BLOODHOUND AND ITS HISTORY

IN introducing a lecture on Bloodhound before the Guided Flight Section of the Royal Aeronautical Society, the chairman —Dr. G. W. H. Gardner, Director of the R.A.E.—commented upon the interest the subject had aroused and upon the large number of people present; although some 200 guest tickets had been issued, it had been necessary to refuse a further 100 applications. The Ministry of Supply—said the chairman—had approached the Bristol Aeroplane Co. in 1949 with regard to the building of a surface-to-air missile. Mr. David Farrar, the Bristol Aircraft chief designer (G.W.) and the author of the paper, had been closely connected with the project since that date.

At the start of his lecture Mr. Farrar remarked that a guided-missile system was large and complex, and in preparing the lecture he was faced with the difficulty of having too much material. He had therefore decided to concentrate on the development of the missile itself. From the outset it was agreed that Bristols and Ferranti should be equal working partners in the project, and this arrangement had worked well.

At the time when the project was started there were already two other surface-air missiles under development in the U.K., and the recommendations of an investigating committee were available. This committee had suggested that the main requirements for the weapon were the need for high fire-power, long range and great development potential, without involving new radar techniques. The long-range implied flight at high altitude, and suggested the use of all-the-way homing guidance, coupled with ramjet propulsion; at that time there was no supersonic ramjet in this country. It was decided that the most economical accessory drive would be to use ram-air turbines. Two test vehicles were designed and flown within five months of the start of the work. The first of these was used by Ferranti for guidance development, and was designated CTV-4. The use of sub-miniature valves caused some early failures, but these were overcome by the development of new valve-testing techniques. The other test vehicle was the JTV-1, which not only became the first British ramjet missile to fly at supersonic speed, but also successfully proved various possible boost configurations.

In deciding upon the shape of the actual missile it was necessary to bear in mind the requirements of the radar installation and the need for sub-dividing the components for handling purposes. Three possible families of shapes were investigated, as indicated in the diagram. In the first the ramjet was integral with the missile body and the homing eye was located in the intake nose cone. Space for equipment was naturally restricted, and this difficulty was overcome in the second layout by using side intakes integral with the wings. Lack of knowledge of this intake arrangement counted against it, and finally the use of podded ramjets was chosen as the best solution. After consideration of a number of moving or fixed, two- and four-wing arrangements, with two or four ramjets, the present twin-ramjet, twist-and-steer configuration was chosen. (Mr. Farrar commented that this was the wing arrangement favoured by nature!) The compromise between wing and homing-eye size was decided with a bias towards the latter, as this also helped range potential. The actual shape chosen was much like the present Bloodhound, except that four indexed tail fins and a tandem boost were proposed.

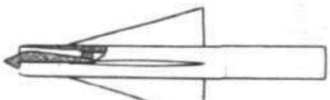
Five different series of test vehicles were used during the development of the actual missile. These ranged from the quarter-scale XTV-1 aerodynamic dart, through one-third scale controlled missiles and full-scale boost and ramjet vehicles, to the final XTV-5 fully guided weapon. During the course of development the tandem boost was dropped in favour of the overlapped type, as trouble was experienced due to lack of stiffness at the missile/boost attachment. A ramjet was designed in the U.S.A. by a joint Bristol-Boeing team. Designated the BB-1, the 16in-diameter unit was constructed, flown to America and had developed full thrust within the short space of nine weeks. After a number of design changes it became the current Thor engine.

Wing/body incidence was found to be sufficient without the need to resort to moving-tail fins, but the cruciform tail arrangement caused unstable effects at high incidence and in the presence of ramjet efflux. These fins were therefore replaced by a pair of fins in line with the wings. The wings do not interfere with ramjet performance, but the shock of the engines helps to counteract the adverse effect of the widening wing-root gap at high angles of incidence. Wings designed to meet the pitch requirements were found to be adequate for roll.

The structure is simple and designed for minimum cost. It uses a large number of magnesium castings, especially for bulkheads, none of which are fabricated. There are two backbone members along the top and bottom of the body, and comparatively thick skins. The wings and fins use a plywood matrix with alloy skins. All components are ground-tested in a representative flight environment using infra-red heating lamps.

There are two control loops, for pitch and roll. The basic response of the roll loop is fast, and roll rates and accelerations are high. It is altitude-corrected, and yaw coupling effects are small. A homing system is not so likely to cause the missile to spiral as is beam-riding, since there is a relative phase-advance in roll. The electronic components were designed on the principle that few valves would fail catastrophically. Each valve therefore does the minimum number of jobs in the hope that the effects of a partial valve failure will not be too severe. Potting of units was tried, but abandoned in favour of open units built up on printed circuits. Some transistors are used at critical places. Although a D.C. control system was employed initially, the excessive drift experienced resulted in the adoption of A.C. The electrical generator is driven by an oil pump as this assists control and ground running.

Following Mr. Farrar's paper a film was shown, illustrating some of the failures which occurred in development work. It included some remarkable coloured shots of ramjet operation in flight, and concluded most appropriately with an example of the successful destruction of an evading Meteor target aircraft by a Bloodhound missile. In concluding, Mr. Farrar said that success was due in large measure to the freedom and encouragement given to the design team, and Dr. Gardner was amongst those to be thanked for this happy state of affairs.



Three configurations examined during the early development of Bloodhound: at left, an integral ramjet body with a homing eye in the nose-cone; below left, a development with leading-edge intakes; below, tip-mounted engines