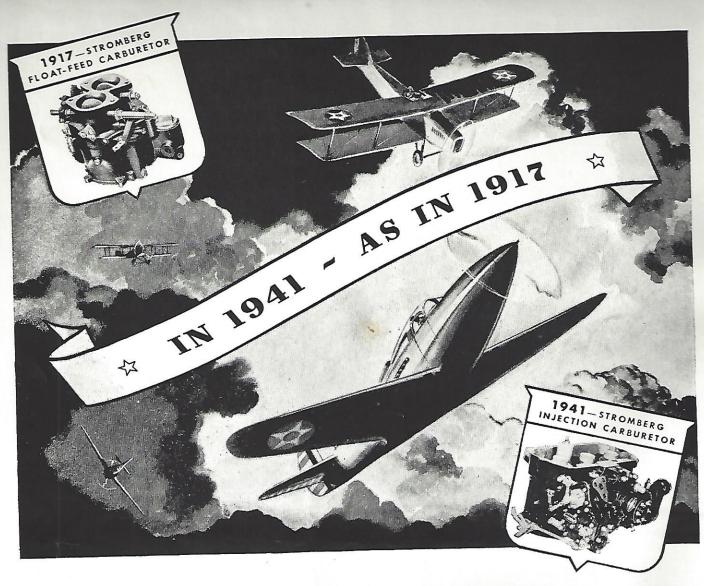
The Story of the Bell Airacobra



Stromberg pioneering again advances America's sky supremacy!

THE early airplane industry floundered along with "converted" automobile carburetors until Stromberg devised a carburetor exclusively for aircraft requirements. This development came in 1917-1923 and, steadily refined through Stromberg research, remained a world standard for many years, widely imitated abroad.

Recently, new giant engines with altitude power output twenty times that of earlier units, demanded and inspired the development of another type of carburetion, totally new . . . the Stromberg Injection Carburetor.

Briefly, Stromberg Injection Carburetion is fully automatic and meters correctly at all loads, altitudes, temperatures, and flight attitudes. It saves fuel, minimizes icing, and has proved most reliable. Its originally successful design has now the added refinements of two years service experience.

Thus, Stromberg pioneering has once more added new laurels to the record of American sky supremacy.

BENDIX-ECLIPSE OF CANADA, LIMITED SUBSIDIARY OF BENDIX AVIATION CORPORATION, WINDSOR, ONTARIO

Stromberg CARBURETION



RAY P. WHITMAN
First
Vice-President



OMER L. WOODSON Vice-President and Assistant General Manager



LAWRENCE D. BELL
President and General Manager



HARLAND M. POYER Chief Engineer



ROBERT J. WOODS Chief Design Engineer

Ringing the Bell

Remember those gadgets at country fairs where you swing a sledge-hammer—and if your swing is strong enough, you send a small weight shooting up a rod—and it rings the bell at the top? In America "ringing the bell" has become a synonym for succeeding in whatever job you take on. A motto for the Bell Aircraft Corporation of Buffalo and Niagara Falls, coined from the name of its founder and present driving force, Larry Bell, might very well be just that—"ring the bell". And his corporation is now ringing it on many counts in this year of grace 1941.

Just how? In the first place, by building up from a little two-by-four office at 1807 Elmwood Avenue, Buffalo, in June, 1935, to one of the largest producers of military fighter planes in 1941, with two plants totalling 1,000,000 square feet of manufacturing area. In the second place, by successfully producing in large quantities a revolutionary type of fighter plane which many aeronautical experts condemned as an impractical freak-but don't any longer. And in the third place, by building a fast ship fast, incorporating into its construction mass-production ideas as revolutionary as the airplane itself, and making them work. Here is a success story that almost sounds like fiction, were it not only too true, and a very reassuring truth to United States and Britain in this their hour of need for the fastest and most destructive thing on wings. And this is a reputation in the world of aerial combat which Bell's Airacobra bids fair to earn for itself before many more months have passed.

Back in June, 1935, Larry Bell, and Ray Whitman, his associate, were ringing bells—doorbells—in Buffalo and points east, attempting the difficult job of raising the necessary capital to purchase used machine-tools for the future shop, while Bob Woods, the designer of the trio, burned the midnight oil at his drafting board, getting on paper his advanced ideas of aeronautical design, to put equipment and capital to work. It was a close working team then, as today, always working, planning and keeping a jump ahead by thinking soundly of the future.

Their first job, which tided them over their development period, was an order to install an Allison motor in an A-11 attack plane. In January, 1936, Bell clinched an important contract to build wings for Consolidated PBY patrol bombers, and the corporation's success in handling this order proved their ideas of how to use production methods in aircraft manu-

facture were sound. Meanwhile Bob Woods' work at the drafting board produced a multi-seat long range fighter which gave the firm its reputation as builders of advanced design aircraft it enjoys today. A number of these "Airacudas" have since been produced for the U.S. Army Air Corps.

In 1938 Bell saw the war clouds gathering, and in their shadow made a hurried visit to aircraft centres in Europe, confirming his opinion that the design for a revolutionary single-engined fighter Bob Woods was then working on was years ahead of Europe's idea. This ship, the first "Airacobra", designated XP-39 by the Army, was ready for flight-testing and more research by the beginning of 1939.

The small Buffalo plant, which combined office and factory building, was turned into the present Administration Building, and first 200,000, and later a total of more than 700,000 square feet of floor space were acquired. French and British orders for Airacobras came in, in 1940, and the U.S. Army Air Corps, thoroughly satisfied with the ship's performance, increased its requirements. Still, full scale production was held back pending further research, although the first production model came off the line in August, 1940. Its builders were making absolutely sure of the performance of ship and armament.

The new Niagara Falls plant, for the production of the export version of the improved P-39-D, was begun in September, 1940, and completed a few months ago. As radical as the ship it is building, this plant incorporates revolutionary production ideas, the results of months of work and worry which brooked no failure. It contains one of the first mechanical production lines, and a template lofting system which eliminates all but the final assembly jigs. Both plants are now well away on production, with the Niagara Falls plant producing for the U.S. Army and the Buffalo factory concentrated on Airacobras for Britain.

Thus, in less than six years, Bell Aircraft has grown from a laboratory with forty employees to one of the most modern aircraft factories which now has more than 9,000 employees and a total of 1,000,000 square feet of the best in factory facilities. This is "bell ringing" with a vengeance—and we wouldn't be surprised if they turned out to be "victory bells". Details of the Corporation's plants and activities, and the Airacobra, "a cannon on wings", which it is producing, are carried on following pages in this section.

COMMERCIAL AVIATION



A flight of Airacobras flying in echelon formation.

WHY THE AIRACOBRA

- and How?

LAWRENCE D. BELI.

PRESIDENT, BELL AIRCRAFT CORPORATION

Why should Bell Aircraft Corporation, a brand new company in an aviation industry that was far from prosperous in 1935, want to build such aircraft as the Airacuda and the Airacobra? How did we, a handful of people, have the courage to tackle a job with so many headaches attached? How did we do it? Those are questions often asked of me in these hectic days of 1941, when we and every other airplane builder are busy building more and more fighting craft for the United States Army Air Corps and the British Royal Air Force.

The story behind the Airacobra and the Airacuda is, I believe, one of general interest. It is a story going back six years, during which period we have always tried to understand completely the problems involved in fighter aircraft construction before we began building the ships—tried to understand even before we began drawing the rough sketches which preceded the designing of our new models. What we tried to do was to analyze the reason for fighter airplanes.

What should the ideal fighter airplane be like? Once we had the answer to that question, in terms of 1935, or 1939 or 1941, we were in a much better position to build a successful product. A position much better, for example, than if we had been content to copy the existing products of other companies, merely seeking to refine and improve them.

We thought of airplanes in military terms. We wanted to lift effective firepower into the skies; to place cannons on winged platforms. In pointing toward such a goal—it seemed almost fantastic six years ago—we insisted, to ourselves, that our designs sacrifice nothing with respect to performance, high speed, ceiling, rate of climb of manoeuvrability.

Today, thoughts of installing rapid fire, shell-throwing cannon in airplanes are commonplace, because it has been done, successfully. Six years ago, no one in the United States or Great Britain had ever built such an airplane. In a nutshell, our thinking was in terms of fire-power, whereas many other people building airplanes had thought solely in terms of the vehicle!

Looking back, I have many times been thankful that we didn't try to fool ourselves about any special abilities we might have had to build craft so much faster they would automatically find a ready market. We realized that there was no reason why other capable aircraft manufacturers couldn't match our high speeds, providing they utilized the same wing loading, airfoil sections, horsepower, and size, available to all.

Back in 1935, when orders for airplanes were mighty scarce, we concentrated upon fundamentals. History told us that fire-power was vital, and that oftentimes, victory went to the fighters who could concentrate fire-power where it was most effective. In our reading of history, we sought to apply the lessons of the past to what would be needed in the future.

In World War I, firepower was lined up on each side of no man's land, with the Allies having to blast their way through the apparently invulnerable lines of German trenches. World War II, we believed, would be fought in the air. This being the case, firepower would be shot through the skies, for most effective use perhaps 500 miles behind the front lines!

We asked ourselves what a fighter airplane should be able to do, and then inspected the best of the current models. We sought to discover their shortcomings, and in our plans to eliminate them.

What we wanted to do was build a fighter which would (1) carry a maximum amount of firepower; (2) incorporate improved landing and ground handling characteristics, and (3) provide greater pilot vision.

We wanted our fighter to be able to do more than blast other fighters and bombers out of the skies. We envisioned an airplane which would be able to fire a cannon shell, armor piercing or explosive which would be powerful enough to knock out mechanized troop movements, and cope with mosquito fleets. We knew, of course, that no bigger bullets would be needed to put a soldier out of action in the next war than during the last. But everything pointed toward bigger potentialities for the airplane in the next World War than killing individual men or dueling individual aircraft.

Another problem was the object of much study. During World War I, aircraft had to operate under far less ideal conditions than those provided by the mammoth airfields being built in 1935. Even with their top speeds of 100 miles an hour and landings at 50 m.p.h. the records showed, many, many airplanes were smashed in 1918 during landing and takeoffs on wartime fields. What would be the story during the next conflict, when again fighter pilots had to operate from

improvised fields, perhaps even highways? If Jennies washed out their landing gear in 1918, what about 300-mile-an-hour craft, with landing speeds up to 100 miles per hour!

The only practicable answer we could find was tricycle landing gear. Use of this would permit takeoffs and landing in cross winds, if necessary. And also would eliminate the hazards of night operation, without the aid of million candlepower floodlights. We knew that fighter pilots, fatigued from the strain of combat, would need to be relieved as much as possible from the responsibilities which conventional landing gear presented, when used on high performance aircraft.

To our way of thinking, the ever present demand for more speed had robbed fighter airplanes of a vital characteristic, good visibility. The call for speed had been answered by bigger engines. The larger engines, naturally, cut down vision, when mounted in front of the pilot. Some way had to be found to improve vision!

The answer to all three problems—firepower, tricyle landing gear and visibility—was supplied by use of an extension drive shaft. We at Bell Aircraft were called radical because we decided to use

At the time we were designing the Airacobra, we had already gained a wealth of experience from our earlier development of the Airacuda. In this twin-motored multi-place fighter, we had used drive shafts—much shorter, of course, than the one required in the Airacobra—to transmit power from the two Allison engines to pusher propellers. Consequently, we were confident that the drive shaft principle was aeronautically practicable.

In the Airacuda, also we had made forward strides with respect to firepower. Details of the armament and fire control arrangement of this craft are still government restricted, but it may be raid that the Airacuda, besides mounting as two 37 mm. cannon in power turrets, utilized a very accurate range finding device, together with an automatic computer.

The function of fire control equipment is the spotting of the target in the field of view of the telescope which forms part of the range finding equipment, to determine the target range. In the Airacuda automatic and continuous adjustment of the gun to fire to the target is made electrically, with proper gun pointing corrections made by the automatic fire control computer device. Our fire control



An Airacobra ready for delivery to the R.A.F.

this method of transmitting power from the engine to the propeller, but we weren't radical. All we were doing was to utilize the method of transmitting power which had been standard practice for as long as a century on ships and every other vehicle, except the airplane. And even the first airplanes built by the Wright brothers carried power from engine to propellers by means of bicycle chains! equipment was developed in co-operation with the Ordnance department, under the direction of the United States Army Air Corps.

With this development work behind us, the task of engineering the Airacobra—with its tricycle gear, cannon and superior vision—was appreciably easier for us at Bell Aircraft than would have been the case for a company which had built conventional designs only. It should be recalled, also, that even at that time German aircraft manufacturers were installing 20 mm. cannon on specially designed vee-type liquid-cooled engines so that they fired through hollow propeller hubs.

But 20 mm. cannon failed to satisfy our requirements for effective airborne firepower, and besides the superiority of the 37 mm. projectile had been convincingly demonstrated. Then, too, there was no engine either in the United States or the British Commonwealth of Nations which would accommodate any cannon, much less a 37 mm. These conditions forced use of the extension drive shaft, with the rear-positioning of the engine.

From the engine placement we also obtained an arrangement which enabled a generous tread for the rear wheels and a long nose for the nose wheel. Vision, too, was greatly improved by the position of the engine behind the pilot.

To achieve these advantages, we made a weight investment of 50.7 pounds for the 103½-inch drive shaft and the single centre bearing which it needed. We also secured an installation—with the reduction gear directly behind the propeller—which enabled speedy removal of the engine for overhaul or other service reasons without molesting the propeller, reduction gear, drive shaft or cannon! Since then some 6,000 hours of actual flight testing has been given this drive shaft installation, with results beyond even our bravest expectations!

What had we gained from this design? Tricycle landing gear, which enabled use of four-lane highways for takeoff and landing purposes. In the event of wartime conditions, when landing fields would be bombed, or for emergency landings, our triycycle-geared craft was still safe to bring to earth. This, of course, was no less true with respect to night operations. Here again, actual flight testing, has borne out our contentions. Recently, two Airacobras collided near the end of a takeoff run. What happened? The right wing of one ship was sheared off, just outside the bulkheads which hold the leakproof gas bags. The left wing of the other was crumpled, inside the wing tip. But neither ship upset, and both ships were flying again within a matter of hours!

Improved vision, beyond the obvious advantages, was to be important for several reasons which we hadn't anticipated. The second World War, with its vastly expanded night flying operations and its tremendous demands upon the physical stamina of the brave young men in fighter defense, was to make necessary an airplane in which tired pilots, coming back after grueling night battles to darkened airdromes, needed every particle of vision which careful design could give.

Ever since we founded the company, Bell Aircraft has believed that the most important consideration in firepower was the size of the projectile—the force of the punch. To translate our thoughts into Sunday punch" by Joe Louis would be ever so much more potent than a hundred blows struck by a bantamweight. What we wanted was a "Sunday punch" for fighter airplanes, a weapon which would be to airpower what the 16-inch gun is to the navy. The 37 mm. shell-firing cannon was the answer.

At the same time we were concentrating upon the design of cannon-carrying aircraft, other builders were seeking to improve their products by adding more and more small caliber guns. The .30 caliber machine gun certainly had its place in the aircraft of World War I, but that it has no place in the aeronautical World War II, except for ground strafing is, I am confident, a point upon which agreement is general today.

The Airacobra has been called a sky tank, and its potency merits such a name. But it has special advantages over the land-lumbering tank. Whereas the tank must break its way through enemy lines, and is baffled when its path is obstructed by rivers or other barriers, the sky-tank can swoop through the air, even attacking its quarry from the rear if such be the best strategy. Air attacks by the Airacobra against light tanks and other motorized enemy movements, in conjunction with dive-bombers and other planes, would be potent medicine against land forces.

A single, well-directed hit of an armor piercing 37 mm. shell on the relatively unprotected sides and rear of a light or medium tank would very probably knock it out of commission, either killing the personnel or crippling the intricate operating mechanism and in time of war, a tank out of commission is as worthless as one blasted to destruction! If the Airacobra were using explosive shell ammunition, the potentialities would be the same as if a giant were tossing potent hand grenades, with the accuracy of a super marksman, from a distance of a mile or more!

We have said repeatedly that at Bell Aircraft we hold no secrets to the production of high performance airplanes. We know no secrets denied to the other manufacturers.

The successes we have enjoyed during the past six years were largely due to the fact that we were firepower minded. We are today armament minded. We never forget that fighter planes are supposed to be able to fight, and that the best fighters are the ones with the toughest wallop!

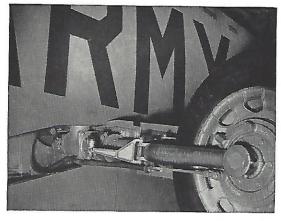


A corner of the new Niagara Falls plant building. From doorway at left the finished ships are rolled out on to the apron, ready for test flights.

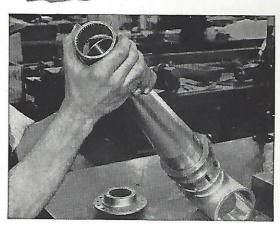
Torrington Needle Bearings

REDUCE SIZE, WEIGHT, FRICTION

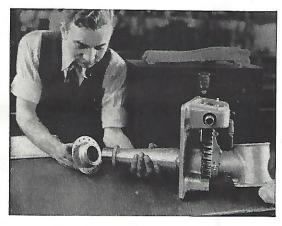
for Bell Airacobra



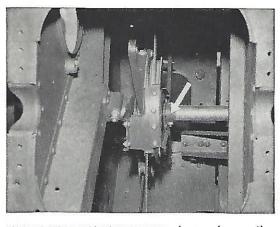
"ONE OF THE BEARINGS THAT CAN BE USED in the landing gear . . . a vital part of the spindle assembly" is how the compact, anti-friction Torrington Needle Bearing is described by engineers of Bell Aircraft Corporation. Shown above is l. g. assembly on newest Airacobra Interceptor Pursuit Planes of U. S. Army.



"THE LIGHT WEIGHT and extremely small O.D. of the Torrington Needle Bearing permits reduction in dimensions and weight of surrounding members," Bell engineers state, adding, "For its size, the Needle Bearing is found to be more efficient and has greater capacity than any other type of bearing."



SHAFT SERVES AS INNER RACE of the Needle Bearing in landing gear assembly. The bearing unit—consisting of accurately drawn, hardened outer race and a full complement of precision-ground, throughhardened rollers—is quickly and easily installed or removed for inspection.



Alleron QUADRANT OF AIRACOBRA, shown above adjacent to control stick, also is given anti-friction operation by the use of compact Torrington Needle Bearings. Needle Bearings have large capacity for retention of lubricant, in which rollers and shaft constantly turn.



If you have a bearing problem where high load capacity, small size, light weight, ease of assembly and lubrication are vital considerations, investigate the advantages of the Torrington Needle Bearing. Our Engineering Department will gladly work with you in adapting these advantages to your assemblies. For detailed information, write for Catalog 115. For Needle Bearings to be used in heavier service, consult our Engineering Department for special bearing designs.

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TORRINGTON NEEDLE BEARING

BELL PLANT PRODUCTION

Not Only Did Bell Aircraft Confound Its Critics by Succeeding with an Entirely New Concept of Fighter Design — It Is Setting Production Records by Plant Practice as Revolutionary as the Airacobra Itself — Building a Fast Ship Fast

By PERCY T. COLE

Associate Editor, Commercial Aviation and Aircraft Production

It wasn't much more than a year ago that a lot of experts were saying, with much sage nodding of heads, that the aircraft manufacturing business never could make planes as the automobile makes motor cars, on a moving line.

You couldn't they mostly all agreed, have uniform parts and subassemblies arriving by tributary lines just when they were needed so that the hand, the thing, and the place exactly meet in time.

So now, just a little over a year since these "experts" said it couldn't be done—it is being done. It seems the engineers and officials of the Bell Aircraft Company at Buffalo didn't know it couldn't be done. They went ahead and did it, to the utter confusion of the experts.

Yes, it is happening. Down at one end of the long building wherein is housed

the Bell factory at Niagara Falls Airport, you can see it. It isn't an overhead travelling assembly line like they have in the auto factories. It is an endless chain travelling in a groove in the concrete floor. The chain moves slowly, but it does move, not spasmodically, but steadily.

Down at the starting end the fuselage, looking like a hollow Venetian barge, is placed on a low-slung carriage, and the carriage is attached to the assembly-line chain. The fuselage moves, and as it moves from the first on through a series of sixteen stations, everything is added. At last the engine is mounted and the finished machine rolls off the line. Body and wing sections, engines, landing gear, hundreds of big and little subassemblies, some of them built right in the factory, others built perhaps hundreds of miles

away and shipped to the Bell plant, finally reach the moving assembly line where the grand assembly takes place.

Birth of Mass Production

As you watch that line, you know what you are looking at. You are watching the application of the automobile industry's method of mass production to airplanes. What you may not realize is that you are looking only at beginnings—that is to say, at an aircraft industry which is today just about where the automobile industry was twenty-five years ago. Once the idea of mass production reaches its full stature, there is no telling how far it may go. There is no definite limit. The motorcar industry has not yet reached its limit—who can tell about the aircraft industry?



From here they fly. The end of the production line at the Niagara Falls plant. Note cleanness of line, absence of jigs and fixtures.

Designed to Air Corps and Navy Specifications

HYDRAULIC



ACTUATING CYLINDERS

> VACUUM SELECTOR VALVES

SALUTING THE BELL AIRACOBRA

The pipe and tube fittings, flexible hose and valves used on the Bell "Airacobra" are Weatherhead equipment.

For combat plane and bomber or commercial giants of the sky-Weatherhead airplane parts are ready. In addition to the equipment illustrated, Weatherhead airplane parts include valves, Dural tube and pipe fittings, and high, medium, and low pressure flexible hydraulic hoses, all manufactured to Air Corps and Navy Specifications. Increased production facilities are enabling us to keep pace with the demands of the National Defense Program.

THE WEATHERHEAD COMPANY ST. THOMAS, ONTARIO



WEATHERHEA

At the moment, and for as long as the war lasts at least, Britain and her allies of necessity must be chiefly interested in the fast construction of the best military plane to be had. It must be built quickly, and many, many planes must be made.

Building of airplanes in the past has been a slow, complicated and expensive process. It is still expensive. It is still complicated, but not as much so as it was. It is still slower than we would like. But the Bell Aircraft engineers have made great strides within the past year. They are producing the Airacobra, the "cannon on wings", and they are doing it without too much fuss, without thousands of skilled workmen, with the minimum of wasted effort and material.

Simplicity for Efficiency

In producing the Airacobra, hundreds of expensive, complicated jigs have been eliminated. Thousands of manhours are saved and production increased by the ability to co-ordinate the engineering design department, the shop, and the "lofting" department.

Other aircraft manufacturers, with the heat of the emergency pressing them onwards, are rapidly placing emphasis on lofting as a means of simplifying their production problems, but it is Bell Aircraft that has been and still is the leader in this new aviation technique.

The layman usually considers aircraft lofting as a complex operation borrowed

from shipbuilders to draw out full-scale lines that fair or streamline the shape or contour of a fuselage or wing. This is, of course, a vital function, but equally important is the ability to make templates in flat metal of practically all the structural members of the aircraft as well as the dural skin. Up to this point, there is nothing unique about lofting. For several years the mold lofts in other companies have been making templates to guide shop departments in routing or cutting out shapes in flat metal, and furnishing the pattern makers with templates to guide them in making form blocks so the metal component could be accurately shaped or formed with flange in the hydraulic press.

However, at Bell, lofting technique has been developed to a degree wherein it is the basis and secret of the simplified production plan. Hundreds of these same flat metal templates are made up, representing practically every structure in the airplane. One may be a small section of the skin; another may be a bulkhead or rib section. The material cut from one may remain flat; the other may be formed with flanges. Each template is so formed and perfectly co-ordinated that when the dural metal is cut from the template, each part exactly fits its neighbor on the completed airplane. There can be no mistake.

Even under-size rivet holes are all there, drilled from the template. The parts will

Two engineers laying out the fuselage contour in the loft of the Bell plant. Bell has revolutionized lofting practice.

not fit together in any but the proper manner. The rivet holes eliminate the necessity of blueprints in the shop to lay out and space the rivet holes. Thus, if the template is made correctly—and it always is, when the engineers get through checking—the various parts must be correct. Then, through all this co-ordination, all parts of the plane can be matched together like a boy works with his Meccano set.

Blazing New Production Trails

It took months of planning and untiring effort on the part of Bell's engineers, shop personnel and lofting department before things worked out rightbut it was worth it. To make this unique lofting system practical, everyone had to have faith and work together. The engineers had to change from favorite structural members eliminating extrusions, drawn pieces and complex curved sectors wherever possible so that the shop men could put drill holes in flat metal and form the pieces later. If the shop found it impractical to form the shapes that the engineers designed without having the locating holes vary through stretching, then they had to scrap that design, get together and find a way out of the diffi-

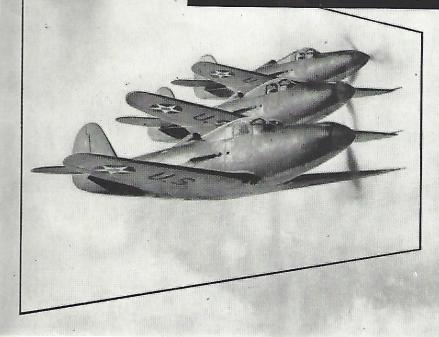
The aft fuselage of the Airacobra is nearly one hundred per cent. lofted. The deck section serves as a foundation for the structure since it is a fairly large piece, unless it is held securely while the rivet holes are drilled through the locating holes and partially riveted, it is apt to twist throwing the structure out of line. Consequently, it is inserted in this jig, pinned together by fasteners and enough rivets inserted to hold it securely; the jig time is only a matter of minutes. No blueprints are required and mistakes are eliminated due to the locating holes. Once the deck is removed, it is held in a simple assembly buck as illustrated and two men working in the most convenient position complete the riveting.

One Jig for Main Assembly

The bulkheads or ribs are completely lofted eliminating jigs and fixtures so that they can be built in minimum time on the assembly bench. Note the many parts besides the complex tail bulkhead. These are merely pinned together with fasteners, rivet holes drilled through the guide holes and rivets inserted. It would be impossible to construct this small part without a quantity of drill jigs and fixtures if it were not for lofting. The only

(Continued on page 26)

Cannon Over the Clouds!



Snap-on

salutes Bell achievement in the creation of

AIRACOBRA

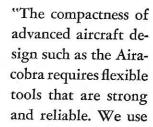
new Ace of America's

"Flying Artillery"

Snap-on is proud of its part in making possible the record-breaking production of America's new super-pursuit plane, the sensational, cannon-carrying AIRACOBRA . . . developed from experimental stages to mass assembly line output in less than 300 days!

Again the accuracy, speed and dependability of Snap-on tools prove their worth to industry in times of emergency as well as in the daily grind of regular manufacture. In the words of Bell Aircraft Corporation:

A few of the Snap-on Tool applications at the Bell Aircraft plant.

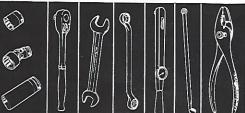


Snap-on tools because they fill this bill best for the Bell Aircraft Corporation."

Snap-on tools and service are conveniently near you from 34 factory branches at key air centers throughout America. Write for information.



2200
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TOOLS — FROM
MIDGET WRENCHES
TO HEAVY DUTY
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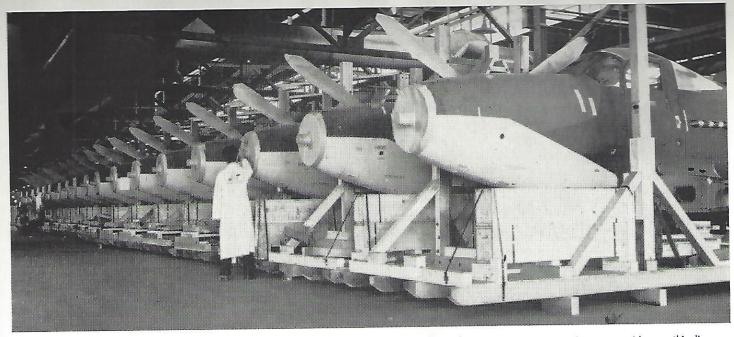






SNAP-ON TOOLS OF CANADA, Ltd., Dept. F-8, 800 Howard Avenue, Windsor, Ontario

COMMINEROINE MINISTRA



A day's work for Britain. A line-up of finished 'Cobras mounted on skids ready for crating and shipment. Concrete evidence, this line-up, that Bell is delivering the goods to the R.A.F.

Designing and Building the airacobra

Many and Complex Were the Design and Construction Problems Facing the Bell Engineers In Perfecting the "Cannon On Wings" as a Mass Production Ship

By OMER L. WOODSON

Vice-President and Assistant General Manager

and

HARLAND M. POYER

Chief Engineer, Bell Aircraft Corporation

In addition to wise conception of what a fighter airplane should be, Bell Aircraft Corporation's success with its interceptor pursuit model, the Airacobra, has been due principally to the achievement of an excellent design which provides these characteristics and the establishment of a remarkably efficient, though simple, production system. Behind each lies thousands upon thousands of hours of systematic effort. This is the story of the designing and the system of production control which Bell is now using with such good results.

Engineering Development

Three years ago, Bell Aircraft engineers conceived a somewhat radical design for a fighter plane—radical from the standpoint of existing aircraft at the time, but entirely practicable according to our views

of what an airplane should be. Its exterior was exceptionally smooth, but its interior arrangement included a maze of equipment which presented grave engineering problems. Perhaps the most radical feature of the Airacobra was the location of the engine amidship, with the pilot placed forward in a cabin equipped with automobile-type doors. An extension drive shaft running under the pilot to a reduction gear box in the nose of the fuselage furnished power to the propeller. Cooling was achieved without the use of oil or prestone coolers "hung" outside the fuselage; instead they were located within the structure of the plane.

Experience, of course, has shown that the Airacobra was no designer's nightmare. Actually, it embodied no engineering features which were not entirely

sound. It was conceived to fill a definite need, and its success, in large part, is due to the determination which enabled the designing and building of the prototype.

Our goal, as designers, was an interceptor pursuit, possessing outstanding firepower typified by the 37 mm. cannon, ability to climb high and fast, manoeuvrability and vision. In so many words, we assigned ourselves to the task of building the world's best fighter airplane in terms of 1938, together with the added condition that it have a tremendous amount of firepower. Not an easy job!

One of the most important design considerations was the extension drive shaft. This has repeatedly been placed in the spotlight, and justly so. Thousands of hours of flight testing have failed to reveal any flaws, either in the conception or execution of this method of trans-



mitting power from engine to propeller.

The drive shaft represents a remarkable development in modern day aviation, but not because of any involved engineering problems. It merits special attention because of the possibilities it presents for improvement of aerodynamic characteristics, vision, manoeuvrability and accessibility as well as opportunities for greatly increased firepower. After all, there is nothing so remarkable about the fact that the engine is not located in the nose of the airplane. As a matter of fact, even when we were working out the criteria for design of the Airacobra, we began to wonder why the nose had ever been chosen for engine placement!

Design Problems Complex

Problems encountered in the structural design of an airplane are fundamentally the same. They involve (1) an analysis of all possible loading conditions, and (2) design of a structure to withstand such loads and yet permit all mechanical units installed in the craft to operate successfully under possible deflected conditions of the loading structure. The design of our extension drive shaft was no exception to this rule.

Besides designing the fuselage structure to withstand all possible normal loads, we had to build it so that it provided a sturdy platform for the 37 mm. cannon and the .50 caliber machine guns mounted in the nose, as well as serving as a rigid and satisfactory mounting for the gear

box and intermediate shaft support bearing.

Because the Airacobra's tricycle landing gear equipment is the first ever to be used on a production model of a single engine pursuit airplane, a brief description may be in order. Its main wheels have high pressure tires and hydraulic multi-disc type brakes. The nose wheel is a standard smooth contour tire, similar to that used as a tail wheel for multimotored airplanes. No brake is installed on the nose wheel but a puncture-proof inner tube is used. Shock struts on all wheels are of the air-oil type, with adequate strokes to absorb the energy resulting from severe landings. The nose wheel swivels 60° either side of center permitting short radius turns. Also noteworthy is the hydraulic device in the nose wheel strut which automatically dampens swiveling action, eliminates shimmy and otherwise improves stability under all operating conditions. Once off the ground, the nose wheel automatically returns to its exact center position, so that it can be retracted into the forward fuselage. An electric motor retracts all three wheels simultaneously, and when in retracted position, all wheels are completely covered by smooth flush-type fairings, which are actuated automatically. Of course, an emergency hand crank system is provided for manual operation of the wheels in case of electrical system failure.

We should make no attempt to say that the engineering development of the Airacobra was easy. It wasn't. But the months of effort by our engineers will long be remembered as the most interesting period in their lives. Competition was keen among the various groups assigned to individual responsibilities, and everyone sought to do the best possible job. The result, of course, was that the structural designers evolved the most efficient structures they could conceive; weight control engineers fought a winning battle to eliminate excessive weight; aerodynamists found months of labor rewarded by smooth and undisturbed flow and power plant engineers accomplished smooth functioning of the engine.

After the prototype had been test flown, the conflict abroad forced considerable change in the conception of what constitutes a wartime airplane. True, we had anticipated what would be needed with respect to armament. But we had to add new armor plate, self-sealing fuel tanks, and even more armament! Armor and fuel tank protection alone accounted for the addition of 500 pounds to the weight of our Airacobra! And additional armament brought the total carried to more than 34 of a ton. Truly, we were fortunate to have incorporated such generous margins of overload in our original design!

Producing the Airacobra

When the Airacobra was first designed the growing war clouds seemed very far away to most of us in America. But by the time testing of the prototype was well under way, the probabilities of a national emergency in the near future made speedy quantity production of our interceptor pursuit plane a necessity. Besides needing great quantities of machine tool equipment, jigs and fixtures, as well as thousands of workers, we knew we needed planning. Without intelligent preparation for such a mass production assignment as we were given, there would have been little chance for ultimate success of our effort.

In this effort, engineering and production supervision worked together. All possible hand work was eliminated, through the combination of accurate tooling and expert lofting. We were also convinced that all parts should be interchangeable, and planned accordingly.

Without providing the correct materials at the correct place and at the correct time, overwhelming delays would result. Not only that, but we knew that a delay at one point often resulted in even greater losses farther down the assembly line. Our goal was to secure a constant flow of



A view of the metal-working shop at one of Bell's plants.

MASTERY!

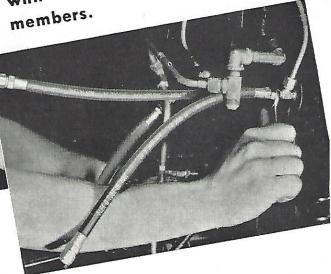
Airacobra P-39 in Flight

• This potent cannon-carrying fighter airplane, with a speed in excess of 400 m.p.h., demands the finest materials available to the aviation industry.

The Airacobra is fully equipped
 with FLEX-O-TUBE flexible



"Flex-o-tube" at Panel Boards



THE FLEX-O-TUBE COMPANY

Manufacturers of Flexible Hose Assemblies for Panel Boards and Hydraulic Actuated Units

LAFAYETTE AT FOURTEENTH . DETROIT, MICHIGAN



The Lofting Room at Bell Aircraft where many a knotty problem in production design has been solved these past few months.

parts to each point on the assembly line, and behind these were built all of the various sub-assembly lines and systems which originated as soon as raw materials were received at our factory.

Basically, our final assembly line consists of 14 individual stations, along which the Airacobra fuselages move toward completion. Exceeding care was used in determining the time necessary for each operation, so that the work at one station would not be permitted to hold up the entire line. Once this study was completed, assembly operations were divided, and assigned to the various stations, so that the alloted work could be accomplished in eight hours.

At each of the stations along the final assembly line is located a storage rack in which is kept the parts to be installed at that station, and to keep a running record of the materials on hand, thus preventing shortages and work stoppages, a simple checking system on charts has been devised. Though simple, it has worked well

But the fact remains that no matter how simply the assembly line may be set up for operation, production would be crippled unless material is fed smoothly to this line. As in most companies, this responsibility was assigned to the production division, and their work began as soon as the airplane design had progressed to a point where its production seemed practicable. They worked closely with engineering during the design stages, to insure conception of an airplane which could be manufactured in quantity at a reasonable cost. In passing, it should be said that complete control rested with the engineering department, but that co-operation was excellent between the men who drew the designs and the men who were to build the aircraft. It is our belief that the pre-production work which was done was largely responsible for the ease with which the Airacobra can now be built.

New Lofting Practice

Another factor which was of vital importance was the introduction of a new principle concerning the transferral of engineering designs on paper into the physical parts of the airplane. Whereas other aircraft manufacturers had used the lofting principle to a limited extent, we made every single part in the mold loft. It may be said in passing that the decision to use 100 per cent lofting practice was reached when the design was well on its way toward completion. Despite the fact that some 30 per cent of the original design had to be scrapped, the benefits gained more than compensated for this additional effort.

The Airacobra was broken down into five primary units and then each of these was divided into their individual parts. Whereas usual practice had been to loft the larger parts of each unit, and then tool for the others, we lofted each part individually, even machined parts and fittings. As a result, inexperienced shop workers can take two parts and match them perfectly, because not only has the outline of the design been matched, but all of the assembly holes are in correct position. Pilot holes are provided which the workman uses for matching, and parts are held together during production by clips inserted in these guide holes.

Use of the 100 per cent lofting system has eliminated about 30 per cent of the fixtures heretofore needed for production. Consequently, production has been speeded up, because the parts are consequently easier for the workman to get at. Engineering drawings were also eliminated from the plant, with templates only being needed. Here again, production was speeded up, because workmen didn't have to be trained to read prints, nor did they have to spend time studying drawings.

Because of its importance to the entire production method, the loft naturally enough developed as the principal place where troubles were spotted. Any mistakes in design for any part, no matter how small, were discovered at once in the loft. And when production was started, as a result of our preparatory work, we were freed from the countless delays and confusion which would have resulted as workmen found that parts they were building wouldn't go together properly. Planning engineers had studied the drawings as released by the engineering department, and thus had checked that the parts, if properly made, would definitely fit together to produce the desired dimensions and assure proper functioning.

In general, the responsibilities of other departments working toward production at Bell Aircraft includes:-(1) tool design, whose responsibility is the specifications for purchase, design and initial operation of all tools. This department works closely with the mold loft to obtain maximum advantage of lofting; (2) work order section, which issues orders, procures required material and has control of all receiving, shipping and stocking of this material; (3) purchasing department, which is responsible for purchases of all kinds, and (4) production control section, which interprets the master schedule in terms of actual unit parts, and stipulates the time at which any part is to be placed in production so that it may be completed when needed for assembly. It is this section's responsibility, also, to insure that the work order, the tools and the materials

FULLY UP-TO-DATE

BELL'S AIRACOBRA IS PRODUCED WITH FARNHAM'S PRODUCTION MACHINERY

So are the planes produced by 30 Leading American Manufacturers

FARNHAM MANUFACTURING CO.

BUFFALO, N. Y.



Final wing assembly department where wings are rushed to completion to keep a date with the urgent production lines.

are delivered at the proper time so that previously arranged schedules may be met.

With responsibilities assigned in this manner, the factory division need concern itself only with the administration of labor. It is its responsibility to produce various parts within the standard time determined by the time study personnel, using the tools and following instructions as specified on operation sheets. In this story, it is unnecessary to discuss further our time study methods, other than to say that a 25 per cent coverage, beyond the studied productive time, is provided as a cushion to assure smooth flow of work.

Referring back to the 14 stations on the assembly line, we have four such lines now in operation, two at our new Niagara Falls assembly plant, building Airacobras for the United States Army Air Corps, and two at our Buffalo plant, engaged in constructing increasing numbers of Airacobras for the British Royal Air Force. At both plants, subassembly departments are so located that their own production lines feed into the correct station along the assembly lines.

The first parts to be made are the basic parts of the fuselage. The Airacobra has been designed so that the main structure of the fuselage consists of two longitudinal beams extending from the nose back to the point behind the engine, with the rear engine placed somewhat back of the center line of the wing, so that all main sections joined to the fuselage outside of the tail are attached to these two longitudinal beams forward of the engine.

Our lofting practice is used for the assembly of these two beams, which are later joined together with the center wing section. Once completed, they are placed in a moveable dolly, which will eventually start down the assembly line. These dollies then pass through their own department, and as soon as the basic fuselage structure is completed, it is ready to be rolled onto the final assembly line.

The first four stations on the line complete the assembly and installation of units inside the fuselage, so that the engine may be installed at station five. From here on, all subassembly lines feed into the main assembly line. At station six, the pilot's cabin is attached, after having been subassembled elsewhere in the plants.

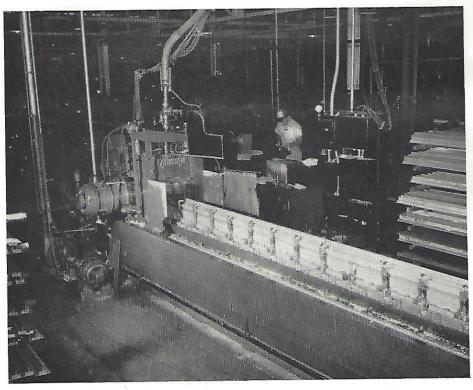
At station nine, control surfaces and the rear section of the fuselage are attached, and small parts are installed at the next three stations, with armor plate, fuselage armament and landing gear being attached at the final stations. When the Airacobra rolls off the line, it is ready for attachment of the wings—which have

motion is provided the two assembly lines by endless chain conveyors, sunk into the floor, to which the dollies are hooked. The latter system, obviously, is preferable, but at Buffalo, we have experienced few holdups, so carefully has the operations schedule been planned.

By way of conclusion, it seems fitting to quote from an address this spring by Major General Henry H. Arnold, an outstanding authority on questions aeronautic, for proof that the co-operative efforts by Bell Aircraft's engineering and production divisions have borne good fruit.

General Arnold:-

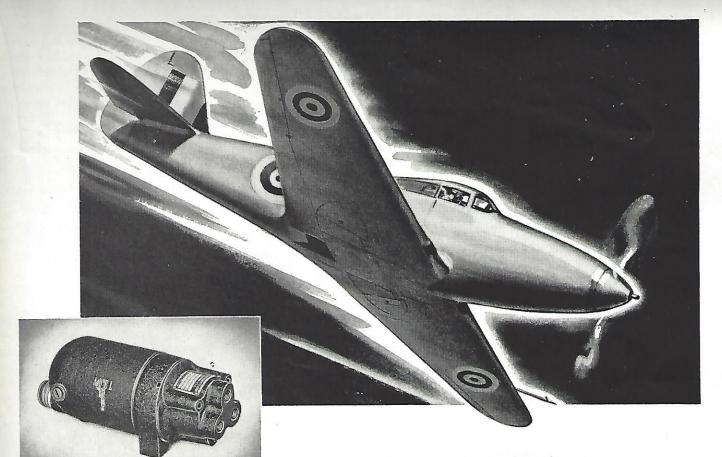
"I can tell you now that one of the world's fastest pursuit airplanes, the Airacobra, is now in production in the United States. This remarkable airplane is worthy of its name. It is armed not only with machine guns, but with cannon as well. To facilitate operating these guns and provide better visibility for the pilot, the engine is located in back of the pilot. We expect great things of the Airacobra, in its final form with armor plate and its leakproof tanks.



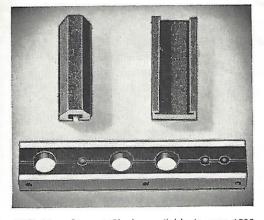
A specially-designed spar milling machine which cuts wing-spar fabrication time down to a minimum on Airacobras.

themselves passed along their own assembly line—and then either fly away delivery to the Air Corps or boxing for shipment.

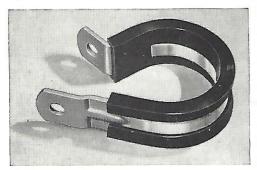
Our assembly lines at the Buffalo plant move manually, with timetable schedules being set up for the movement periods. At the new Niagara Falls plant, constant "In this day and age, our fighting planes with their keen, alert pilots must be able to climb rapidly high into the air—far above hostile bombers, manoeuvre easily and have the speed to place themselves where they can blow their adversary's plane to pieces. That our Airacobra can do."



Adel Series "J" Anti-Icing Pump—the proven ANSWER based on four seasons of actual service conditions. For propellers, windshields, carburetors.



ADEL Lines Support Blocks, available in over 1500 standardized types to support from 1 to 36 lines. Top—"Adelite" synthetic rubber.



ADEL Line Support Clips, the ONLY clips with Universal Approval of U. S. Army Air Corps, U. S. Navy and Commercial Air Lines.

ESSENTIAL EQUIPMENT

From blue print to mass production in 300 days...that's the record of the cannon-carrying Bell Airacobra. To accomplish such speed, Bell engineers could risk no loss of time with experimental units—that's why they specified ADEL'S time-proven, standardized line support and anti-icing equipment!

Eastern Sales Engineer, J. Henry Reisner, Hagerstown, Md.

