Bristol BEAUFORT

The first aircraft assignment at Woodville was the Beaufort Torpedo Bomber. Components produced by G.M.-H. are shown in red.
DESIGNED and built by the Bristol Aeroplane Company of England, the Beaufort Torpedo Bomber was in initial production in England shortly before the outbreak of war.

When it was decided to build this aircraft in Australia, further changes in design were necessary because of the use of substitute materials and components and these, together with change notices coming through from overseas, and others occasioned by new short-cuts to production being developed, were responsible for considerable modifications in the Australian version of the Beaufort.

The Beaufort is a twin-engine, heavily armed aircraft, possessing exceptional manoeuvrability. It is of all-metal construction, with stressed skin wing design. It was equipped to operate both as a torpedo and medium bomber.

Powered with two Pratt & Whitney Wasp twin-row 1200 h.p. engines, the Australian Beaufort is equipped with Curtiss Electric or Hamilton Hydromatic full-feathering propellers, hydraulically operated retractable undercarriage, and a power operated gun turret.

Carrying a crew of four, the Beaufort has taken part in most of the principal aerial operations in the South-West Pacific Area, blasting all the most important targets in New Guinea and New Britain, sinking enemy cruisers, destroyers, submarines, and shipping, and carrying out extensive reconnaissance and convoy work.

The first order received at Woodville was for fuel tanks, and certain components to enable the Beaufort Division of the then Aircraft Production Commission to complete the production of ten Beaufort machines sent out from England for the initiation of the Beaufort programme in Australia.

Then came an order for 50 sets of aircraft components, and as this order was to be considerably increased, approval was given by the Government for the erection of a plant at Woodville for the production of aircraft components.

Following the completion of this building, the fabricating set-up was transferred and production increased enormously. Up to the time of transfer we had only handled minor sub-assemblies, but with the increased tempo of production major assemblies were allotted to the Woodville Plant.

With the development of the Beaufort programme certain processes foreign to the normal Woodville production procedure were introduced into the Plant, such as Salt Bath treatment of aluminium alloys, anodising of these alloys, and spot-welding of light alloys. In fact, one of the few light alloy spot-welders in Australia was at Woodville. Special pneumatic riveting equipment was developed resulting in faster and improved production; also special machines were developed for special operations such as those for high speed vertical drilling, radial arm drilling, and for punching and driving two rivets per stroke.

New methods of production resulted in a number of modifications to the design of certain components. Notable amongst these was the re-design of the cannon and dinghy stowage doors. These were cut down to two major parts, deleting some 15 to 20 components. The new method meant that these doors comprised an inner and outer pressing similar to the construction of the luggage compartment door of an automobile. The old type of door comprised tubular frame and bracings, riveted to the metal exterior covering. The re-design of the nose ribs of the Beaufort and the Beaufighter to a pressed part deleted the fabrication of several components, and considerably lightened the part. In other words, the automotive technique of metal pressings was applied with successful results. In all these modifications, the keenest co-operation was extended by the Department of Aircraft Production.

The building of the Beaufort in Australia was no mean performance for a country uninitiated in the production of modern front line aircraft. The entire aircraft, including power installations, embodied some 39,000 parts all basically different in manufacture and G.M.-H. is extremely proud of its achievement in having provided some fifteen thousand of the airframe components for each of 700 sets of aircraft plus a considerable number of spares, and delivered them well within the scheduled time, despite the complexities of their production.

[101]
BEAUFORT ASSEMBLY

Two views of the assembly operations at Woodville
IN ACTION

Australian-built Beaufort Bombers, and Beaufighters, wrought havoc amongst the enemy in the New Guinea area. In the top picture a Beaufighter is taking off on a strafing mission, while below, a Beaufort has just delivered its bombs on a Japanese-held position on the coast of New Britain. A former commanding officer of the Beaufighter (LV) Squadron was a member of the G.M.-H. staff.
This was the second major aircraft project at Woodville. Components produced by G.M.-H. are shown in red.
DESIGNED originally by the Bristol Aeroplane Company Limited in England as a night fighter, the famous Beaufighter proved to be one of the most successful aircraft of the war. Its great versatility enabled it to be used as an intruder or attack aircraft, for strafing and interception, and for attacks on barges and shipping.

The Australian version of the Beaufighter, as with Beaufort, was considerably modified to meet both operational and production requirements.

The armament of the Australian Beaufighter comprises four 20 mm. cannon, and six light or four medium machine guns. It is also capable of carrying a useful bomb load, and was adapted to use rockets.

Equipped with two Bristol Hercules sleeve-valve engines, the Australian-built Beaufighter has a gross weight of 25,000 lbs., and at sea-level is probably one of the fastest machines of its class in the world, representing a considerable advance on the Beaufighters operating on the European front.

Apart from the engine and propellers, practically every item of parts and equipment was manufactured in Australia, and the production of the first aircraft within a period of fourteen months from the arrival of the first English engineering drawings and data in Australia indicates the efficiency of the production methods attained in the Australian aircraft industry.

Engineering and tooling drawings did not commence to arrive in Australia until March, 1943, being received in the form of small photographic negatives some 62,000 of which had to be enlarged for use as tracings for the preparation of over 300,000 blueprints by the Department of Aircraft Production.

The first 500 drawings for specific part numbers were received at Woodville in March, 1943, rising to a cumulative total of over 5000 by December and we were entrusted with a far higher proportion of assembly work than had been the case on the Beaufort.

The production policy set by the Department of Aircraft Production on the Beaufort bomber was based on area requirements, but this was changed on the Beaufighter project by establishing schedules on priorities. This improved method of control reduced the works in process, but required more rigid control to achieve the exacting target set G.M.-H. by the Department. Constant revisions, parts being added, deleted, or changed from one priority to another, material shortages, and so on, all contributed to the production complexities of this programme.

Change notices were particularly heavy, and although at times both tooling and production were slowed down by the numerous modifications, our product rate was satisfactorily achieved.

To expedite the Beaufighter project, 66 Beaufort Bomber sets were remodelled to the requirements of the former, and standard parts in short supply were often cut out by hand. Initiative, therefore, played a prominent part in enabling us to reach a peak production of 20,000 parts daily, and enthusiasm was maintained at high standard by the publication of outstanding performances of the Beaufort, which was already in action on the New Guinea front.

The same technique applied to the cannon and dinghy stowage doors on the Beaufort was applied to the undercarriage doors of the engine nacelle, that is, fabricated doors being replaced by pressed metal doors, comprising an inner and outer panel, similar to the automobile body type of construction.

The first Australian Beaufighter successfully passed its test flight in May, 1944, about fourteen months from the date the engineering drawings and data commenced to arrive from England. By September, 1944, scheduled production had been achieved, and Beaufighters were being delivered at a figure equivalent to the landed cost in Australia of English Beaufighters, despite the problem of producing small quantities of parts at each production set-up. On the Beaufort and Beaufighter projects at Woodville, production comprised over 60,000 production tools, 15,000,000 fabricated parts, and over two and a half million assemblies.

G.M.-H. received high tribute from the Department of Aircraft Production for the part they had played in the production of Beaufort and Beaufighter aircraft.
BEAUFIGHTER

Assembling the Beaufighter engine nacelle panel, at Woodville. The undercarriage doors are being fitted by the operator at Woodville. See the opposite page.
This is the interior view of the undercarriage door of the Beaufighter engine nacelle. The motor bodybuilding technique has been successfully applied by G.M.H. eliminating many small components and a considerable amount of riveting, as will be seen by comparison with the original door of English design shown below. This development resulted in easier production and the saving of weight in the finished door.

AN AUSTRALIAN DEVELOPMENT

The original English design for the undercarriage door

This alternative design was developed in England to cut down the number of small components.
BEAUFIGHTER

Underfloor assembly for the Beaufighter, ready for packing and despatch
This rocket-firing Beaufighter has just taken off a beach flying strip on the north coast of New Guinea, to attack the Japanese positions in the Rabaul area.
Our Pagewood Plant was requested to undertake the assembly of the wing for the Mosquito Fighter Bomber. G.M.-H. was responsible for the sections shown in red, the fuselage components being produced at Woodville.
THE MOSQUITO aeroplane earned for itself worldwide fame as probably the highest speed multi-purpose aircraft of the war, and peculiarly, in this age of aluminium alloy and metal stressed skin construction, is almost entirely constructed of wood in various forms.

In 1943, the Government decided that the manufacture of the De Havilland Mosquito DH-98 type high-speed Twin Engine Aircraft was to be undertaken in Australia, and accordingly the De Havilland Company of Australia was entrusted with this project, and they in turn, requested that we should be given the contract for the assembly of the wing unit.

To give some general dimension of this contract, the wing is built up of some 3000 individual pieces of woodwork and 300 complete sub-assemblies, embracing a total of more than 7000 separate components being finally assembled in the main wing jigs which took up considerable floor area, since the span of the wing is 54 ft. 2 in., with a total surface area of 436 sq. ft.

Innumerable difficulties were experienced in the early stages of the production of this Mosquito wing, the majority of them caused by the fact that a number of the components and sub-assemblies from the sub-contractors, all being wood, were affected by climatic change, and yet many of the tolerances called for limits as close as .001 in.

Great care, too, had to be exercised in selecting and training operatives to carry out the necessarily fine work entailed in the handling and fitting of 3000 pieces of woodwork in each wing. It was our experience that even skilled tradesmen had to be given a minimum of three weeks' training.

There were approximately 2500 productive man-hours in the assembly of a Mosquito wing, and this, in terms of our normal business of assembling motor vehicles, is equivalent to the production of about 70 vehicles.

When the wings were delivered to the De Haviland Company for building into the aircraft, they were complete to the extent of hydraulic and electric service lines, petrol and oil piping, doped and marked—all ready for installation as a finished unit.

We delivered our first sample wing, not altogether complete, in about three months from commencement, and after overcoming many supply problems we quickly reached our target of four complete wings per week. Subsequently we increased this to five per week, just as the war came to a successful conclusion.

Our Woodville Plant was also associated with the building of the Australian Mosquito, in the supply of a large number of a wide variety of metal components for the fuselage. These included the pilot's seat, which was regarded as a particularly vulnerable spot in the aircraft. In the Australian Mosquito the back of these seats was specially protected with demagnetised armour plate.
The finishing touches are being made to a Mosquito Wing at our Pagewood Plant. On the opposite page, below, are components, including nose, cannon, and tail-wheel fairing, hinges, vent pipes, etc., and below, fuel tanks, and pilot seats, produced at our Woodville Plant.
Avro LINCOLN

This successor to the Lancaster Heavy Bomber was the last aircraft project undertaken by our Woodville Plant, before the cessation of hostilities. All components produced by G.M.-H. are shown in red. An indication of the size of the aircraft is provided in that each wing tip is as large as the port or starboard Beaufort wing assembly.
THE LINCOLN

Successor to the Lancaster

The Avro Lincoln bomber, sections of which were in course of development at Woodville just prior to the end of the war, is the Mark IV version, successor to the famous Avro "Lancaster." It is the very latest of its type to be developed for the Royal Air Force Bomber Command and represents many advances over its predecessor in design and performance.

Only a very limited number had been produced in England when the "cease fire" sounded in Europe. In fact, an amount of preliminary work had been done on the project in Australia, before the prototype had flown in England.

The Lincoln, with a wing span of 120 feet, is almost twice the size, in all dimensions, of the Beaufort and Beaufighter, thereby materially altering the manufacturing requirements as regards Plant layout and equipment. These alterations took place as the Beaufighter programme diminished.

Because of the larger sizes and different pressures involved, the previous rubber pressing equipment proved inadequate, and a hydraulic press of 3000 tons capacity was installed. Using a six feet by three feet rubber pad, a unit pressure of 1 ½ tons per square inch was obtained, which is in line with the latest overseas practice.

To heat treat parts for this press and for a brake press, it was necessary to install a new salt bath, twelve feet long by four feet wide, fitted with a power hoist to move the material from the bath to the quenching tank. The tank used previously was approximately half this size.

Due to the probability that Australia might be called upon to produce spare parts for English aircraft operating in the Pacific War Zone, absolute interchangeability was planned; this included the securing of fixtures from England for all important mating-up points, while the majority of skin contours were determined by templates from England also, and not, as was usual, from the line drawings.

Although the full allocation of Lincoln parts had not been completed when the war finished, the programme was to be similar to that of the Beaufort and the Beaufighter, that is, approximately 6200 small pressed parts for all areas, about 1800 small sub-assemblies and 50 larger assemblies.

The largest components comprised:

1. The outer wing, or wing tip, which in itself is as large as the Beaufighter main plane;
2. The complete outboard engine Nacelle Fairing, comprising all the sheet metal aft of the engine bulkhead;
3. The Tank access doors;
4. The Centre Section between spars, including all formers and portion of Bomb Bay floor.

An interesting comparison, in terms of man hours, between the Beaufighter and the Lincoln was disclosed. In the case of the former aircraft, one set of parts produced by G.M.-H. absorbed approximately 5500 man hours, while the estimated total of man hours for one set of Lincoln parts was 13,000, the general effect being that while volume was reduced, the amount of labour required was approximately the same for both projects.

Because of the comparatively low volume, the whole tooling programme was approached from the standpoint of very simple, quickly produced tooling.

Owing to the high pressure in forming, press tools were manufactured from zinc alloys, and shaped directly from master templates. Initiative was displayed by the Tooling Department in organising a simple yet effective change-over tool, which permitted right and left hand parts being formed with the one die. Another successful departure was the development of a type of router pad which saved a considerable number of man hours, by the use of an alclad guide plate, instead of the usual steel plate. The general practice permitted by the materials used, was to machine directly from master plates, avoiding, wherever possible, individual marking-up and machining.

The Lincoln used approximately 130 standard rolled sections. For the Australian programme, however, it was planned to produce 90 of these sections by Press Brake, as the quantity required and the time factor would not permit of the other system. This necessitated some intricate forming to close tolerances but the Project was rolling quite satisfactorily well before the war ended in the Pacific.
LINCOLN

Top picture shows the engine rib assemblies, while below is seen the frame and skin assembly of the outer wing on the Lincoln Heavy Bomber

[117]
AIRCRAFT RECOVERY

HE “Cease Fire” in Europe released the major portion of the combat units of the Royal Navy for service in the Indian and Pacific Oceans to co-operate with the United States’ fleets in the speedy liquidation of Japan.

Headquarters for the Royal Navy were established at Sydney, New South Wales, and the appearance of a number of British aircraft carriers in Sydney Harbour indicated that the Royal Naval Fleet Air Arm were going to play an important part in the operations against the enemy. As part of the naval establishment, facilities had to be found for the servicing and maintenance of aircraft and the provision of spares.

A valuable contribution to the supply of spares could be made by salvaging all usable parts, aircraft sections, instruments, engines and components, from aircraft damaged in operations and at training centres, and eventually G.M.-H. were approached with an urgent request that they undertake the responsibility for this recovery of all possible parts from such aircraft.

In line with our policy of making every possible contribution to the national effort, we agreed to carry out this work, although personnel and plant area were not readily available in our Pagewood Plant, Sydney.

At that time the project had no priority, and the Manpower authorities in New South Wales, already hard pressed because they “had scraped the bottom of the labour pool,” informed us that they could not make labour available for the work. This information was passed on to the Naval authorities with the suggestion that it might be better if they tried to place the work elsewhere with an organisation whose facilities would be comparable with our own, and who might have a sufficient number of men to undertake the job to their satisfaction.

For some reason or other, the Navy felt that they wanted the work done by G.M.-H. in the Pagewood Plant, and appealed in Melbourne against the decision already made by the Manpower authorities. They were successful in having the project estab-
lished on a high priority, and labour was made available for the work.

It meant a considerable amount of re-vamping of our factory area to utilise approximately 20,000 square feet inside our building, and another 20,000 square feet for storage purposes in our compounds. However, we made the necessary arrangements, and within a week of our accepting the contract, crashed aircraft commenced to flow into the Plant.

All damaged aircraft were despatched to us through the Royal Naval Pacific headquarters, and many different types, including

(Continued on page 120)

This Corsair, badly damaged in combat, broke in two as it crash-landed on the deck of a British aircraft carrier. Although the break was right at the cockpit, the pilot stepped from the machine unhurt. The aircraft is shown here in the storage compound at Pagewood.
Reading left to right from top: Damaged aircraft from the Royal Naval Fleet Air Arm arriving at our Pagewood Plant for tear-down and recovery of usable components. In the storage compound at Pagewood, operators commence to dismantle the machines. This Avenger came from the G.M. Eastern Aircraft Division, via Europe and South-West Pacific combat zones, to G.M.-H. in Australia, to be dismantled. Recovered components awaiting inspection by the Naval Authorities, prior to package and despatch to the Naval Stores.

Avengers, Hellcats, Corsairs, Stinson Reliants, Fireflies, Martinets and Seafires—the marine version of the famous Spitfire fighter—came into Pagewood for attention.

It so happened that the Eastern Aircraft Division of General Motors was responsible for the production of a large number of Avengers and Hellcats, for both the Royal and U.S. Navies, and the pride we shared with every other member of the G.M. family in the splendid combat records of these machines was stimulated by actually handling these aircraft in our Sydney Plant, 11,000 miles from the Eastern Aircraft Plant. It was another example of an unusual situation created by the upheaval of war.

One Avenger, pictured here, had six operational flights over Germany before transferring to the Pacific, and finally crash-landing on the deck of an aircraft carrier.

This Aircraft Recovery assignment held considerable interest for the employees engaged on the work, as they avidly absorbed the many and unusual stories that attended the mishaps of many of the aircraft. Considerable interest was shown in a Corsair, which, badly damaged in combat, just managed to make the "flat-top" and crash-land on the deck, breaking in two as it did so. The break was right at the pilot's cockpit, and to the amazement of the crash crews, the pilot coolly stepped from the wreckage, quite unharmed.

Tragic, too, were some of the stories, supported by grim evidence on some of the aircraft, and every employee engaged on the project took more than usual interest in his work. This was the first assignment they had tackled where the items concerned had already been engaged in combat. Previously they had helped to build items which had yet to be consigned to an operational area.

When the aircraft were delivered to the Plant, they were torn down and all recoverable parts removed, cleaned, examined, sorted and packaged, and despatched to destinations determined by technicians attached to the Royal Navy.

This was just another job on which we certainly did not have all the answers when we commenced, but during the period of our learning to carry out the operations in the most economical and expeditious manner, we achieved the desired result of giving the Navy an immediate service.

The task was performed to the complete satisfaction of the Naval Authorities. When the war with Japan ended, the project was assuming such proportions that arrangements were being made to extend the area allocated for the work.

[120]
AVRO "ANSON"

Reconditioning for the R.A.A.F.

FOLLOWING the entry of Japan into the war there was a large concentration of the R.A.A.F. in Western Australia, and in addition to the operational squadrons, there were a number of training centres established in that State. One of the machines used for bomber training and for coastal reconnaissance was the Avro "Anson," and arrangements had been made for repair and maintenance work to be carried out locally on these machines rather than call on the distant facilities of the Eastern States. With the increasing Air Force activity the normal aviation repair facilities became overtaxed, and in January, 1943, arrangements were made by the Department of Aircraft Production for the G.M.-H. plant in Perth to take over the repair and overhaul of "Anson" mainplanes, which were of wood and fabric construction.

Our Perth personnel handled the project so efficiently that the contract was soon extended to cover the repair of trailing edges, rudders, and tailplanes. Subsequently it was still further extended to include the re-conditioning of petrol tanks, undercarriage and landing gear, the hydraulic flap mechanism, and all electrical wiring used in the mainplanes.

Although the men working on this re-conditioning programme had never had any previous experience in aircraft work, they quickly became proficient, and ultimately reached the stage where they were making worthwhile suggestions for effecting certain repairs. Following is a typical example.

The front and rear spars form the backbone of an "Anson" mainplane and these spars consist of an upper and lower boom which run the full length of the wing. The boom is made up of several laminations of spruce pine and is shaped to conform to the contours of the plane.

It often happened, as the result of an accident, that the wing tip of the mainplane was torn away, carrying with it portion of the spar. Repairs were effected by splicing a new end section to the spar.

In service, a certain amount of oil from the engines finds its way on to the lower boom of the front spar which absorbs the oil, resulting in the disintegration of the glue between the laminations and making the spar unserviceable.

Some of our Perth personnel were so interested in finding some means whereby these mainplanes could be put into service again, that they gave up their spare time to work out a solution to the problem. They suggested that, in view of it being permissible to splice a new end to the spar, a similar operation could be carried out on the centre section.

The Air Board gave its approval for an experimental job to be done, and when completed, it passed rigid inspection by the Department of Aircraft Production, and was adopted as standard practice by the R.A.A.F. and the Department of Aircraft Production.

The plywood position was particularly acute during the first two years of the project, and from an ordinary commercial viewpoint, the general supply situation would never have been considered satisfactory. It was frequently necessary to improvise in essential items of equipment, but despite these handicaps the programme was carried out to the entire satisfaction of the Department of Aircraft Production, from whom a congratulatory letter was received.

In no case were our men obliged to confess themselves beaten by the problems inevitably associated with such a project, and when the contract lapsed at the end of the war in the Pacific, mainplanes and other Anson parts had been re-conditioned to the value of over £100,000.
ANSON

General view of the dismantling operations of the Avro Anson aircraft in our Perth Plant. Below is shown a re-conditioned Anson mainplane frame, ready for the plywood skin.
The undercarriage and landing gear of the Ansons were completely re-conditioned at our Perth Plant
AIRCRAFT FUEL TANKS

General Motors-Holden’s Limited became the largest manufacturers of these components during the war and supplied the tanks for every type of aircraft made in Australia, including BEAUFORT • BEAUFIGHTER • MOSQUITO • BOOMERANG • WIRRAWAY TRAINER • WACKETT TRAINER • and LINCOLN •
JETTISON FUEL TANKS
SPECIALLY CONSTRUCTED FOR USE ON ALLIED FIGHTER & BOMBER AIRCRAFT IN THE PACIFIC AREA
FUEL TANKS
South Australia
ENGINE PROJECTS

Power Units for the Services

The entire war production effort of G.M.-H. was outstanding, not only for its diversity, but also by reason of the fact that many of the items encompassed had never previously been attempted in Australia. This strongly applied to the provision of power units of various types for the Services, as not only was G.M.-H. entrusted with seven different projects under this heading, but the production of two of them, the Gipsy Aero Engine, and the small radial engine for the 18 in. Naval torpedo, was achieved in Australia for the first time.

In the case of the Gipsy Aero Engine, this unit was required for the De Havilland Tiger Moth Training Aircraft, the airframes of which were being manufactured in Australia, but the engines were to be imported. The rapid development of the war situation in Europe made it impossible for these engines to be brought from England, and we were requested by the Government to accept the responsibility for their production in Australia.

With the expansion of the war in the Pacific area, Australia was also called upon to produce the 18 in. Naval torpedo, and G.M.-H. was directed by the Government to build the complex, high-precision engine, and several sections of the torpedo casing.

We were also allocated the task of producing the Gray Marine unit in Australia; this was urgently required as the power unit for the 40-ft. Army workboats to be used for the transport of supplies to and from the various island bases in the South-West Pacific. Owing to tremendous demands in the various war theatres, it was not possible for the Australian requirement to be met overseas, and the Government therefore decided to embark on the production of the General Motors Diesel-powered Gray Marine unit in this country.

To fill the immediate need for power units for these Army workboats, Cadillac engines, adapted for marine work, were fitted, and the responsibility for the production of these Marine Conversion Units also fell to G.M.-H., all four assignments were entrusted to our Melbourne Plant.

To maintain their ground transport at full working capacity, the American Forces in the South-West Pacific, in the early days of the campaign, approached G.M.-H. with a view to setting up an engine reconditioning service in our Pagewood Plant. This meant a considerable re-arrangement of a section of the Plant which had been engaged on the production of 25-pounder gun howitzers. However, the task was tackled with the same enthusiasm and thoroughness which characterised all our war projects, and to the entire satisfaction of the American Army.

Another unusual assignment was the re-conditioning of the famous Allison liquid-cooled aero engine, which was the power unit on most of the American Fighter aircraft in the South-West Pacific. This work was done in our Brisbane area, and although practically all the operatives were "green" labour at the beginning of the contract, the production target was successfully achieved.

As the pattern of the war in Europe quickly revealed itself, it was felt in Australia, that in the event of hostilities extending to the Pacific, and this country being threatened with invasion, tanks were essential for our defence. However, at the time there did not seem to be any prospect of Australia being able to import suitable units, and the Government decided to embark upon the immediate production of an Australian-designed tank. The power for the tank was to be provided by a clover-leaf assembly of three Cadillac engines, which had to be modified to adapt them to tank usage. The assembly of these engines was allocated to our Pagewood Plant.

Thus our efforts were spread over several different types of engine projects, for use in aircraft, motor vehicles, motor boats, tanks, and naval torpedoes.

In the following pages, the various projects are dealt with under their separate headings, and it will be seen that in conformity with our pledge given to the Government at the outbreak of war, we gave of our best endeavours and successfully achieved our objectives.
THE GIPSY AERO ENGINE

For R.A.A.F. Training Aircraft

THE reverberations of the terrific aerial blitz against Poland by the Axis were still echoing throughout the world when the Empire Air Training Scheme, bold in its conception and comprehensive in its planning, was launched.

Australia unhesitatingly accepted her share of responsibility for the success of the Scheme, and carried out her commitments by which she undertook to supply 16,000 fully trained Air Crew personnel by March, 1943, with a further 10,000 trained Air Crew personnel each succeeding year. In addition, she supplied some thousands of Ground Staff to service E.A.T.S. Squadrons formed from Australian personnel in the first three years of the Scheme.

It was early in October, 1939, that the then Minister for Supply and Development, the Hon. R. G. Casey, invited the Managing Director of General Motors-Holden's to come to his Office, and discuss Australia's responsibility in this tremendous Empire Air Training Scheme. The complete lack of formality was only paralleled by the crisp positiveness of action by the Government through its Minister, Mr. Casey. He explained that airframes of the famous "Moth" type were being built by the De Havilland Company in Australia, but the non-availability of Gipsy Major Aero Engines was a serious problem. These aircraft were essential for the initial training of R.A.A.F. pilots.

"This is a challenge to Australia," declared Mr. Casey, "Will your Company step up to it?"

"Yes," replied Mr. Hartnett, and without more ado they got down to details.

These were formally acknowledged in writing by the Minister with a definite instruction to proceed with the production of the Gipsy Major Aero Engine in Australia.

Drawings which had been in Australia for about four years were made available in January, 1940, together with their hundreds of amendments attached, but not posted to the drawings, and these were brought up to date. The next problem was the conversion of the measurements of these drawings from the metric to inch system of measurement, the standard Australian workshop practice. This sounds a small item, but it necessitated the conversion of approximately 41,500 dimensions from the metric system to inch, sometimes to 5 decimal places, a considerable sum total of calculation; 500 major parts averaged 80 conversions each. The crankcase required 900 such conversions. Even the 100 minor parts averaged 15 conversions each. This in itself was a tedious piece of calculating but technically applied revealed the complex problem of determining tolerances with their interference factors, which in practical terms meant insuring that the parts were interchangeable with metric or inch, and that the respective fits between parts remained in accordance with the design of the engine.

Then there was the location of materials, some of them never produced in Australia before, but absolutely essential for the production of this engine. A case in point was Magnesium which was, for the first time, manufactured from Australian raw materials by the Broken Hill Pty. Ltd.

The hundreds of components required for each engine called for many different kinds of engineering skill and equipment. Scores of manufacturers who were so closely associated with us in the manufacture of motor car parts were asked if they would assist, and they rallied spontaneously to the task. We provided the necessary drawings and specifications. In the final analysis the only imported parts in the engines were the magnetos, carburettors, and ball bearings.

By the time all the preliminary work was completed it was clear that over 80 manufacturers would be collaborating in making the various parts of the Gipsy Major Engine.

Among these manufacturers, arrangements were made for producing experimental sets of components. Two imported prototype engines were disassembled, one set of the English components being retained by G.M.-H. as a master set, and the other being distributed among the component manufacturers. As the experimental Australian-made sets were delivered they were inspected, and from them two complete sets of approved Australian-made components were selected. Of these two sets,
one of each component was retained by General Motors-Holden's Ltd. as a master set, and the other was returned to the manufacturer as the approved sample for quantity manufacture. Every part made had to be exactly interchangeable with the similar part of the military version of the English-made Gipsy Major aero engine. All preparatory problems had now been solved. The orders for actual production were placed.

Because of the lack of the highly specialised equipment in Australia for the production of many of the components in this engine, some interesting procedures were adopted which were highly successful. Here are a few examples.

The production of the cylinder barrel was undertaken in three stages. Firstly, the straight-carbon-steel hollow forging and rough machining. Secondly, the boring of the barrel and machining of the external fins, and thirdly, the final honing. The boring of the cylinder barrels and machining of the fins was done on modified general purpose machines. The rough forging weighed 35½ lbs., the finished job weighed 7½ lbs.

Much developmental work had to be done in order to evolve the technique of local production of the Cylinder Head. It started as an aluminium bronze casting, which in itself involves a highly specialised technique. Throughout the operation of casting, the quality of material had to be rigidly controlled. In the finished stage the component underwent a stringent porosity test, 80 lbs. air pressure being applied under water.

This work was being undertaken by two suppliers, each casting and machining half of the total number of cylinder heads required. Machining entailed a large number of operations, owing to the somewhat irregular shape of the combustion chamber, the limits on cubic capacity of which are very critical. For each cylinder head 23½ lbs. of metal had to be melted to produce a finished head weighing 10½ lbs.

The studs proved by no means easy to make. Their specification called for use of a tough high tensile steel, and the degree of accuracy necessary for the threads was maintained overseas by thread grinding. Because of the complete absence of thread grinding equipment in the initial stages of production, it was necessary to cut the thread on ordinary chasers. In addition, the required gauging equipment was unavailable and alternative methods had to be evolved.

All the component parts were delivered to the Aero Engine Department of General Motors-Holden's Ltd. at Fishermen's Bend, where they were quarantined—inspected with all necessary precision instruments and gauges for measuring and weighing.

It was seven months almost to a day after the handing of blue prints to the co-ordinating contractor with instructions to proceed, that the first completed engine underwent its 50-hour type-test.

This test engine was built from parts taken at random from the Bond Store and assembled under normal production methods, and then was run at 90% full power and upwards for 50 hours in 5 periods of 10 hours each, interrupted only by sufficient pause to perform the routine operations of adjusting valve clearances, changing the oil, cleaning oil filters, etc. Power output, fuel consumption, oil temperatures, oil consumption, cylinder head temperatures, etc., were all continuously charted throughout the test, and the engine came through with flying colours.

The engine, four-cylinder, in-line, air-cooled and inverted, has a compression ratio of 5.25 to 1, with an International power rating of 118-122 B.H.P. at 2100 R.P.M., and a maximum power rating of 128-132 B.H.P. at 2350 R.P.M. (full throttle) at sea level.

Apart from the production of motor vehicles for the Services, this was the first real war job the G.M.-H. personnel in Melbourne had undertaken, and all concerned, including the large number of sub-contractors, unhesitatingly gave of their best, working long hours—particularly in the critical period of the first test of the first Australian-made engine.

When the 1000th engine was being accepted on behalf of the R.A.A.F. by the Minister for Aircraft Production (Senator Cameron), in the course of a tribute to the technical skill of all concerned, he stated "Their sustained effort, ingenuity, capacity and enthusiasm has triumphed over all obstacles, and has been the measure of their success in manufacturing aircraft engines. The record of production within seven months, starting from scratch, is probably unexcelled in any part of the world."

Over 1300 complete engines plus a large number of spare parts were delivered to the R.A.A.F., a production rate of three engines a day being achieved during the peak period. These engines have also been sent to Malaya, India, New Zealand, and South Africa where they have given excellent service.