THE DESIGN AND DEVELOPMENT OF NAVAL AIRCRAFT

BY

LIEUTENANT-COMMANDER D. M. HARDY, R.N., D.C.AE.

INTRODUCTION

The aim of this paper is to describe the present organization for the desigr and development of aircraft for the Navy. This is essentially a team effor between the Admiralty, the Ministry of Supply and the Aircraft Industry.

There are two divisions of the Admiralty which are primarily concerned the Director of Air Warfare (D.A.W.), who formulates the Staff Requirements and the Director-General of Aircraft (D.G.A.), who is responsible for all the material aspects of naval aircraft, and their equipment.

However, it is the responsibility of the Director of R.N. Aircraft Researcl and Development (D.(R.N.)A) at the Ministry of Supply to ensure that the firms develop aircraft which meet fully the Admiralty's requirements, and a the same time are up to all the approved Ministry standards. In order tc exercise this responsibility a Development Project Officer (D.P.O.) is appointec for each major aircraft project. These D.P.O.s are either commanders o lieutenant-commanders of the A/E specialization, or civilians of equivalen rank.

It is intended to show that the task carried out by D.(R.N.)A's department is an essential one which, if not done by the M.O.S., would perforce have to be done by the Admiralty. Such a change would, however, be contrary to the current trends towards the merging of the higher direction of the three Services.

HISTORY

It may be of interest to quote the words of Sir Winston Churchill in two notes written for the Minister for the Co-ordination of Defence in 1936.* One note, concerning his proposals for the creation of a Ministry of Supply, reads as follows :—

'What is needed is to unify the supply command of the three Service departments . . . (The Admiralty would retain control over the construction of warships and certain special naval stores).

'This unification should comprise not only the function of supply, but that of design. The Service departments prescribe in general technical terms their need in type, quality, and quantity, and the supply organization executes these in a manner best calculated to serve its customers.'

The other note concerned the proposed formation of a Fleet Air Arm, whereby the Navy would be given control of its own aircraft. The passage quoted below refers to the method by which the Navy would put forward its requirements :—

'It is not intended that the Admiralty should develop technical departments for aircraft design separate from those existing in the Air Ministry or under a Minister of Supply. They would, however, be free to form a nucleus technical staff to advise them on the possibilities of scientific development and to prescribe their special naval requirements in suitable technical language to the supply department.'

These words were written when preparation for a war in the near future was uppermost in Sir Winston's mind. However, no effective action was taken to create a Ministry of Supply until the spring of 1939, and even then it was in no way responsible for aircraft.

The Ministry of Aircraft Production, under Lord Beaverbrook, was created in May, 1940, when Sir Winston formed his National Coalition Government, and the supply of aircraft for the Fleet Air Arm passed out of the hands of the Air Ministry for the first time. After the war the Ministry of Aircraft Production was absorbed into the Ministry of Supply. Nevertheless, the present organization remains based on the lines proposed by Sir Winston in 1936.

MINISTRY OF SUPPLY HEADQUARTERS ORGANIZATION

Before proceeding further, it is necessary to describe briefly the present organization of the Ministry of Supply as it effects naval aircraft. The complete M.O.S. organization deals with the supply of all materials for the Army, with guided weapons, atomic weapons, and electronics, in addition to the supply of aircraft. The top level M.O.S. Headquarters organization is shown in FIG. 1, D.(R.N.)A being near the centre at the bottom of the chart. This demonstrates what a small part of the whole this department represents. D.(R.N.)A is responsible to the Deputy Controller for Military Aircraft, who is normally a rear-admiral. This post is at present held by Rear-Admiral A. S. Bolt, D.S.O., D.S.C. He is, in turn, responsible to the Controller of Aircraft, who at present is Air Chief Marshal Sir Claude B. R. Pelly, K.C.O., C.B.E., M.C., A.D.C. FIG. 2 shows the organization within the department. Names of officers at present holding these posts are given on p.469 of this *Journal*.

* *The Second World War*, Volume 1, Appendices Band C.

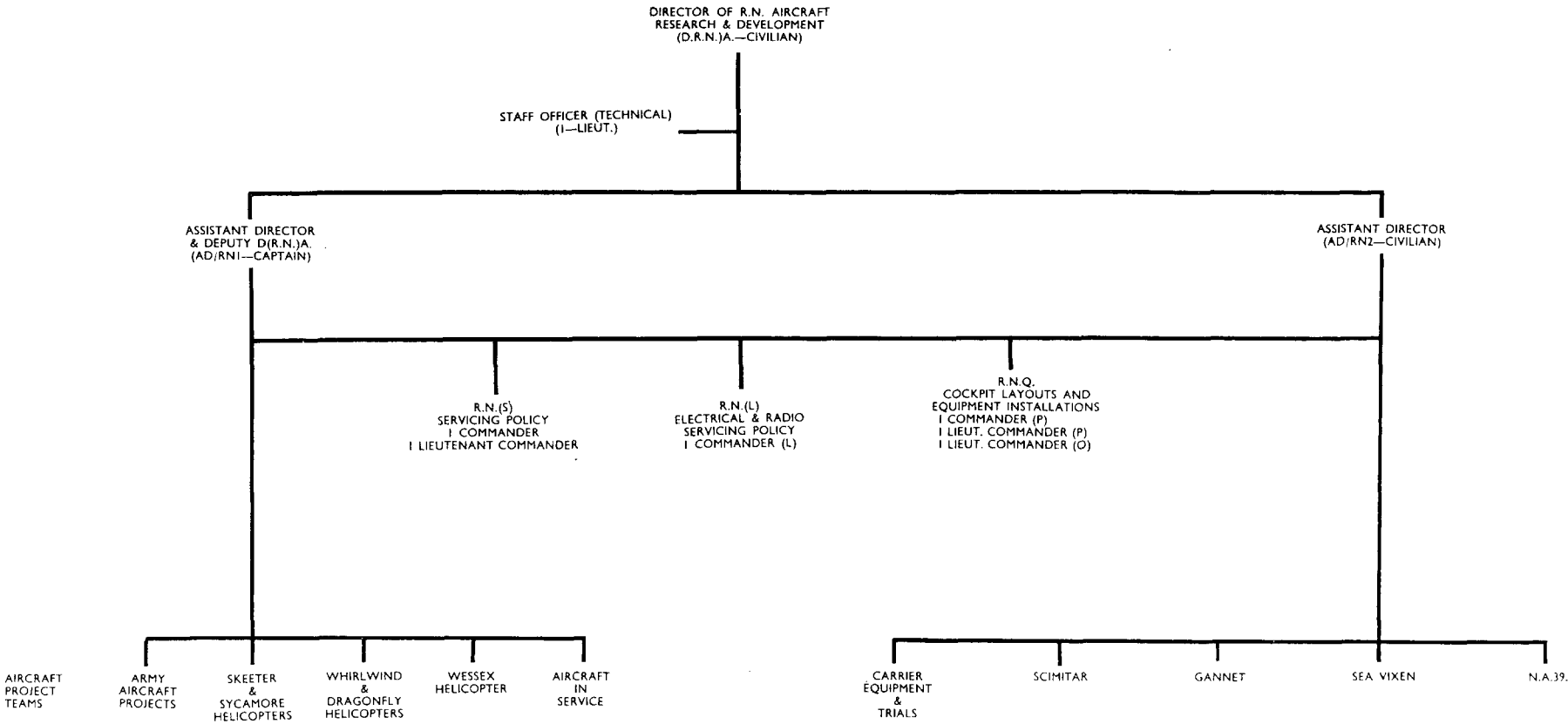

FIG. 2—DEPARTMENT OF R.N. AIRCRAFT RESEARCH AND DEVELOPMENT (M.O.S.)

Note: Project teams usually consist of :—

Development Project Officers (D.P.O.)—Commander, Lieutenant-Commander or Civilian.

Deputy D.P.O.—Lieutenant-Commander or Lieutenant.

All the above officers are of the A/E Specialization unless otherwise stated. Where necessary an 'L' officer is also included in the Project Team.

Each major aircraft type is the concern of a project team. This team is responsible for co-ordinating the design and development of the aircraft from its first conception as a Naval Staff Requirement, until its acceptance into Squadron service by the Navy. Even after this, there is much work to be done by the Department in progressing modifications, both to meet additional Staff Requirements, and to rectify faults which have come to light in service. In addition, a new Mark of the aircraft may have to be developed. However, the actual production of aircraft, once they have been developed, is the responsibility of the Director-General of Aircraft Production. Naturally, close liaison is necessary between his department and the Research and Development departments.

In fulfilling his task the D.P.O. has a deputy, whose broad responsibility is to ensure that the aircraft is satisfactory from the servicing viewpoint. There are many aspects of this, some of the more obvious being the design and provisioning of special-to-type tools and ground equipment (the latter in conjunction with a separate department—Serv. R.D.), interchangeability, spares provisioning and, of course, the basic design of the aircraft and its systems. In all this he is advised as necessary by R.N.(S), who is responsible for servicing policy and who works in close liaison with the complementary section of the Director-General of Aircraft's Department at the Admiralty.* This organization ensures that all project teams are working to a common standard in this respect and, for instance, ensures that no unnecessary special-to-type tools are designed for one particular aircraft. R.N.(L) performs a similar function for electrical and radio equipment. When necessary, the project team also includes an electrical officer.

The other separate unit within the D.(R.N.)A Department is R.N.(Q), staffed by four aircrew officers. These officers assist the project teams in all matters affecting aircrew equipment, and cockpit layouts. The D.P.O.s themselves are sometimes also pilots.

An additional responsibility which has recently been given to D.(R.N.)A is the recognition of the fact that the Royal Navy is the major helicopter user in this country. Thus, D.(R.N.)A is now responsible for research and development of all military helicopters. (The only exception to this arrangement is the Bristol twin-rotor helicopter which is being developed for the R.A.F.). The Army have recently been given responsibility for all their own aircraft up to 4,000 lb all-up weight, and an Army officer is now included in D.(R.N.)A's department.

Mention should also be made of D.(R.N.)A's responsibility for Carrier equipment, which is developed at the Naval Air Department of the Royal Aircraft Establishment at Bedford. This work includes the development of catapults, arresting gear and barriers, and has, until recently, also included the mirror sight. D.(R.N.)A is responsible for the programme of the Naval Air Department, and monthly meetings are held to progress it.

Finally, it should be pointed out that D.(R.N.)A has only limited responsibility for in-service aircraft (i.e. after a full C.A. Release, as described later, is given). This is because aircraft defects are the responsibility of a separate department—that of Research and Development of Aircraft Defects (R.D.A. Defects). However, for those defects which are so important that the C.A. Release may be affected, action is normally initiated by the D.(R.N.)A Department in conjunction with the firm concerned.

* D.G.A. now holds the overall responsibility for what were formerly the Directorates of Aircraft Maintenance and Repair (D.A.M.R.), of Aircraft Equipment (D.A.E.), the aircraft side of the Directorate of Radio Equipment (D.R.E.) and the Air Armament Section of the Directorate of Naval Ordnance.

THE EVOLUTION OF A NAVAL AIRCRAFT

The Naval Staff Requirement

The Staff Requirement is written by the Director of Air Warfare, and is sent to the Controller of Aircraft at the M.O.S. for action. Preliminary discussions will have already taken place, to enable D.A.W. to ascertain the ' state of the art ' in the design of aircraft to meet the type of role which is envisaged. In some cases, there may already be an aircraft in existence, or projected, which is likely to meet the requirement. In fact, it is not unusual for the requirement to be written round a known basic aircraft, in which case negotiations with the firm concerned will immediately proceed.

If, on the other hand, there is no existing aircraft which approaches the requirement, the M.O.S. sends copies of a Tender Specification, based on the Staff Requirement, to selected firms, who are invited to submit tenders. The tender includes full information on cost estimates, and a technical brochure giving details of the design. Models of the aircraft will also be provided. After lengthy consideration by the M.O.S. and D.A.W., a Tender Design Conference is held to decide which of the tenders should be accepted.

The Specification

The Specification is a contract document, and it is therefore especially important that it should be accurately and unambiguously defined. The D.P.O. is technically responsible for its contents. It may appear in three different forms : the Tender Specification, mentioned above, the Development Specification, and the Production Specification. After the Tender Design Conference, the Development Specification is prepared, with the chosen firm's design study in mind. The draft Development Specification is then circulated to all concerned, including the firm, and an Advisory Design Conference is called by D.(R.N.)A, to discuss and to agree to the final form of the Specification.

The Development Contract

The way should now be clear for the contract to be placed, provided costs are agreed, and the necessary financial approval given. The D.P.O. will raise the initial requisition which, under the present system, will be for a ' development batch ' of aircraft. The number of aircraft varies from three to over twenty, depending on cost, time-scale, and the likely production order. Whenever possible, the initial contract is limited to those items of the project which it is essential should be ordered at once, since it is becoming the practice to extend the contract each year, provided progress is satisfactory. For example, the initial contract might be for three aircraft, and ' long-dated materials ' for a further nine. (Long-dated materials are those which take more than about nine months to supply). A year later this might be extended to twelve complete aircraft, the following year to an additional forty sets of long-dated materials, and thereafter to a production order.

Commencement of the Design

The contract being placed, the firm can proceed with the design. Under the ' weapon system concept ', which was instituted some two years ago, the firm is responsible for the complete integration of the aircraft into a weapon system, not simply the provision of a flying machine. This conception is an essential one for modern aircraft, when the carriage of present-day weapons involves so much more than the installation of machine-guns, or the attachment of bombs. The idea of all-weather operation also involves the incorporation of so much extra electronic and other equipment that it must obviously be the parent firm's responsibility that the complete weapon system will meet the Specification in all respects.

MINISTRY OF SUPPLY

HEADQUARTERS TOP LEVEL ORGANIZATION

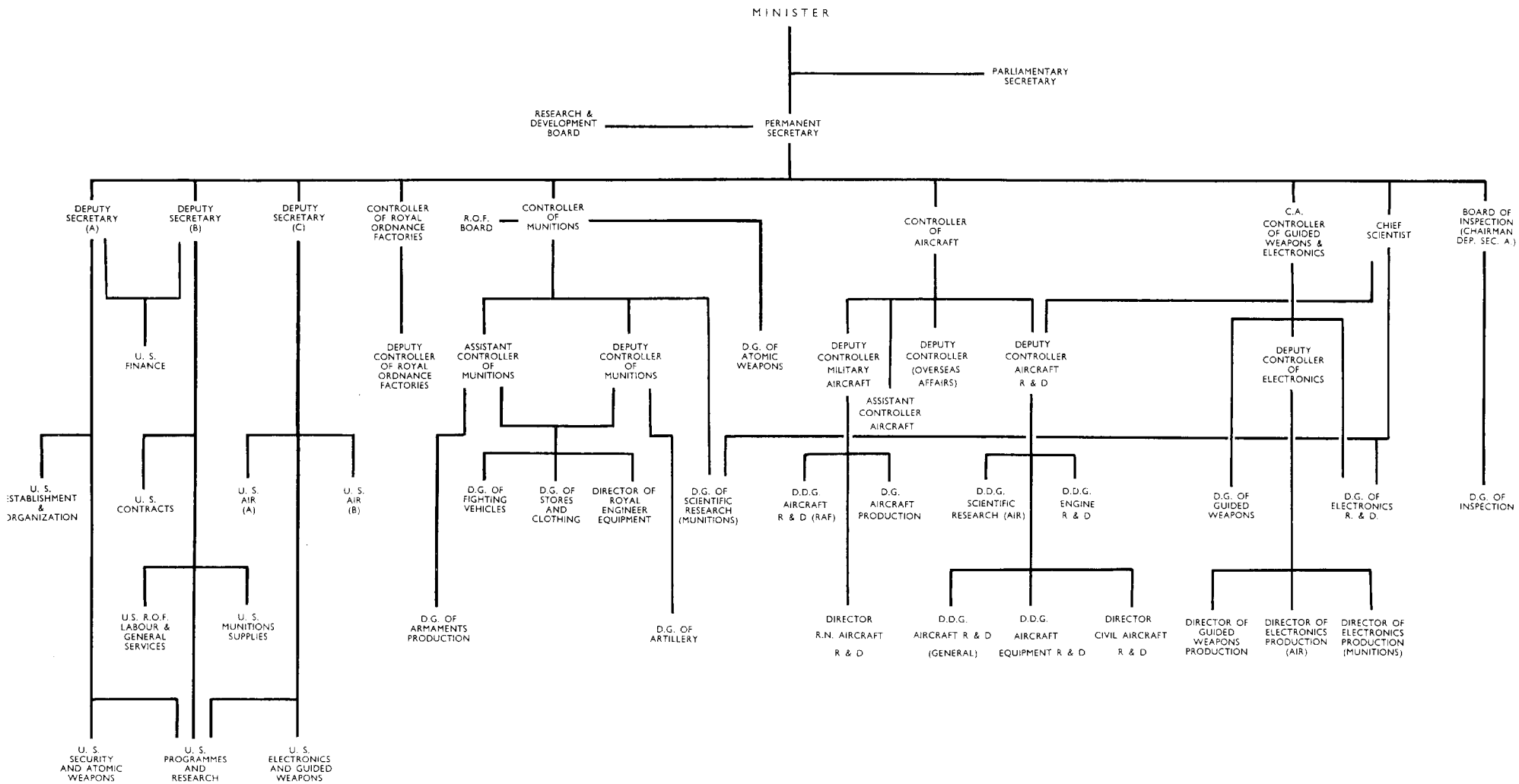

FIG. 1

In a similar way, the D.P.O. is responsible, not only for the airframe, but that the aircraft as a whole is being designed and built to meet the Specification and the programme, and in accordance with approved standards and procedures. In order to achieve this he must work closely, not only with the firm and the Admiralty, but also with the many other specialist branches of the M.O.S. headquarters. In addition, the Royal Aircraft Establishment at Farnborough and Bedford, the Aircraft and Armament Experimental Establishment at Boscombe Down and the Royal Radar Establishment at Malvern (all M.O.S. establishments) play an essential part in the development of a new aircraft.

An important factor in achieving the necessary co-ordination between all concerned is the holding of a Design Progress Meeting, which is at Director level, at about three-monthly intervals. At these meetings the firm is called upon to make a statement of progress since the previous meeting. D.A.W. and D.G.A. are thereby kept informed and, at the same time, are able to keep D.(R.N.)A and the firm in touch with currect thought and policy as regards Admiralty requirements. This is, of course, in addition to the ordinary day-to-day liaison. Directives both in policy and in design matters are given by D.(R.N.)A to the firm at these meetings.

A.P.970

In the paragraph above reference was made to ' approved standards '. It is in Air Publication No. 970 that the general requirements for the design of military aircraft are laid down. Its purpose is to amplify the requirements given in the Aircraft Specifications, and it includes any requirements which arise directly or indirectly from the operational functioning of the aircraft. It covers the following main categories of requirements :—

(i) The comfort and safety of the crew, guidance being given in such matters as the placing of controls and seats, and the pilot's view

(ii) The basic considerations of design, strength, and stiffness, which are intended to ensure that the aircraft can carry out its duties safely and without danger of structural failure

(iii) The aerodynamic and flying qualities

(iv) The installation of engines, of oil and fuel systems, etc.

(v) The servicing and reliability of the aircraft, in order to ensure efficient operation and a reasonable service life

(vi) The flight tests to be made by the firm prior to delivery of a new type to an experimental establishment.

A.P.970 is, therefore, somewhat voluminous, and to ensure that it is fully complied with is a tedious process.

If the firm wishes to depart in any way from these rules, a concession is sought from the D.P.O. The latter will then, if necessary, consult the specialist department concerned at the M.O.S. and, where applicable, the responsible Admiralty department. On the basis of their advice and bearing in mind the overall effect on the design of the aircraft, a decision will be given for or against a concession. An example of this is as follows :—

A.P.970 states that the oil tank capacity should be sufficient to cater for an endurance of *two* hours more than the theoretical absolute maximum, based on maximum fuel consumption and maximum allowable oil consumption. This requirement is equally applicable to helicopters and to fixed-wing aircraft. In the case of the Whirlwind this would necessitate the fitment of a much larger oil tank than was fitted on the Sikorsky S.55, on which the Whirlwind design is based. This would involve a significant weight penalty, and some re-design.

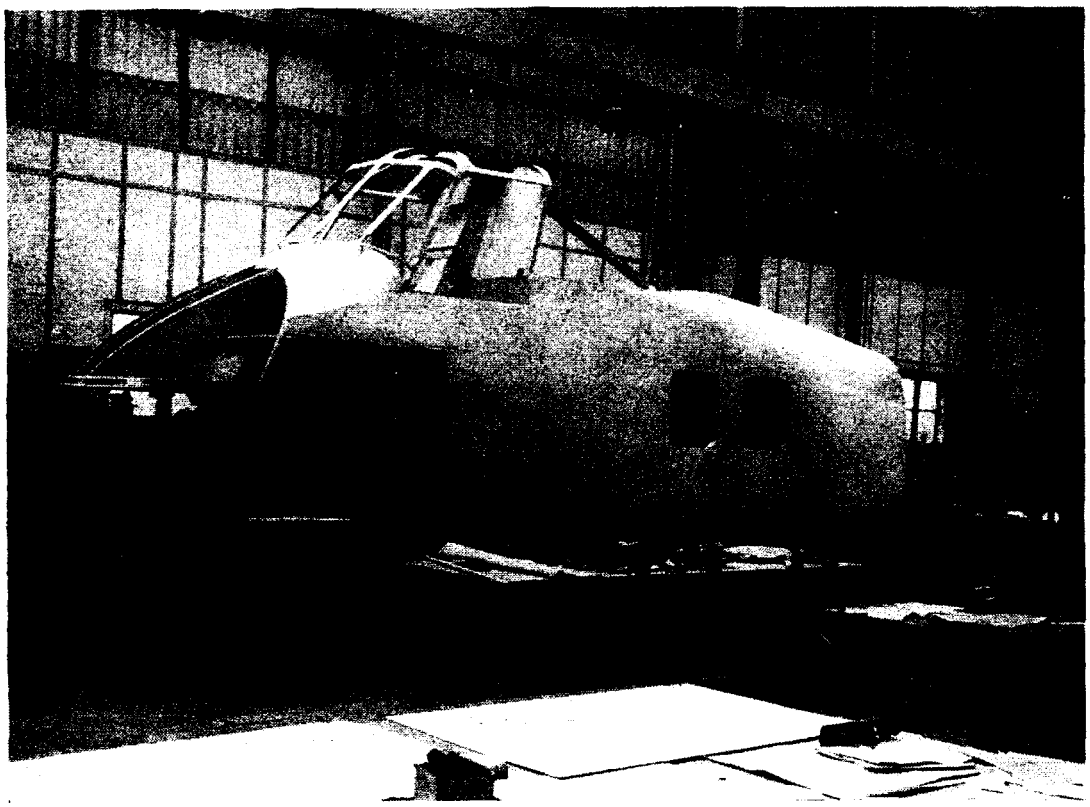

FIG. 3—WESTLAND WESSEX MOCK-UP

After consultation with the specialist branch which deals with oil systems, the firm was asked to check that under no circumstances could oil pressure fluctuations occur, due to temporary starvation, when oil equivalent to only *one* hour's consumption remained in the tank. This test gave satisfactory results, so that a concession was given.

The case for a concession is sometimes more simple, since the same set of instructions in A.P.970 cannot possibly be applied in every detail to every variety of aircraft. Indeed, a separate volume is now in the course of issue for helicopters.

The Mock-up Stage

Within a year of placing the contract, a mock-up, which is usually of wood, should be complete. The purpose of this, besides being essential to the firm's design team, is to provide the future user with an opportunity to criticize the proposed layout of cockpits, cabins, and equipment before any hardware is manufactured. The D.P.O. calls the Mock-up Conference, at which these criticisms are discussed, and decisions are made as to what alteration is required. R.N.(Q) plays an important part in this conference.

At about the same time, D.G.A. sends a team from the Naval Aircraft Maintenance Development Unit to carry out what is called an 'engineering appraisal' of the mock-up, to assess the aircraft from the point of view of servicing and mechanical design. Of course, this may only be possible to a limited degree on a wooden mock-up, but it is usual for all the systems to be fully represented. The N.A.M.D.U. team will also study drawings, and discuss controversial points with the firm's section leaders. The issue of the N.A.M.D.U.'s comprehensive report on this appraisal is followed by a conference, chaired by R.N.(S), at which the action to be taken on the N.A.M.D.U.'s recommendations is decided.

The Main Design Stage

Soon after the mock-up conference is over, the flow of completed drawings from the drawing office should rapidly increase. The firm's Production Department will then be able to commence the ordering of material, and the design of the necessary jigs and tools. The Design Department will also have to commence the design and manufacture of the development test rigs necessary to prove the various aircraft systems, and to test the structure in accordance with A.P.970. It is in this last respect that the Structures Department of the R.A.E. gives the firm invaluable advice and assistance.

Again, when the mock-up is complete, the firm should be in a position to compile the Schedule of Equipment, or Appendix ' A ', for the aircraft. This is, in fact, Appendix ' A ' to the aircraft specification. This lists all the parts and equipment which are not supplied by the parent firm and, in addition, all removable items which may not be essential in all roles of the aircraft. Some of these items (' embodiment loan ' items) are common to other aircraft and will be supplied by the Air Ministry or Admiralty. It is the D.P.O.'s responsibility to ensure that all these items will be available in time to meet the aircraft programme. This is, of course, a most important but tedious job, but the various M.O.S. specialist departments give invaluable assistance in providing the necessary information. When all the available information has been collected, a ' Development Planning Enquiry ' is held. This is a meeting which reviews the critical items and decides what action should be taken to hasten their supply or to provide an alternative.

Completion of the First Aircraft

It will be some two or three years from the placing of the development contract, depending on the complexity of the aircraft and other factors, before the first aircraft is completed. If there is no production contract, many of the parts will be hand made, without special jigs. However, if the contract is for a development batch of, say, twelve aircraft, with hopes of a production order to follow, a considerable proportion of the necessary jigs and tools may be manufactured earlier than would be the case with a prototype aircraft, which would be unlikely to have such certain prospects of a future order. This limited tooling will enable full-scale production to be put in hand more expeditiously as soon as the production order is placed. Even so, it takes about two years from the placing of a production order to the delivery of the first production aircraft.

The problem of interchangeability is also bound up with the extent of jigging and tooling provided in the early stages. The number of aircraft which will be accepted as non-interchangeable is written into the initial contract, and varies with the background of the project. For example, since the Sea Vixen was ordered late, the initial naval contract was for production aircraft, which were supposed to be fully interchangeable from the start. In fact, some concessions had to be given on the first four aircraft. On the other hand, in the case of a completely new aircraft it may be that the first ten or twelve are not fully interchangeable. Full modification procedure is introduced from the first fully interchangeable aircraft. For record purposes it is sometimes introduced earlier.

By the time the first aircraft is complete, the programme of rig tests should be sufficiently well advanced that flight clearance may soon be given. The fuel, hydraulic, electrical, and other systems, should have been subjected to a comprehensive series of tests, to prove their functioning, reliability, and resistance to fatigue. The various parts of the structure should have been subjected to the tests agreed earlier with the R.A.E. Before a first flight is attempted, however, there will be a series of taxi-ing tests, working up to

FIG. 4—THE FIRST WESTLAND WESSEX ON INITIAL FLIGHT

take-off speeds on fixed-wing aircraft, and prolonged tie-down ground running on helicopters.

Initial Acceptance Conference

As soon as practicable after the completion of the first aircraft, a full-scale conference will be held at which the aircraft will be inspected and the cockpit and equipment installations reviewed. This is called the Initial Acceptance Conference, and it will be the first big conference of this type since the mock-up conference about two years earlier. The aim will be to ensure that the experience gained in equipping the development batch aircraft will enable the first production aircraft to be to a standard fully acceptable to the Navy.

FIG. 5—SEA VIXEN F.A.W. MK. 1 UNDER TRIAL WITH ROCKET BATTERIES FITTED

Similarly, a second N.A.M.D.U. appraisal will be carried out on an early aircraft at about this time. This will obviously be a much more accurate appraisal than the one of the mock-up, but any changes now required will necessitate modifications, since manufacture of parts will already be proceeding. A conference on the appraisal will be held as before.

Firm's Flight Trials

About half of the development batch of aircraft will remain at the firm for development flying. In the first place it is necessary to prove the aircraft simply as a flying machine and not as a weapon carrier. One aircraft will probably be used continuously on performance work in order to ascertain the range of speeds and heights, or ' flight envelope ', at which the aircraft will fiy. Another may be used on strain gauge work to check the stresses during flight in those components which are most important, or which require checking in any way. Another may be allocated for the trial installations of modifications, another for autopilot trials, and so on.

Trials at A. and A.E.E., Boscombe Down

As soon as possible, after the first flight, a 'preview ' of the aircraft will be given to A. and A.E.E. pilots, either at Boscombe Down or at the firm. This will enable a critical report to be written by the establishment at an early stage, so that, if necessary, any poor features can be rectified at the outset. This is the counterpart, on the flying side, of the N.A.M.D.U. appraisal of the prototype.

It will be at least another year before the A. and A.E.E. receive an aircraft permanently for evaluation and trials. In all, about six aircraft will be allocated to the establishment for a period of about a year, for a series of flight trials

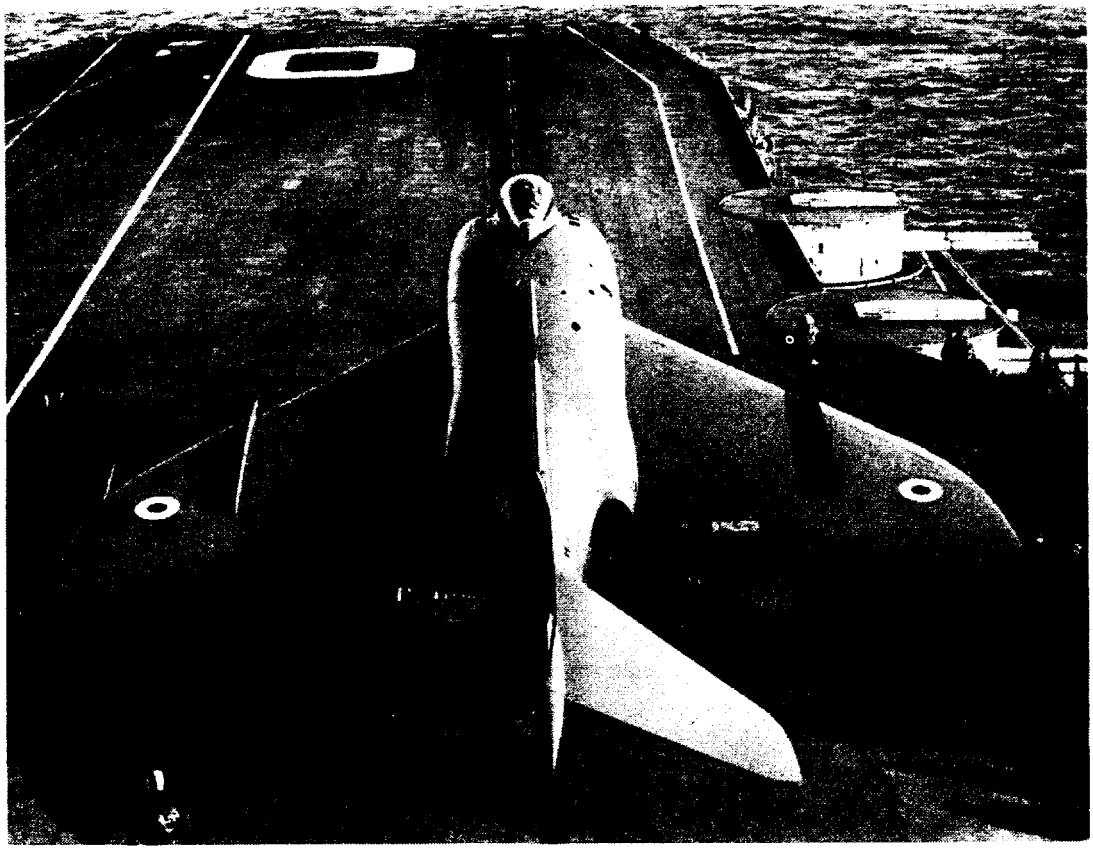

FIG. 6—SCIMITAR F MK. 1 ON CATAPULT OF H.M.S. 'ARK ROYAL'

aimed at a full release of the aircraft to the Navy. Each aircraft will carry out a definite task, in a similar way to the aircraft which remain at the firm. However, the A. and A.E.E. task can be better defined than the firm's, being rather less subject to development changes. Some of these tasks will be :—

(i) Handling and performance trials
(ii) Preparation of Pilot's Notes
(iii) Armament trials
(iv) Radio trials
(v) Tropical trials
(vi) Winterization trials
(vii) Engineering assessment.

The climatic trials are carried out abroad by A. and A.E.E. personnel on detached duty.

It is evident that there is liable to be some overlapping between trials done at the firm and those done at A. and A.E.E. To a limited extent this is necessary and desirable, so that a check is kept on the firm's work but, as far as is possible, duplication is avoided, so that time and money is saved.

Ship Trials

It is essential that the deck-handling and take-off characteristics of the aircraft should be established at an early stage. Before embarking the first aircraft in a Carrier, it undergoes a series of trials with the Naval Air Department at the R.A.E., Bedford. Equipment here includes the Mk. 13 arrestor gear, and the long-stroke steam catapult, fitted on the airfield to provide for actual landings and take-offs. The initial conditions for Carrier operation are

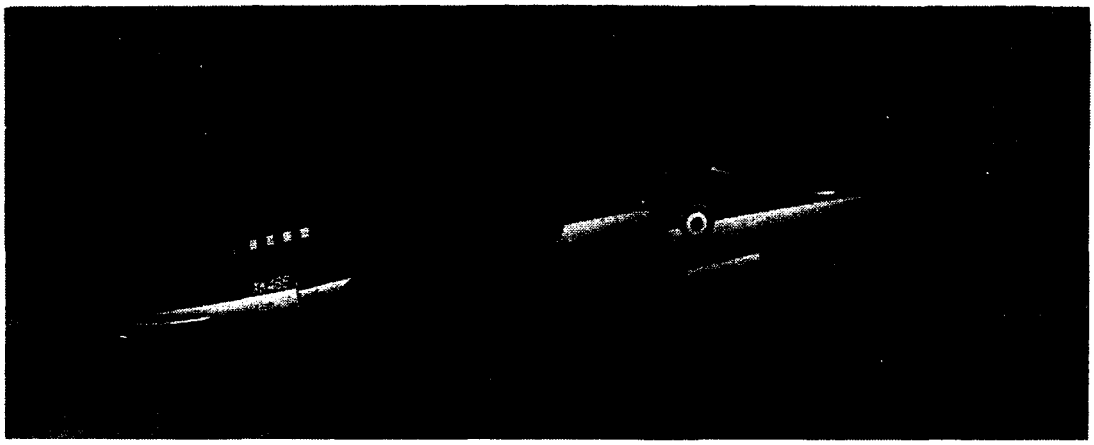

FIG. 7—BLACKBURN N.A. 39 TAKING OFF ON INITIAL FLIGHT

thereby established, including minimum approach and landing speeds and the appropriate mirror sight settings, at various all-up weights.

At about the same time as the 'preview' at Boscombe Down, the first aircraft will carry out its first deck landings and take-offs from a Carrier. The pilots will be from the firm, Boscombe Down and R.A.E., Bedford. Full deck trials will take place at a later date, at a time which fits in with both the aircraft development programme and with the Carrier programme. These trials usually take about ten days, and during this period about 200 landings and take-offs are carried out, including, if possible, about 100 on one individual aircraft.

Special Maintenance Party

Not long after the first flight a naval 'Special Maintenance Party' is formed. This unit generally comprises one lieutenant-commander (A/E), one lieutenant (L), and team of ten senior ratings. The S.M.P. Officer may be said to have two main duties. Firstly, he should work closely with the Deputy D.P.O. in advising the firm on the maintenance requirements of the Navy. Secondly, and more important, he and his team should find out all about the aircraft, well in advance of its introduction into service, so that he can assist the first service users in maintaining the aircraft. He issues monthly reports on his findings.

The S.M.P. Officer is appointed at a time in the evolution of the aircraft such that a $2\frac{1}{2}$-year appointment will extend to about the time of formation of the second squadron.

Final Acceptance Conference

About six months after the development batch aircraft start their programme at Boscombe Down, the first production aircraft should be completed. A Final Acceptance Conference will then be held at which changes introduced since the Initial Acceptance Conference will be reviewed, and the standard to which the production aircraft are to be delivered to the Navy will be finally agreed. This will be the standard to which the initial C.A. Release will apply. (Development batch aircraft will subsequently be brought up to this standard if they are delivered to the Navy). A N.A.M.D.U. appraisal may also be carried out on the first production aircraft, if sufficient changes have taken place since the previous appraisal to make it worthwhile.

THE FIRST A.E.W. GANNET AT THE S.B.A.C. SHOW, FARNBOROUGH, SEPTEMBER, 1958

C.A. Release

This document is the release to the Service, which is based on the trials which have been carried out at the A. and A.E.E. It is drafted by the D.P.O., in consultation with Boscombe Down, but is issued with the authority of the Controller of Aircraft himself. The initial release is usually a somewhat limited one, which can be issued before some of the less important aspects of the trials have been completed. Any restrictions initially imposed are removed progressively as the trials continue. The time which elapses from the placing of the development contract to the issue of the initial C.A. Release is normally between four to six years, depending, of course, on the background of the project.

Intensive Flying Trials

A naval unit with four to six aircraft is usually formed at about the time of the initial C.A. Release. Sometimes it is formed somewhat earlier and special clearance is given for the naval pilots of the flight to fly the aircraft. The object is to build up as large a number of flying-hours as possible before the aircraft goes into front-line squadrons, in the hope that, by then, the teething troubles will have been overcome. The target is usually 200 hours per aircraft in three to four months.

The Admiralty is responsible for this trial, but the D.P.O.s take an active part in ensuring that there is no delay in the necessary action being taken by the firms concerned as a result of the trial. This is also the S.M.P. Officer's busiest time.

Immediately after the successful completion of the Intensive Flying Trial the first front-line squadron will be formed. This may be said to complete the evolution of a naval aircraft.

CONCLUSION

It will be clear, from what has been said, that the provision of a new aircraft weapon system for the Fleet is a long and difficult affair, involving a very large

number of different departments and establishments. Among these authorities, it is only the M.O.S. Development Project Officer who is able to co-ordinate and continually progress the design, from the first receipt of a Naval Staff Requirement, until its successful introduction into service. Some people are ready to criticize the length of time required to train and give experience to the type of naval engineer officer who can best hold down such a post. With aircraft costing up to half a million pounds each, this task is so important that the Navy would be well served if it gave ten years to his training and, after employing him in this job, never used him again. In fact, of course, we do much better than this.

The present system has been gradually evolved since 1945, but, if the implications of the Defence White Paper of 1957 were to be taken to their logical conclusion, the existing projects would be the last of the piloted aircraft. However, I believe this to be far from the case, and this organization, or something very like it, should be necessary for a long time to come.

This paper has dealt largely with the administrative aspects of the problem. In a future article, it is hoped to describe some of the particular engineering problems met in one of the current projects.

APPENDIX

It had been intended to list here previous articles in the *Journal* which cover any part of this very wide field. However, there have been few, and the last was published five years ago. There is only one which should perhaps be mentioned. This is entitled ' Maintenance Considerations in Aircraft Design', by Lieutenant-Commander K. A. B. Macdonald, in Vol. 6, No. 3. This paper gave D.A.M.R.'s viewpoint on maintenance design problems at that time. The major organization change at the M.O.S. since then is that the Servicing Research and Development Department (Serv. R.D.) has been drastically cut down, and is now only responsible for ground equipment. Previously it had dealt with all aircraft servicing problems, and was, therefore, D.A.M.R.'s main contact for future aircraft at the M.O.S. Surplus staff from Serv. R.D. were transferred to the aircraft departments, such as D.(R.N.)A. Most of them became Deputy D.P.O.s, and were, therefore, still responsible for servicing, but also became members of closely knit project teams.