'STATISTICS PROVE . . .'

BY

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The Author, unlike the high-pressure advertisers of today, does not propose to convince anyone that statistics prove anything in particular, but he does intend to discuss briefly the use of statistics in the operation and maintenance of aircraft, and to enlarge somewhat on the machinations of the Defect Analysis Section of the Naval Aircraft Maintenance Development Unit, from which vantage point he has been viewing the matter of statistics for two years.

In the Fleet Air Arm, there are a number of Information Centres into each of which is fed a stream of reports, mostly with names not pleasant to the ear such as ' Annadee ' and ' Dass ', and raised in accordance with practically every variety of order which exists. They come in all sizes, from signals to booklets and, between them, they no doubt give at least one complete picture of all aspects of the operation and maintenance of naval aircraft. Quite possibly it does not matter that no one person can see the whole of the picture, or pictures, but it may be of interest that the R.A.F. have now introduced a system whereby at least the outline of the picture, and much of the detail, is visible to all who are interested. This scheme accounts for every five minutes of every aircraft's ' working day ', and also thoroughly dissects every unserviceability, whether routine or accidental. All the final arithmetic is done by machinery, by a well-known firm of calculation-contractors, but, even so, the number of Service personnel involved must be prodigious, and the R.A.F. appear to be meeting many obstacles in progressing the scheme.

Just such a scheme, in a small and ' handraulic ' way, can be, and has been, operated by the Defect Analysis Section (N.A.M.D.U.) in certain cases such as Intensive Flying Trials, but in general its activities are limited to the dissection of non-routine unserviceabilities (that is, defects) on about six of the current types of aircraft. Before describing how this is done it is necessary, for the benefit of those readers not specialized in A/E, to go back rather a long way.

Defect Recording in the Fleet Air Arm

Every naval aircraft has an Aircraft Servicing Form (Form A.700), which is really a 116-page note-book, in which everything of interest to the Technical Officer is recorded, including all defects. If a component is removed from the aircraft and subsequently dealt with in the workshops, that action is recorded on an Aircraft Component Servicing Form (Form A.703), only the serial number of which need be recorded in the Form A.700. There are other forms in the series, but suffice it to say that, if the records are properly kept, it is possible to trace the history of a defect from symptoms either to rectification or sale as scrap. In point of fact, no attempt is made to trace it farther than ' return to stores ' (except that the answers to any investigations by the makers are promulgated, as will be described later). As all these records are required to stay with the aircraft, and in any case are not always as self-explanatory as might be wished, it is necessary to have a Defect Recorder in residence. This unfortunate, regarded by all and sundry as a confounded nuisance if not actually a spy, is an artificer or mechanician who has generally done a short course at the Defect Analysis Section, and has been selected by the Air Engineer Officer to pass on to that section the required information.

The Defect Recorder's main job, then, is to scrutinize the Forms A.700 of the aircraft concerned, obtain additional information recorded on other forms, or in people's memories, and generally enable himself to report at fortnightly intervals the defects on each aircraft, together with the date and flying hours at which they occurred, how they were found, the rectification with man-hour cost, the modification state of the defective component, and any Defect Reports (Forms A.21—a much more detailed report raised on certain defects) being rendered. At the same time he reports the sorties flown, the more important routine inspections, the embodiment of modifications, and the change of components or engines at life-expiry or as a result of an accident.

The Defect Analysis Section

The Defect Analysis Section is accommodated at Wykeham Hall, Lee-on-Solent, the headquarters of the Flag Officer Air (Home) ; although it is no longer purely a Home Air Command concern, since it covers all ships and establishments at home and abroad. It consists of an air engineer officer and a dozen senior rates of the A/E, Electrical (Air), and Radio Electrical (Air) trades, together with a quantity of office equipment and calculating machines, but no crystal balls. From the information reported by the Defect Recorders, taken in conjunction with the running histories of the aircraft, the section keeps up a Central Index of Defects, and are able to supply information therefrom to the Ministry of Supply, the manufacturer, or whoever may be interested.

More or less on the sample principle, four-monthly Analyses of Unserviceability are issued, with a selection of the possible functions such as ' the rectification man-hour cost per 100 hours flown ' or ' the defect arisings per 100 sorties '. An Annual Review, containing rather deeper dives into the unknown such as ' the variation of rectification man-hour cost with hours flown since last important routine inspection ', is also issued.

The Defect Report (Form A.21) and the ' Blacklist '

As mentioned earlier, certain defects are made the subject of a Defect Report (Form A.21), which is not only capable of giving a comprehensive story of the defect including what led up to it, but is the only form of evidence which is at present accepted by all concerned as requiring some definite action. In order to encourage the user units to concentrate their reporting activities in the places where it is considered they will do the most good, a ' Blacklist ' is issued by the Defect Analysis Section (on behalf of the Director of Aircraft Maintenance and Repair) at monthly intervals. This lists those defects on which Forms A.21 are, and are not, required, the answers to investigations into previous Forms A.21, and gives a general indication of how such matters are progressing. The ' Blacklist ' is not very statistical, but it is part of the Defect Analysis Section's task, and statistics are utilized in the selection or eventual relegation of ' Blacklist ' items.

Some Results

One startling result, startling at least to the average maintenance rating or anybody who is aware of the reputations of some of our aircraft, is that the average maintenance rating only works for 2 or 3 days per annum on the rectification of defects. This figure is based on ' ratings allowed in support of the flying task '—it does not, for instance, include the personnel of the Defect Analysis Section. Some actual figures are given in TABLE I. One asks oneself what they do for the rest of the year, and an answer, albeit an elderly one, is to be found in the reports of the now defunct Operational Research Unit, which are, unfortunately, still shrouded in security. It may be significant, however, that nearly 45 per cent of the aircrafts' ' working day ' on the Gannet Intensive Flying Trial was occupied in routine servicing, and that since that trial both the servicing schedules and the modification programme have unfortunately increased.

The effect of routine servicings on the incidence of defects is difficult to demonstrate because of the variety of servicings and periodicities, but the variation of defects arising between the rather more important six-monthly servicings does follow a fairly consistent pattern ; not, as one might expect, as illustrated in FIG. 1A, but as in FIG. 1B.

TABLE 1

Aircraft		*Defect Arisings per 100 Hrs. Flown*		*Man-hour Cost per 100 Hrs. Flown*	
		1952	1953	1952	1953
Firefly	Less than 30 months old (equiv.)	42·9	33·8	83·4	69·7
	More than 30 months old (equiv.)	48·3	35·0	92·4	70·8
	Reconditioned ..	44·0	35·2	83·7	75·5
Sea Fury	Less than 30 months old (equiv.)	34·5	—	89·6	—
	More than 30 months old (equiv.)	44·0	—	113·6	—
	Reconditioned	35·1	—	103·6	—

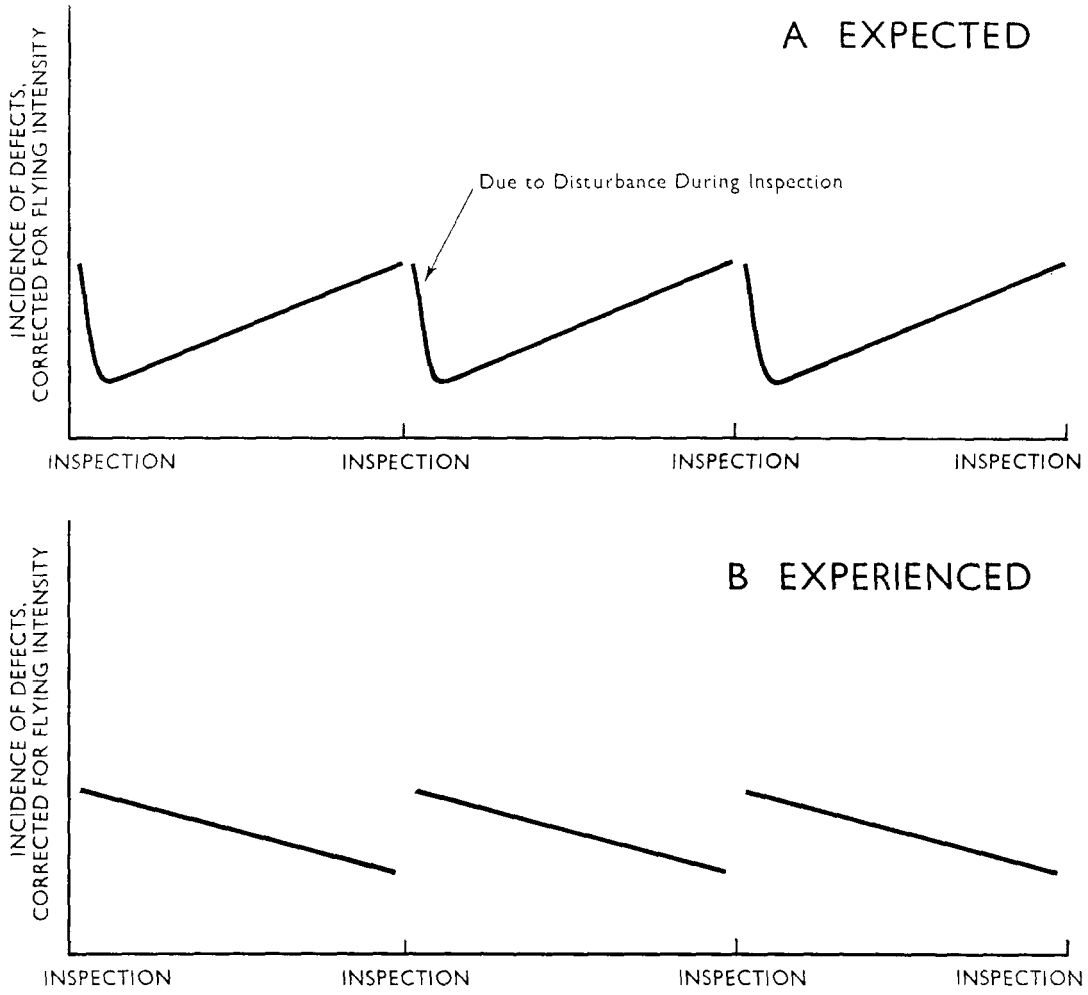

FIG. 1—VARIATION OF UNRELIABILITY WITH USE AFTER INSPECTION

Civil operators, and much of the R.A.F., base their routine servicings on flying hours, while the Navy now base theirs chiefly on time, which is much easier to forecast. A question to which it would be nice to find the answer is: 'do naval aircraft deteriorate with age or with usage?' The answer is surprisingly elusive, since there do seem to be good and bad aircraft, and the good ones just naturally get used more. Some aircraft even appear to improve with age, like certain foods, but in general FIG. 2, which actually represents Seahawk aircraft, airframe trade, period 1st March to 30th June, 1955, seems to illustrate the variation fairly typically. TABLE II also appears to shed some light on this subject, and it is a pity that the necessity in defect analysis for concentrating on modern aircraft rarely results in much information on the real old-timers.

A statement in the last paragraph, that 'there do seem to be good and bad aircraft', will no doubt be regarded by some as heresy, but it is prompted by FIG. 3 (based on the same sample as FIG. 2); while many of the aircraft which contribute to the right-hand side of the graph can be excused because they were prevented from flying by defects or other reasons, they cannot all, and those which cannot be excused are not connected by any common factor, such as

TABLE 2

Man-hour Cost of Rectification per Maintenance Rate, Per Annum				
Aircraft Type and Employment		1952	1953	1954
Sea Fury	Front Line	24·4	—	—
	Flying Training	33·6	—	—
	Total	25·9	—	—
Firefly	Front Line	26·3	27·3	—
	Flying Training	24·1	26·3	—
	Total	20·7	27·3	—
Attacker	Front Line	32·9	21·0	—
	Flying Training	24·9	24·1	—
	Total	30·5	19·8	—
Seahawk	Front Line	—	22·4	36·2
	Miscellaneous	—	16·6	28·7
	Total	—	21·5	33·7
Wyvern	Front Line	—	—	35·9
	Miscellaneous	—	—	18·4
	Total	—	—	31·7
Gannet	Intensive Flying Trial	—	—	28·3
All	Total	23·7	23·4	30 2

having the same aircrew or groundcrew, or Defect Recorders, or age, or what-have-you—they just seem to be an uneconomical proposition. Fortunately there are correspondingly excellent aircraft on the left of the graph, but nobody is worried about those.

For many years elderly gentlemen, particularly aviators, have been telling their juniors, particularly air engineer officers, that ' the way to keep 'em serviceable is to fly 'em ' ; whatever the juniors have been answering, they may have wondered if it is true. FIG. 4, which is based on frontline Seahawk squadrons between July, 1954, and February, 1955, may suggest an answer.

Traps for the Unwary

The method used for assessing the man-hour cost of rectification (i.e. accepting the word of the supervisory rating who did the job) appears to be highly suspect, and, in fact, the times reported for changing a Python engine change unit, for instance, vary between 8 and 219 man-hours. This sort of thing is understandable because, quite apart from sheared studs and other hold-ups, a man may easily forget that he had two or three mates, or suddenly become conscience-stricken about only having signed for one half-hour job in the last week ; but the results of a stop-watch timed operation, like the Gannet Intensive Flying Trial, agree so well with the normally reported figures that confidence is somewhat restored.

Another point which deserves consideration is that as aircraft get older, as a type or individually, they tend to be flown and maintained by people who are more used to them and more *blasé* about recording their defects ; the turn-over of aircraft and personnel slows this process down, and certainly any reduction in the rectification cost with the passage of time is not constant, as

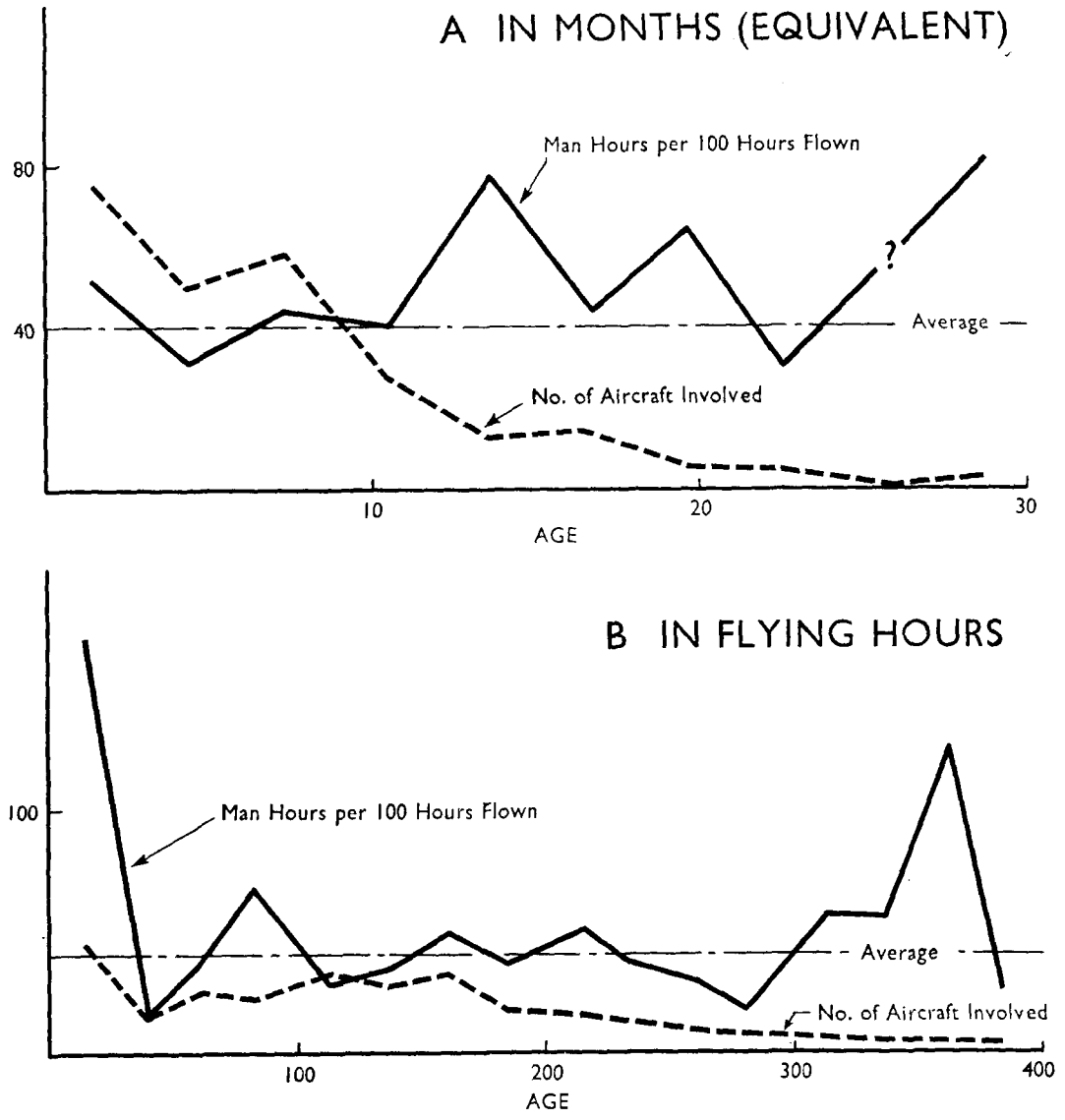

FIG. 2—EXAMPLE OF VARIATION OF MAN-HOUR COST WITH AGE OF AIRCRAFT

shown in FIG. 5. Rather similarly, to some extent the more the aircraft are flown the less they can be maintained, simply because there are only 24 hours in a day, and this point must be watched. In FIG. 4, the sample was chosen with this in mind, and it is hoped that the choice of a number of squadrons, each with a programme to carry out and a degree of flexibility in aircraft usage, over a period which should include a six-monthly inspection with its attendant rectification of 'deferred defects', has avoided that particular pit-fall.

Passing to a more technical use of the Central Index, it may be suggested that a certain item (e.g. decarbonizing a cartridge starter) in a servicing schedule is a nuisance and a drain on man-power—could it not be down-graded ? Possibly the Central Index shows no cases at all of whatever the item is intended to prevent, but this may be entirely due to the schedule item, which may be really necessary and successful. The Central Index simply would not know.

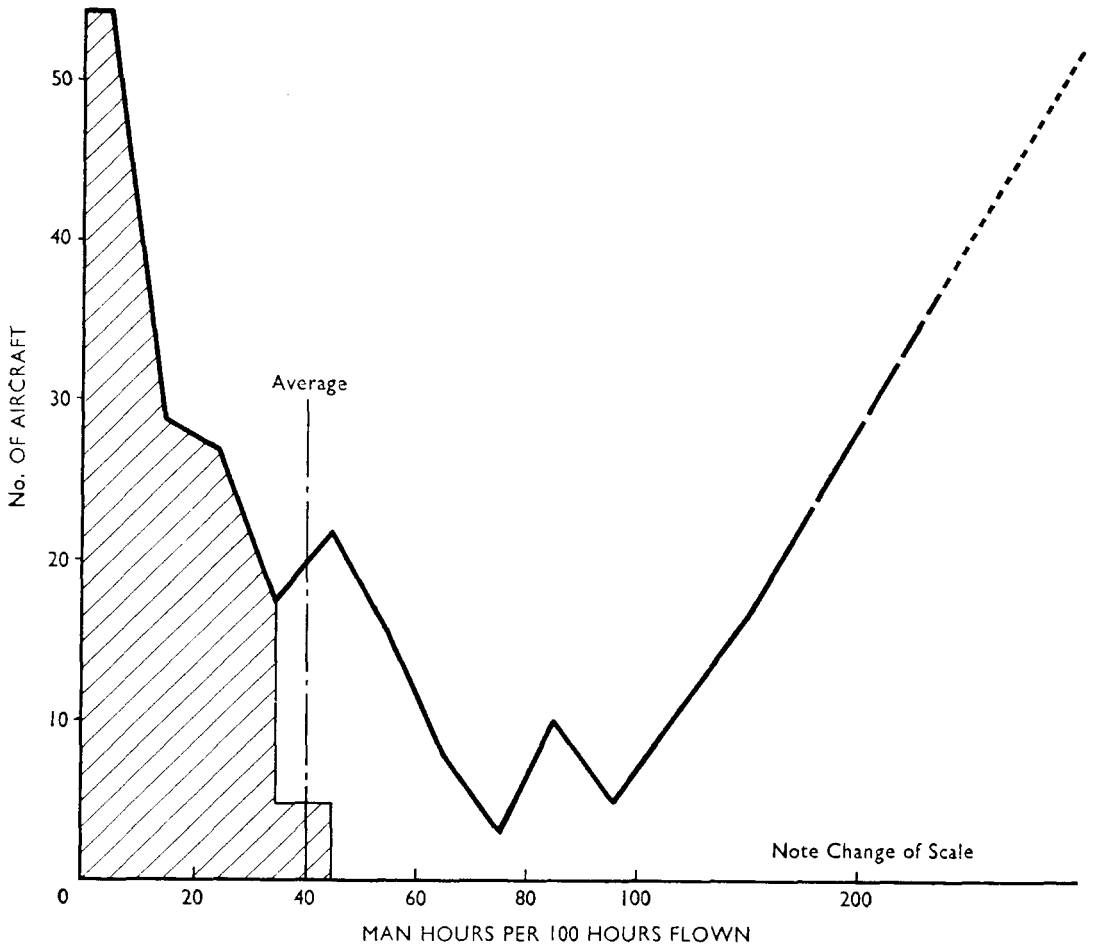

FIG. 3—EXAMPLE OF THE DISTRIBUTION ABOUT THE AVERAGE RECTIFICATION MAN-HOUR COST. SHADING REPRESENTS HALF THE AIRCRAFT

Conclusions

As is well known, and has been repeatedly stated elsewhere, ' statistics can be made to prove anything ', and there is a temptation to present the bare figures and let staffs and others draw their own conclusions, but unfortunately, even if the figures are really naked and unashamed, the people who should draw the conclusions often have not enough time ; so there is also a temptation to draw the conclusions for them, without, as remarked early in this article, being able to see the whole picture. However, after two years, one ought to be able to conclude something, and the present incumbent has come to believe the following :—

(*a*) The deterioration of complete aircraft is not generally rapid, and is more a function of time in use, than of hours flown during that time.

(*b*) The improvement of the aircraft by modification, and the improvement in methods of maintenance and handling with experience during the life of the type, is barely enough to offset the effect of increasing age ; this is partly due to what may perhaps be best described as ' fashionable ' defects (e.g. Griffon 74 cam wear, Seahawk fuel tank deterioration, and Python fuel system corrosion). The Sea Fury used to have one fashionable defect after another, as the deck-landing stresses and strain were

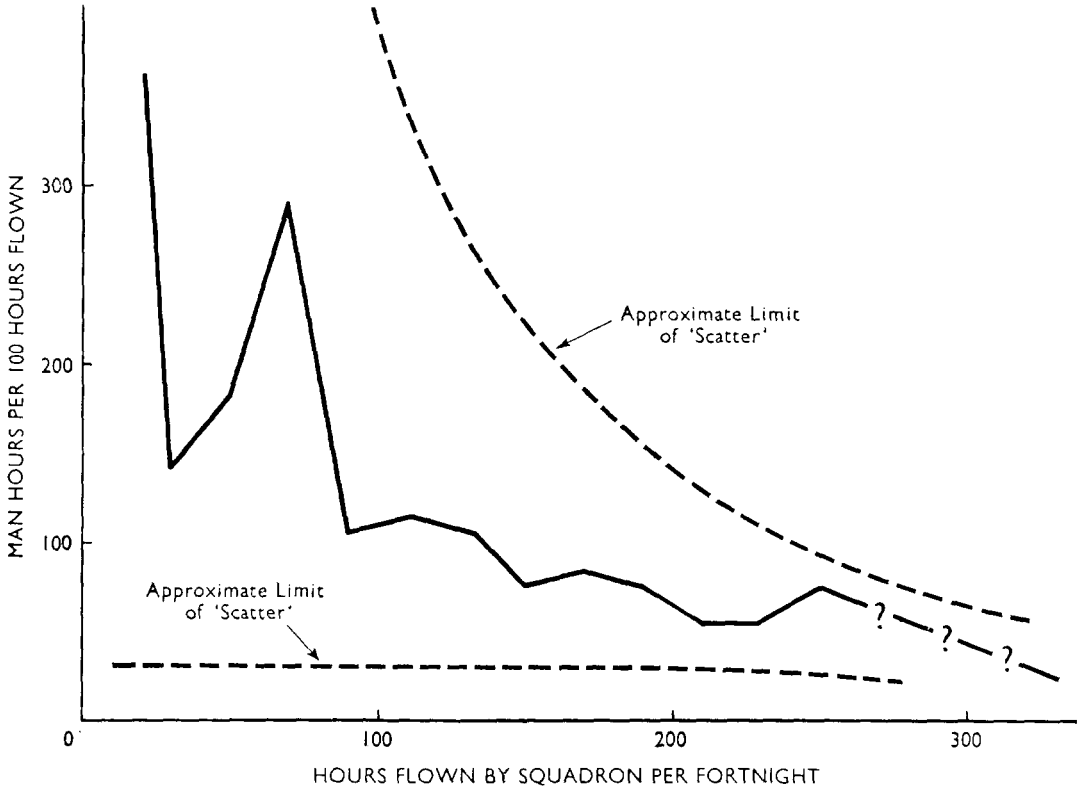

FIG. 4—VARIATION OF MAN-HOURS PER HUNDRED FLYING HOURS WITH FLYING INTENSITY

modified farther and farther up the undercarriage, centre-section, and finally the fuselage. The pilots must have felt like ' poor little Vera, as the great big saw came nearer and nearer.'

(*c*) While it may sometimes be desirable for an aircraft to be taken completely apart and put together again ' as new ' (i.e. reconditioned), this does not become necessary by Service standards at a certain age, whether measured in months or in flying hours. The Author considers it should be done when the aircraft is unsatisfactory and uneconomical, and generally disgusts a Board of Survey which has been requested by the Air Engineer Officer. (This is admittedly difficult to predict for the purposes of plans and estimates, but then so is Category 4 Repair.) This remark does not of course include engines and other removable components, but only the aircraft as a whole.

(*d*) A ' life ' for a component is rarely indicated by failures in naval service, because our samples are almost invariably too small and our operating conditions too varied (though generally harsher than in the R.A.F.).

(*e*) Something like forty or fifty times as much effort is spent looking for and attempting to avoid defects, as is spent in rectifying them. This sounds like the much vaunted ' maintenance by prevention rather than cure ', but so many of the defects occur shortly after an inspection that much of this effort seems to be wasted. Suggestions from user units for the down-grading of items so that this can be corrected are rarely forthcoming, while suggestions for up-grading, tending more and more to ' maintenance to destruction ', continue to flow in.

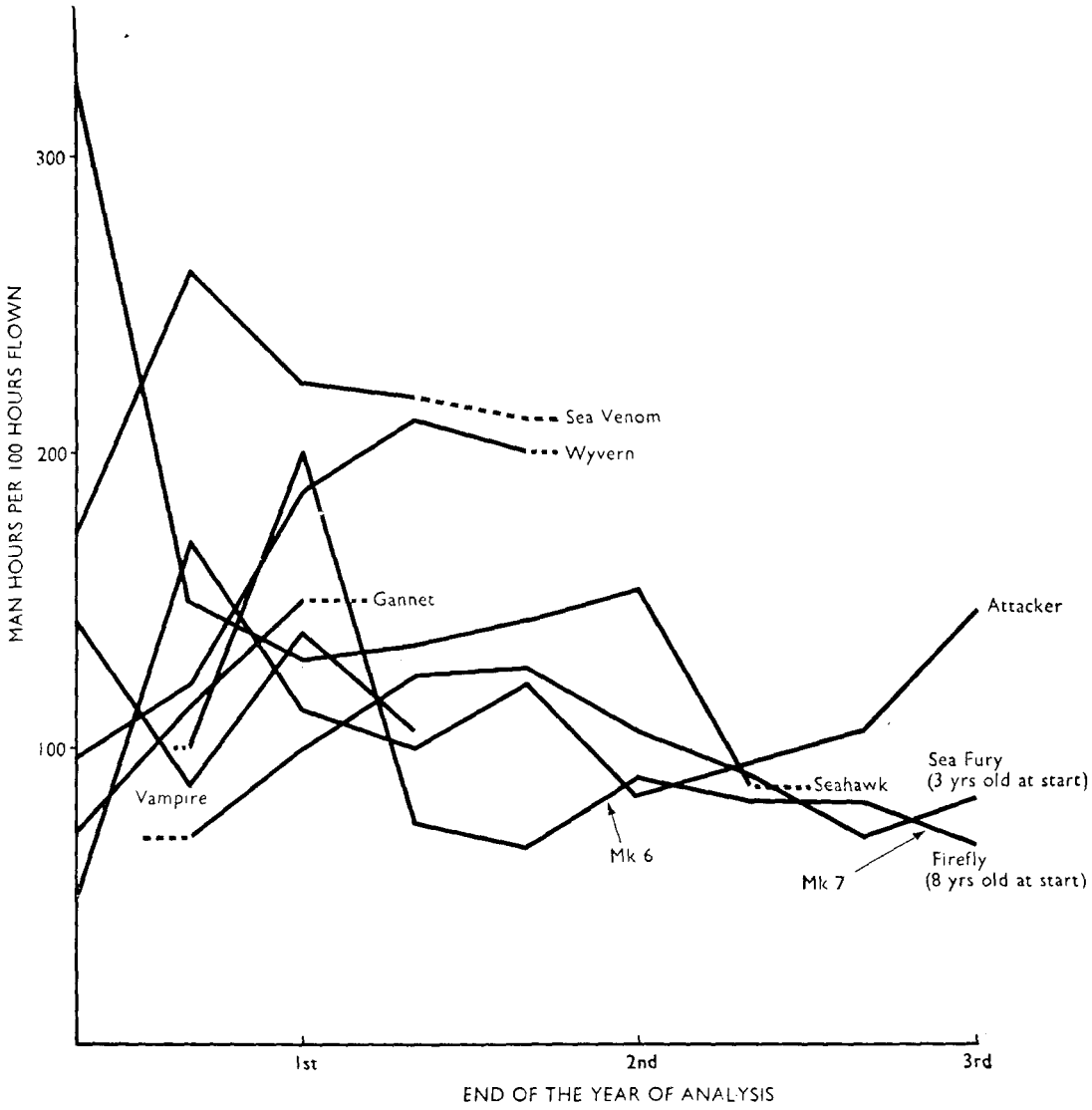

FIG. 5—VARIATION OF MAN-HOURS COST DURING LIFE OF AIRCRAFT TYPE

Air engineer officers may not agree with these conclusions, but if there is any suggestion that they are based on phoney figures, the Author would point out that the figures do not come out of a hat, but are provided by the air engineer officers in question, and the remedy is obvious.