared to be quite normal, based on preliminary tests of this aeroplane. Later experience, however, indicated that the spin characteristics of tailless types vary from one design to another, in the same fashion as may be expected in conventional types, and that no broad generalization as to spin behavior can be made with safety.

N9M, FLYING MOCKUP FOR BOMBER

The N1M was first flown in July of 1940 and about a year was consumed in a combination of aerodynamic tests and attempt, to solve engine cooling problems. As soon as good sustained flight demonstrations could be made on schedule the Army Air Forces took active interest in the program and top-flight officers, including General H. H. Arnold and Major General Oliver P. Echols, encouraged us to investigate the application of the all-wing principle to large bomber aircraft. To this end it was decided to construct four scale models of a larger aeroplane. These were designated N9M (Northrop Model 9 Mockup) and they duplicated, except for the power plant and propeller arrangement, the aerodynamic configuration of the proposed XB-35 aeroplane. This design is shown in Fig. 9.

The first of these aircraft was completed and test flown on December 27, 1942, and had completed about 30 hours of test flying with pilot (and sometimes an observer) when it crashed, killing the pilot. The machine bad been on a routine test flight across the desert away from its base, and was out of sight of technically qualified observers at the time of the accident. However, all evidence pointed to a spin, and the attitude of the aeroplane on the ground indisputably indicated auto-rotation at the time of impact.

Fig. 9
A Northrop N9M.

This loss was a serious setback and work was started immediately to recheck the spin characteristics of the aeroplane in a spin tunnel. It was later determined, both in the tunnel and in flight, that recovery was good, although a bit unconventional (requiring aileron rather than elevator action), but that the spin parachutes which had been attached to the aeroplane for the low-speed stalling and stability tests then in progress were ineffective as to size and improperly located.

SPINNING AND TUMBLING CHARACTERISTICS

Subsequent models, over hundreds of flights, gave no trouble. The low-speed stall and spin tests with rear C.G. positions were accomplished without further difficulty and the N9M proved an invaluable test bed in which various control configurations could be proved in detail. A large number of additional rudder configurations were developed and tested on the N9Ms; likewise different types of mechanical and aerodynamic boost for the control surfaces were investigated, as well as the general behavior of the aeroplane in all types of air, and with different C.G. positions.

In connection with the model spin tests of this aeroplane, an investigation of the tumbling characteristics of the type was made in the spin tunnel. These tests showed that if the model was catapulted into the airstream with an imposed high velocity about the pitch axis in either direction, it would continue to tumble or come out of the maneuver, depending on comparatively minor differences in elevon and C.G. position. In other words, under circumstances of induced rotation about the pitch axis the recovery was marginal. However, it would never tumble from any normal flight condition, such as a stall, spin, or any other to-be-expected maneuver. In some configurations, if dropped vertically trailing edge down into the wind stream, a tumbling action would be induced which might or might not damp out. This was not judged a serious matter in view of the fact that a vertical tail slide is hardly a maneuver to be courted, even by a fighter aeroplane, let alone a 100-ton bomber.

The three remaining N9Ms have been flown almost continuously since their completion dates to the present. Only recently have all desirable test programs been completed and the aeroplanes relegated to a semi-retired status from which they are withdrawn only for the benefit of curious pilots.

XP-79, ROCKET - POWERED AEROPLANE

In September of 1942 we conceived the idea of combining the newly developed liquid-rocket motors with a flying wing in a high speed and highly maneuverable fighter. The physical dimensions of the human frame immediately became a limiting size factor and for this reason, as well as because much higher accelerations can be withstood for longer periods in the prone position, it was decided to place the pilot prone in this design. Three experimental, full-size glider versions of this little aeroplane were rapidly completed and a long series of glider tests undertaken. In order to achieve the utmost in low drag, and lightweight, the original aeroplanes were mounted on skids and the first glider tests were attempted with an automobile, tow. Because of the rugged construction of the gliders they had a fairly heavy wing loading and the equipment provided for towing proved to be incapable of achieving enough speed for take-off.

As a second expedient, detachable dollies were built from which the aeroplane was expected to take off at flight speeds. Fig. 10 shows this arrangement. Minor crack-ups occurred With this configuration and it was finally decided to compromise the aerodynamic cleanness of these first test aeroplanes in order to provide a rugged permanent and dependable landing gear for experimental purposes, as shown in Fig. 11. The unusually large fin used here was required to stabilize the fixed landing gear, a substantial portion of which extended ahead of the C.G. After this gear was installed, and with another aeroplane as the towing medium, the take-off difficulties were eliminated and a number of successful glider flights were made.

Fig. 10
A glider version of the XP-79 with detachable dollies for take-off.

These aeroplanes were flown both with and without wing-tip slots and slats, which were tested for the purpose of eliminating tip-stall difficulties, as will be described later. They were also flown with a wide variation in vertical fin area, to determine the amount necessary or desirable for various flight conditions.

Fig. 11
Experimental version of the XP-79 with fixed landing gear shown during one of the early rocket-powered flights.

In one memorable test during which the aeroplane was equipped with a fixed slat, a rather peculiar accident occurred. The pilot, as mentioned before, lay prone within the wing contour. Two escape hatches were located approximately opposite the centre of his body, one on the upper surface, the other on the lower surface. The handle, which released the escape hatches, was located close to the handle, which released the towing cable from the tug aeroplane. At the start of this particular flight, after a successful climb to 10,000 ft., the pilot inadvertently released the escape hatches at the time of his release from tow, and as a result partially fell out of the aeroplane. The instinctive grasp on the control mechanism resulted in an indescribable wingover maneuver. When things calmed down the pilot found himself in a steady, uniform glide with the aeroplane upside down. Minor movement of the controls seemed to produce little effect and the much-shaken individual crawled out of the aeroplane, sat on the leading edge of the centre section while he checked his parachute harness, and then slid off to make a perfectly normal parachute descent. The aeroplane, undisturbed by the change in C.G., continued a long circling flight of the test area and finally landed in a normal continuation of its upside down glide, a short distance from the take-off point. It was rather seriously damaged but not so much so as to prevent repair. A later check in the wind tunnel indicated that there was a very stable region in inverted flight with this particular slat combination. Later the slats-were abandoned as unnecessary and perhaps undesirable.

The airframe was considered suitable for the purpose intended long before the rocket motors had been developed to a degree of reliability considered safe for use, but finally a small motor having about five minutes' duration, was installed and a number of rocket-powered flights were accomplished. Fig. 11 shows the aeroplane during one of these tests. The first powered flight occurred in July of 1944.

Although the first concept of the XP-79, as this fighter was designated, was as a rocket-powered vehicle (similar in basic idea to the Messerschmitt ME-163), it soon became apparent that the completion of the rocket motors would be far behind schedule and that serious difficulties were attendant to this development. One of the basic concepts, for the full-size motor was that the fuel pumps would be driven by rotation of the combustion chambers, which were set at a slight angle to the thrust axis in order to develop torque. It was not foreseen that the rotation of the combustion chambers would have a serious effect on the combustion therein, and this difficulty, never completely solved, caused the abandonment of the particular engine, which was being developed for the project.

XP-79B TURBO-JET AEROPLANE

As no alternative rocket engine was available, it became necessary to modify the design to incorporate turbo-jet power plants, and the second of the XP-79 series, called the XP-79B, shown in Fig. 12, was completed with two Westinghouse B-19 turbo-jets and first airborne on September 12, 1945. The take-off for this flight was normal, and for 15 minutes the aeroplane was flown in a beautiful demonstration. The pilot indicated mounting confidence by executing more and more maneuvers of a type that would not be expected unless he were thoroughly satisfied with the behavior of the aeroplane.

After about 15 minutes of flying the aeroplane entered what appeared to be a normal slow roll, from which it did not recover. As the rotation about the longitudinal axis continued the nose gradually dropped, and at the time of impact the aeroplane appeared to be in a steep vertical spin. The pilot endeavored to leave the aircraft but the speed was so high that he was unable to clear it successfully. Unfortunately, there was insufficient evidence to fully determine the cause of the disaster. However, in view of his prone position, a powerful, electrically-controlled trim tab had been installed in the lateral controls to relieve the pilot of excessive loads. It is believed that a deliberate slow roll may have been attempted (as the pilot had previously slow rolled and looped other flying-wing aircraft developed by the company) and that during this maneuver something failed in the lateral controls in such a way that the pilot was overpowered by the electrical trim mechanism.

Fig. 12
The Northrop XP-79B turbo-jet aeroplane.

ALL-WING BUZZ BOMBS

Several other all - wing aircraft and wing variations of them were built and tested during the same period. Shortly after the advent of the V-1 an all-wing "buzz" bomb was designed and built, the final configuration of this missile being shown in Fig. 13. This aeroplane housed the German V-1 resonator in a duct in the centre of the wing and carried twice the German warhead in cast wing sections on each side of the power plant with fuel in the outer wings. Several were built and flown successfully.

The first of these buzz bombs was tested as a pilot-controlled glider with good success. It was very small, as shown in Fig. 14 *(ed. – there was no equivalent image available showing crewmen working around the aeroplane),* and incorporated a number of extra bumps, which were originally conceived to be the best way to carry standard 2,000 lb. demolition bombs. In spite of its peculiar configuration, which departed appreciably from the all-wing ideal, it had quite good flight characteristics, was flown on a number of occasions (the aeroplane was successfully slow-rolled) and demonstrated the suitability of the type for the purpose intended.

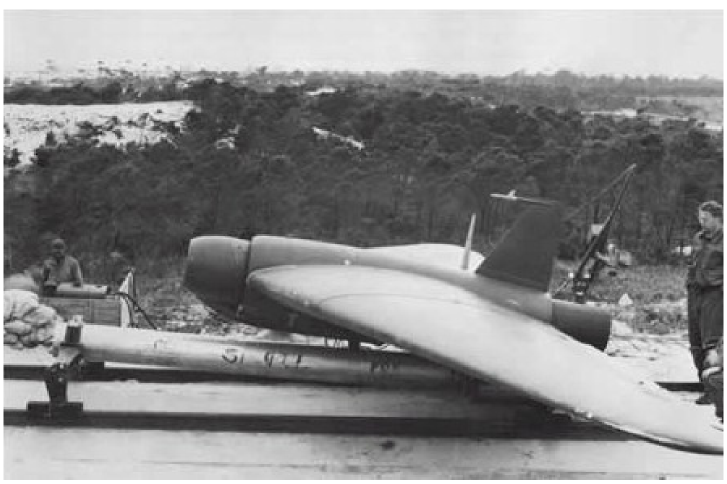

Fig. 13
The Northrop all-wing Buzz bomb.

The one difficulty experienced in this series of tests is worthy of note. The piloted version of the buzz bomb naturally required some type of landing gear for take-off and landing, and in this case we employed tiny, low-pressure air wheels, rigidly mounted in the airframe structure and extending only a few inches below the contour of the aerofoil or, more specifically, the bomb-shaped bumps thereon. Landing on this gear involved bringing the aeroplane in at an altitude of approximately 15 percent to 20 percent of the mean aerodynamic chord just prior to contact, and no amount of practice on the part of the pilot produced a technique satisfactory for this purpose. In every case a change in airflow appeared to develop as the aeroplane approached within a quarter-chord length of the ground. The drag was apparently reduced, the lift increased and the aeroplane rose, in spite of anything the pilot could do, to a height of 8 or 10 ft. above the ground, at which point it stalled and flopped down out of control. This maneuver resulted in a number of rough landings but no damage to either the pilot or the aeroplane. It was later found that the only way to make any sort of smooth landing was to bring the aeroplane in at comparatively high speed and actually fly it on to the ground. This difficulty was not experienced in aeroplanes having normal landing height above the ground, such as the N9M and XB-35

XB-35, LONG-RANGE BOMBER

During all this development and testing of other types and scale versions of the XB-35, the design and construction of the big ship had been under way. N9M aeroplanes had proved the practicability of the design. They closely approached the XB-35 configuration with the exception that they mounted only two pusher engines, located at positions corresponding to points midway between engines 1 and 2, and engines 3 and 4.

The problem of control-surface actuation on the big bomber involved the development and testing of a complete hydraulic control system, as none of the aerodynamic boosts or balances developed and tested in the N9M models had proved satisfactory. The system used in the XB-35 employs small valves, which are sensitive to comparatively minute movements of the control cable and which, when displaced, permit large quantities of oil to flow into the actuating cylinders. This arrangement eliminates any pilot "feel" of the load on the control surfaces unless a deliberate arrangement for force feedback is made. Rather than undertake this latter step, a comparatively simple force mechanism, which is sensitive to accelerations and airspeed, was developed. This device gives the pilot a synthetic feel of the aeroplane which can be adjusted in intensity to anything, he likes, and which has proved satisfactory in flight. For reasons to be outlined shortly, a synthetic feel was much more satisfactory than the feedback of actual control-surface loads, particularly at high angles of attack.

The XB-35 was first flown from Northrop Field to the Muroc Army Test Base in June of 1946. The first several flights indicated no difficulties whatsoever with the airframe configuration. Indications of trouble with propeller governing mechanisms were discerned at an early date and it was shortly discovered that flights of any substantial duration could not be accomplished because of oil leakage in the hydraulic- propeller governing system. On the last flight difficulty with both propellers on one side caused a landing with asymmetrical -power, which was accomplished without trouble.

The next six months, from August to March, were spent in a vain attempt to eliminate these difficulties, plus those caused by a series of engine reduction gear failures. To date the XB-35 has not had sufficient time in the air to fully demonstrate its ability to meet its design performance guarantees. However, large-scale model tests in numerous tunnels have indicated the low-drag figures presented earlier in this paper, and preliminary speed versus power tests completed early this month have given gratifying confirmation of our original expectations. Flights accomplished to date have included all maneuvers necessary for large bombardment aeroplanes. So far, however, violent maneuvers have not been attempted and no exact evaluation of stability and control parameters has been possible. The appearance of the XB-35 in flight is shown in Fig. 15.

Fig. 15
The Northrop XB-35.

Two turbo-jet powered all-wing aeroplanes, having the same basic shape and size as the XB-35 are virtually complete at this time and will be flying late this summer. They are powered by eight jets having a sea level static thrust of 4,000 lb. apiece. They incorporate small vertical fins to provide the same aerodynamic effect as the propeller shaft housings and propellers of the XB-35. Fig. 16 shows a model of this aeroplane.

Fig. 16
A model of a new turbo-jet all-wing aeroplane at present being developed my Northrop.

Let us now turn to considerations of stability and control of the all-wing aeroplane. They are quite different from those of conventional types and, unless reasonably well understood, may lead to discouragement at an early date concerning projects well north further evaluation.

STATIC LONGITUDINAL STABILITY

In any aeroplane the primary parameter determining the static longitudinal stability is the position of the centre of gravity with respect to the centre of lift or the neutral point. Obviously, the neutral point may be shifted aft by adding a tail or by sweeping the wing, or the C.G. may be shifted forward by proper weight distribution, so that from the standpoint of static stability no particular configuration has any special advantage except as it affects the possibilities of proper balance. In an all-wing aeroplane the elimination of the tail makes the problem of balance somewhat more critical but not excessively so.

Unfortunately, for any given aeroplane the neutral point does not ordinarily remain fixed with variations of power, flap setting or even lift coefficient, so that the aft C.G. limit for stability is often prescribed by some single flight condition. In our experience with tailless aircraft, the critical condition has always occurred for power-off flight at angles of attack approaching the stall.

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VHS tape of July 15, 2000 presentation by Stefanie Brochocki on the design history of the BKB-1 (Brochocki,Kasper,Bodek) as related by her father Stefan. The second part of this program was conducted by Henry Jex on the design and flights of the radio controlled Quetzalcoatlus northropi (pterodactyl) used in the Smithsonian IMAX film. This was an Aerovironment project led by Dr. Paul MacCready.
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