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Item Description: This is a draft manuscript of a lengthy report compiled by the RAF Bomber Command Operational Research Section, probably some time in 1945. The report was authored by Dr. Basil Dickins, a rising star in the field of physics who served as Section head during the war. Using a thematic approach it explores in excellent detail the challenges inherent in strategic bombing, making it a valuable source for both historians of air power and those studying Europe in the Second World War.

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CHAPTER 20

EFFICIENCY AND MANPOWER PROBLEMS

Introductory Survey

Scientific methods and techniques are not so obviously applicable to the study of organisational matters as to investigations of, for example, bombing accuracy or the operational efficiency of radar equipment. This seems the most probable explanation why research into organisational matters was not initiated until somewhat later in the European war than research into most other topics with which the R.A.F. Operational Research Sections concerned themselves. By the time administrative research began to be undertaken seriously shortage of manpower had become the major factor limiting the expansion of the Air Force and, so, much of this kind of research was directed towards saving manpower. And in particular, partly because the study of maintenance work lent itself to the scientific approach, partly because early success attended research work into means of securing maintenance manpower economy but mainly because maintenance personnel were so important in affecting directly the amount of flying that could be done, a good deal of the administrative research effort was devoted to the Aircraft Servicing Organisation and maintenance manpower problems.

Serious scientific study of organisational matters began in Bomber Command from a careful perusal of a Coastal Command O.R.S. report on 'The Efficient Utilisation of Manpower with Special Reference to Maintenance Manpower'.(1) This report pointed out the influence on maintenance manpower economy of the irregularity with which in varying degrees any programme of flying was bound to be carried out. If a unit was manned to meet peak loads, then it was likely to be capable of a greater output given a uniform rate of supply of work. A scheme was suggested for careful control of 'in-use' aircraft on 'fit-for-flying' days so that a unit's capacity for flying would be exhausted only when bad weather or lack of opportunity eliminated the possibility of flying in any case and so that the rate of arising of unserviceability would ensure a supply of work to the maintenance organisation throughout periods of no flying. Since irregularity was a notable characteristic of the Bomber Command task, it was not unreasonable to

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(1) Coastal Command O.R.S. Report No. 206 dated 15 November 1942.

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hope that the Coastal Command O.R.S. proposals would be applicable. A great deal of thought was devoted to considering how to evolve such a scheme of 'Planned Flying and Planned Servicing' for Bomber Command but the Command Air Staff was not prepared to accept the restrictions on their operational freedom which the adoption of any such scheme was likely to involve.

Since the planning of flying to even out the servicing load was out of the question, the next step logically was to examine ways of organising the servicing personnel so as best to meet a fluctuating programme of work. This was, in fact, the line of development which research into maintenance manpower economy by Bomber Command O.R.S. now took. By examination of statistical records at unit, group and command level a body of data was carefully built up on the internal workings of various sections of the servicing organisation. From this a quantitative estimate was made of the manpower 'wastage' which could be attributed to irregularity in the in-flow of work. It was pointed out that centralisation and pooling of work could do much to remedy this loss and various changes in organisation were examined to this end. The formation of Group Initial Fitment Depots, the pooling of ground crews, the pooling of maintenance flight personnel and a change in the balance of resources by the addition of aircraft, aircrews and specialist maintenance personnel were recommended. This would result in a considerably increased flying output with no overall increase in maintenance manpower backing. These recommendations were in agreement with the recommendations for a Base Organisation which had meantime been evolved independently by the Engineer Branch. The mutual support which the O.R.S. and the Engineer Branch lent to one another's recommendations led to the adoption of the Base system in Bomber Command.

As a further result of these investigations Bomber Command O.R.S. had become familiar with the details of the workings of the servicing organisation and had gained an insight into associated problems which enabled it to advise on such matters as the relative merits of 2-flight and 3-flight squadrons. An essential background was also thus provided for the ensuing investigations, undertaken at the request of Command Staff, into the correct value under various conditions of the aircrew/aircraft ratio. The object of these investigations was to discover how the resources of aircrew and aircraft should be balanced to ensure the availability of one fit crew to man each serviceable aircraft when the opportunity

for large-scale effort arose. Since the level of aircraft serviceability depended very much on the supply of maintenance manpower and since both crew fitness and aircraft serviceability depended on the pattern and intensity of effort, the relationship between this and the earlier work was a close one. The achievements of this new work were the determination of the correct aircrew/aircraft ratio and of the need for its modification from time to time and, of more fundamental importance, a contribution to the theory underlying the relationship between the numbers of aircraft, aircrew and maintenance personnel in operational units and the flying performed by the units.

In the course of the work on the aircrew/aircraft ratio a scheme was evolved for keeping a graphical check on the balance between each unit's resources of aircrew, aircraft and maintenance personnel. Although this system was not adopted in practice, it is of interest in foreshadowing later work, undertaken when, in view of the manpower situation, the policy was laid down by the Air Ministry that Operational Research Sections should be encouraged to investigate the relationship between flying output and the level of maintenance manning. The investigation thus initiated was bound up with earlier work on the planning and organisation of servicing support for the flying effort not only through the intermediate work on the aircrew/aircraft ratio but also directly. Indeed the object of the investigation was the development for Bomber Command of a system corresponding to 'Planned Flying and Planned Servicing' in Coastal Command but without the latter's limitations on operational freedom. Some new factors affecting the flying effort were unearthed in the course of this work and fresh light was thrown on the effects of other known factors. A system was devised of periodically reviewing each unit's flying effort in relation to its resources of men and equipment and on this basis adjusting, whenever necessary, to a more economical distribution of resources. Since a proper trial of this scheme was prevented by the end of the European war, its utility must be regarded as not proven. In any event the information which it was designed to provide is really essential to a proper planning of resources and such a scheme is likely to be a basis for future planning of support for any flying effort in which a very large measure of operational freedom is indispensable.

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The work mentioned so far has dealt with matters of general organisation and the problem of how best to meet the programme of work necessary to support a given flying effort. Research was also undertaken to find means of reducing the actual volume of work associated with a given amount of flying. Suspicion voiced in a report by Coastal Command O.R.S. that more time was being spent on inspections than was justified by the decrease in repairs and failures which the inspections brought about, led to a Bomber Command O.R.S. investigation into the number of and manhour expenditure on repairs to an aircraft at various stages after the minor inspection. This work led to a 50 per cent increase in the flying hour interval between minor inspections and made possible the equivalent in manpower economy of 10 per cent of personnel in Repair and Inspection Squadrons.

In order to arrive at a satisfactory conclusion on the question of minor inspection periodicity, it was necessary to have detailed information about the manhours absorbed on various servicing tasks. This information could not be supplied with the accuracy or in the detail required by the units themselves but had to be obtained through the agency of a special party of technical personnel who recorded the work done on all the aircraft in one unit in the necessary detail. This is but one example of the need that existed for some means of discovering various details relating to the functioning of Station organisations. Owing to the fact that units were normally under establishment, particularly in the administrative posts, technical personnel had to be mis-employed on miscellaneous duties, and greater numbers were consequently established than were required to undertake the technical duties only. By 1944 it had become evident that the rationalisation of Station duties and the elimination of unnecessary tasks were long overdue, and it seemed likely that there was a considerable waste of manpower on such duties. Accordingly, in order to ascertain to what extent manpower was being wasted on unnecessary Station duties and the extent to which the establishment of technical and administrative personnel could be adjusted, recording parties were formed to observe the state of occupation of the personnel in selected stations in various Home Commands. For a considerable period, before centralisation of control under D.D. Science at the Air Ministry became desirable, each party worked under the scientific control and general

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supervision of the Operational Research Section of the Command in which it was operating. The results obtained enabled the O.R.S. to provide its Command with information on the amount of time expended at units on various activities and to advise on a number of matters connected with Station organisation, for example, on the size of a gang or section appropriate to carry out a given task such as, say, building power plants. From the more long-term view, information, forwarded in digestible form to the Air Ministry could be translated into figures to illustrate manpower potentialities and serve as a basis for provisioning purposes, as, for example, for the forecasting of future total establishments, trades and training capacity. In particular, a recording party working in Bomber Command obtained important information on the detailed working of a new servicing system, the so-called Marston Moor Servicing Scheme.

In addition to the full-scale investigations which have been seen to fit in with a process of fairly logical development, Bomber Command O.R.S. took a number of smaller items of work mostly in order to answer specific questions such as 'How many men are required to service the Fairey Mark I "Window" Launcher?' or 'How many aero-engines are required per month to back a given operational programme under specified conditions?' While these problems did not fit in very well with the general scheme or work, their solution was often made possible or more complete by the background of knowledge provided by the general work.

Thus, administrative research at Bomber Command during the war, while it certainly did not exhaust all possibilities, covered a comprehensive field. Starting towards the end of 1942 with research into the general problems of planning and organising servicing support for the flying effort, background theory was built up for studying and insight acquired into the working problems of R.A.F. organisation. Supported by detailed information, acquired by recording parties, on working conditions and utilisation of manpower at unit level, this work enabled Bomber Command O.R.S. to advise R.A.F. staff, Bomber Command, on such matters as the Base Organisation and the relative merits of 2-flight and 3-flight squadrons, and assisted in the solution of a number of miscellaneous problems which the R.A.F. staff presented to Bomber Command O.R.S. from time to time. The individual pieces of work, which were most successful, were undoubtedly the determination of the aircrew/aircraft ratio and the

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research into the optimum flying-hour interval between minor inspections. The usefulness of the latter piece of work is directly measurable since it led to a 50 per cent reduction in the periodical inspection load on Servicing Wings. Other work, for example, that on the development of a scheme for the statistical control of resources, was less obviously fruitful but resulted in a fuller understanding of organisational issues. Further, some system of centralised control of resources or, at least, the relating of flying achievement to the number of men and quantity of equipment needed to back that achievement is certain to find a place in any future administrative research programme.

The Organisation and Planning of Servicing Support

With an increase in aircraft production it became evident in 1942 that the supply of manpower was to displace the supply of aircraft as the controlling factor which determined the upper limit to the operational effort of Bomber Command. It was important that every possible means of ensuring the efficient use of maintenance manpower should be explored. There was, therefore, considerable scope for research into the various factors affecting operational effort and, more particularly, into the relationship between operational effort and maintenance manning.

The first problem of this nature undertaken by Bomber Command O.R.S. arose from the question whether sending out a small force of aircraft frequently or sending out a large force of aircraft less frequently would result in the greater overall effort over a long period. Bomber Command O.R.S. was asked to study the manner in which serviceability varied with the number of sorties despatched in a given time and to report on which of the two policies, of making frequent small-scale efforts or less frequent large-scale efforts, was more conducive to maintaining a high level of serviceability. The interest of this investigation lies solely in the fact that it was the first approach to the general problem in Bomber Command.(1) The results of the investigation were of little significance since a high serviceability was neither a desirable end in itself nor a reliable indication of efficient utilisation of resources: for example, 100 per cent serviceability might be easily obtained by a unit which did no flying.

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(1) 'The Efficient Utilisation of Manpower Resources with Special Reference to Maintenance Manpower'. Coastal Command O.R.S. Report No. 206 dated 15 November 1942.

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Serious interest in the economics of flying as a scientific study was aroused at Bomber Command for the first time by the publication of a Coastal Command O.R.S. report on the efficient utilisation of maintenance manpower.(1) This paper contained the first scientific analysis made of the organisation behind the flying effort and laid down basic principles governing the efficient working of that organisation. The most significant point about the paper was, perhaps, its explicit recognition that in all flying, and particularly in operational flying, periods of intense flying activity were inevitably sandwiched between periods of no flying, the duration of which would depend on the weather and the need for flying to be done. Coastal Command O.R.S. introduced a classification of squadrons according to the regularity of their effort: the most important classes were as follows:-

(a) Constant Effort Squadrons (on the so-called 'Semi-Saturation Cycle') whose fairly regular effort was subject to minor fluctuations due to weather and other factors.

(b) Variable Opportunity Squadrons which had a comparatively frequent opportunity but somewhat irregular effort.

(c) Fleeting Opportunity Squadrons which were required for infrequent and unpredictable periods of intense activity.

Under the ideal conditions of a perfectly regular flying effort the rate of flow of work to the ground staff would be uniform and the maintenance establishment should correspond to the amount of flying done. But under any practical conditions the rate of arising of work would vary in sympathy with irregularities in the flying. Consequently there were likely to be periods when the ground staff were not fully occupied and other periods when they were working to capacity and, in that event, the actual output from maintenance personnel would fall below their potential output given adequate work at all times. Under these circumstances the maintenance establishment required would not strictly correspond to the amount of flying done but would be influenced by the pattern of the flying effort. It was desirable by eliminating periods of slackness to make the maintenance establishment correspond to the mean monthly flying effort, and so save manpower. In other words, the problem presented itself of finding a means of providing the maintenance personnel with an even flow of work.

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(1) 'An Investigation into the Effect of the Size and Frequency of Operations by Individual Squadrons on the Maintenance of Aircraft Serviceability'. Bomber Command Int. Memo. No. 32 dated 25 November 1942. (A.H.B.2 unindexed).

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The Coastal Command solution to the problem of achieving a smooth flow of work was to fly during periods of activity a number of sorties somewhat in excess of the daily average necessary for the completion of the task. This would result in aircraft becoming unserviceable at a greater rate than the maintenance personnel could deal with them. The extra flying would be 'turned off' when there were only sufficient aircraft to maintain the necessary daily average of flying or when it was considered that there were sufficient aircraft awaiting maintenance to keep the maintenance personnel fully occupied until the next burst of flying was permitted by weather conditions or other relevant factors.

The Operational Research Committee studied and considered the Coastal Command O.R.S. paper (1) on Planned Flying and Planned Maintenance (P.F./P.M.) as these principles came to be called, and it was decided that a study should be made of the possible applications of P.F./P.M. principles to the special problems of each Command. Logically, though not historically, the next step was the production of a paper containing the deliberations of a Coastal Command O.R.S. expert on the problems of Bomber Command. (2)

This paper analysed broadly various factors relevant to the organisation and planning of the Bomber Command flying effort and pointed out in this connection a number of matters requiring detailed investigation. The problem of planning Bomber Command operations was a complicated one. Weather restrictions on the number of occasions suitable for operations were particularly severe for this Command since suitable operational weather had to obtain not only at Base but also en route and at the target a considerable distance away. Again it was desirable to send out a large force on each operation in order to saturate enemy defences and minimise the wastage rate. These and other factors ruled out for Bomber Command the possibility of planned flying in the time-table sense and in the sense of limitation of in-use aircraft on particular days.

Nethertheless it remained desirable to estimate an optimum scale of effort for Bomber Command. This would depend largely on an already decided production programme which was capable of only limited alteration. Large irregularities

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(1) Coastal Command O.R.S. Report No. 206.

(2) 'Planned Flying and Planned Maintenance in Bomber Command'. Bomber Command Int. Memo No. 33 dated 14 July 1943. (A.H.B.2 unindexed).

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were introduced into the pattern of flying activity by the weather. When the weather was suitable it was desirable to operate a force large enough to saturate enemy defences but not so large as to 'overbomb' the target. Where, for example, an expansion of front line strength were contemplated at the expense of a temporary reduction in effort, it was necessary to weigh in the balance the relative values of devastating an industrial target at a given time, or say, six months later and the difference in the aircraft losses likely to be incurred in doing so at the two different times. The possibility of taking into account these and all the other relevant factors was remote but any studies completed would be of great value in removing implicit policy decisions and bringing to consciousness at any rate the nature of the policy implications inherent in any detailed steps.

With the Bomber Command effort thus determined, the next stage would be to determine the numbers of aircrew and of maintenance personnel required to support it. Some details of the problem of ensuring that crew fatigue limited operations on only rare occasions were discussed. On the question of servicing support the paper suggested that all maintenance manning with the exception of that for daily inspections should be on the basis of flying hours per month. Under the conditions of bomber operations, in which a certain amount of dead labour was inevitable, it would not be possible to reduce manning right down to the level corresponding to the mean flying hours per month regarded as a steady effort but centralisation and pooling of work could do much to absorb irregularities in the flow of work. Finally the division of resources to support the training effort required to back the operational effort would be determined. Any limitation of resources encountered in the course of these estimations would lead to a scaling down of effort and consequent readjustment of requirements for all resources.

An attempt had already been made to find a basis for establishing an operational task for Bomber Command as a starting point from which the economical employment of manpower could be studied.(1) The basic hypothesis was that the inflow of new aircraft should exactly balance aircraft wastage, thus maintaining a constant front-line strength. The number of sorties that could be flown in a

(1) Operational Effort based on Rate of Make-up of Losses'. Bomber Command O.R.S. Int. Mem. No. 34 dated 22 June 1943. (A.H.B.2 unindexed).

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month could thus be estimated from the production programme and the wastage rate, and the means of deploying manpower economically to fulfil this task could be investigated. This idea was not, however, acceptable to Command Staff.

It soon became clear that no scheme which involved laying down a definite flying task would be acceptable to the Air Staff at Bomber Command, which felt the danger of losing flexibility in the planning of individual operations. A line of development parallel to that detailed above was, therefore, of perhaps greater importance for this Command. Following the decision of the Operational Research Committee that the possible applications of P.F./P.M. principles to the special problems of each Command should be explored, representatives of the Bomber Command Engineer Staff, of Bomber Command O.R.S. and of Coastal Command O.R.S. met to discuss P.F./P.M. and manpower economy in general.(1) It was decided that a Bomber Command O.R.S. scientist should familiarise himself with the organisation and records of the Engineer Branch at Bomber Command, study the details of the revised maintenance records and organisational methods which had recently been introduced into Coastal Command and consider the application of these records or modifications of them to the work of Bomber Command, visit selected operational Bomber Stations for detailed 'fieldwork' and finally co-ordinate these researches into a scheme for the efficient utilisation of maintenance manpower. The results of these investigations are contained in a paper called: 'A Study of Maintenance Manpower in Operational Squadrons of Bomber Command'.(2)

This paper pointed out that, since the demand for an unrestricted and unpredictable maximum effort was a frequent operational requirement in Bomber Command, it was extremely doubtful whether planned flying, in the sense of a fixed number of aircraft on each fit-for-flying night, was applicable to its operational squadrons. It therefore proposed to deal with the steps which might be taken to enable the maintenance organisation to deal most effectively with the existing greatly fluctuating flying effort. For this purpose it divided the servicing personnel for separate consideration in the following four classes:-

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(1) 'The Efficient Utilisation of Maintenance Manpower'. Bomber Command O.R.S. Int. Mem. No. 35 dated 20 December 1942. (A.H.B.2 unindexed).

(2) Bomber Command O.R.S. Int. Mem. No. 36 dated 4 June 1943. (A.H.B.2 unindexed).

(a) Ground crews, who comprised about 40 per cent of the maintenance establishment, were attached to and responsible for the day-to-day servicing of a single aircraft.

(b) Specialist workers, such as electricians, instrument repairers, wireless and R.D.F. mechanics, metal workers and armourers, who formed about 30 per cent of the establishment, went from aircraft to aircraft, inspecting and servicing the parts and appliances under their charge.

(c) The personnel of the H.Q. Maintenance Flight, who formed about 20 per cent of the establishment, undertook the lengthier repairs and servicing jobs, such as acceptance checks, initial fitments, major and minor inspections, engine changes, modifications and repair of enemy action damage.

(d) The remaining 10 per cent of the maintenance establishment was made up of workshops and stores personnel, cleaners, runners, etc.

Ground crews were not employed at all times at maximum pressure but economy in their manpower offered difficulties. Simple reduction in the number of men per ground crew was not feasible, since the ground crew was already as small as was compatible with safety. If two ground crews were pooled for the servicing of two aircraft, additional flexibility of working would be obtained (since there was often more work to be done on an aircraft than on its neighbour), and fewer men would be required in the combined gang than in the sum of the two gangs working separately. This pooling scheme had been tried with success.

The question of reducing the number of ground crews per squadron was also considered. Each aircraft required for operations or training at night must undergo during the preceding 24 hours a daily inspection and possibly minor repairs also. There was not time for one crew to carry out two such inspections in one day, and to share an extra inspection among more than one crew would be an undesirable division of responsibility. Hence a reduction in ground crews could be achieved only at the expense of reducing the maximum possible effort. Examination of the frequency distribution of the number of sorties despatched per squadron over a period of one year suggested that a reduction of 19 per cent in the number of ground crews per squadron would lead to a reduction of only 4·9 per cent in the number of sorties per squadron. On the other hand ground crews would take less interest in the care and maintenance of aircraft if they were not able always to work on the same one. Also, the call for station duties, night maintenance parties, etc., would have to be met by a reduced number of men.

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Taking the last point into consideration, an increase of 15 per cent in the flying output per ground crew could probably be achieved in this way. The manpower saved might be diverted to form new squadrons or, a more economical procedure, existing squadrons might be enlarged in respect of aircraft and aircrew, but not in respect of ground crews.

The specialist workers were employed to capacity and offered no possibility of economy in manpower, indeed, armourers (bomb) had to be supplemented by other personnel when a specially heavy effort was in preparation.

The number of aircraft under repair by each H.Q. Maintenance Flight each day was given within fairly close limits on Form 'Q', the serviceability state signal. It was thus possible to construct frequency distributions showing the number of days in a given period on which one, two, three, etc., aircraft were in process of repair at selected operational units. A reasonable estimate of the capacity of an H.Q. Maintenance Flight was five aircraft per day. On this basis an analysis was made in which one aircraft-day below capacity was counted for a day on which four aircraft were shown as receiving attention; and so on up to five aircraft-days below capacity whenever no aircraft were shown as receiving attention. The total number of aircraft-days below the capacity of the maintenance staff could then be compared with the actual performance of the maintenance staff in aircraft-days. It was concluded that, with a uniform flow of work, 100 per cent of the existing maintenance strength could cope with 150 per cent of the existing tasks. ~~Alternatively, 67 per cent of the strength could cope with 100 per cent of the existing tasks.~~ Alternatively, 67 per cent of the strength could cope with 100 per cent of the existing tasks, offering a release of 33 per cent of the manpower engaged in H.Q. Maintenance Flights. As the jobs to be undertaken could not be made to arise at regular intervals, investigation of methods of alleviating the effects of irregularity were of the greatest importance.

The possibility of establishing group maintenance organisations to undertake the lengthier repairs and inspections was considered as a means of smoothing out some of the irregularities in the flow of work. By operating with pools of unserviceable and serviceable aircraft, these organisations would ensure full-time employment for their staffs and at the same time be in a position to effect an immediate supply of serviceable aircraft to squadrons in exchange for those which

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were unserviceable. This scheme was not regarded as workable, mainly on account of the difficulty of flying the unserviceable aircraft back to the Group depot for repair. Group Initial Fitment Depots to carry out acceptance checks and the fitting of initial modifications on new aircraft would, however, be a practical proposition and their formation was recommended. The existence of Group Servicing Parties, which consisted of approximately 90 tradesmen used to supplement the maintenance flights of squadrons which had experienced an abnormally high incidence of unserviceability, was commended as a material aid to avoiding a waste of manhours.

The pooling of the manpower in the maintenance flights of the squadrons making up a base or station was also a development which, by smoothing out many of the fluctuations in the arisings of work, would lead to manpower economy. The disposition of the personnel would be in the hands of the Base or Station Engineer Officer who would balance the needs of the squadrons concerned according to their ability to meet operational requirements. The ground crews and most of the specialists would be unaffected by the change. The men of the maintenance flight would be mobile but would remain quartered on their present station, the appropriate, variable number being transported daily from the less busily engaged squadron or squadrons to the others. In step with this arrangement, as many as possible of the subsidiary sections which carried out repairs and testing of parts and accessories away from the aircraft, should be centralised. It was estimated that these measures would make possible the release of approximately 15 per cent of the maintenance flight personnel, that is, 5 per cent of all maintenance personnel, to form a nucleus of skilled labour for new squadrons.

In addition to recommending the centralisation of subsidiary sections on a station basis and the formation of Group Initial Fitment Depots, the paper suggested that squadrons might successfully be enlarged by the addition of 20 per cent more aircraft, 20 per cent more aircrews and 20 per cent more specialist maintenance personnel.(1) This could be expected to lead to a 20 per cent increase in flying, which the existing maintenance personnel, if pooled, and the existing ground crews should have been able to support. It was recommended that

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(1) 'A Study of Maintenance Manpower in Operational Squadrons of Bomber Command'. Bomber Command O.R.S. Int. Mem. No. 36 dated 4 June 1943. (A.H.B.2 unindexed).

an experiment on these lines should be conducted at one Base to test the validity of these estimates but permission to carry out this experiment was refused by Air Staff, Bomber Command, on account of the danger of interfering with operational effort.

In parallel with the Bomber Command O.R.S. investigation, the Engineer Branch had been examining its tasks afresh and had evolved the Base organisation which, it was considered, would largely cover the Bomber Command O.R.S. recommendations. A 'clutch' organisation was to be adopted, with two squadrons to a station and three stations to a base. Major repairs, major inspections, acceptance checks and initial modifications would be performed by the Major Servicing Unit at the Base, where the subsidiary sections would also be centralised. The institution of this system would effect a pooling of manpower which could be expected to go far to level out the effect of fluctuations in the rate of arising of unserviceability.

The next organisational problem tackled by Bomber Command O.R.S. was undertaken at the request of the Admin. Plans Section at Bomber Command. No. 4 Group had found that a higher return of sorties per flight was being obtained from its 2-flight than from its 3-flight squadrons and the Group was accordingly anxious to reorganise some of its 3-flight squadrons into 2-flight squadrons. Before taking any action in the matter, Admin. Plans asked Bomber Command O.R.S. to investigate the relative merits of these two types of squadron.

The Bomber Command O.R.S. investigation which extended over No. 1 Group Squadrons as well as No. 4 Group Squadrons, confirmed the No. 4 Group claim that more sorties per flight were being obtained from 2-flight than from 3-flight squadrons but pointed out that the 2-flight squadrons had more aircraft on charge per flight, more aircrew per flight and more ground personnel per flight.(1) Much, if not all, of the apparent superiority of 2-flight squadrons could be attributed to their more generous supply of these resources but it was possible that the 2-flight squadrons had a slight residual advantage on account of its compactness and the close control which that compactness made possible. It was possible, for example, that detailed briefing and advanced training could be more effectively handled in a 2-flight squadron. In order to amass evidence

(1) 'Two-Flight versus Three-Flight Squadrons'. Bomber Command O.R.S. Report No. B.208 dated 10 May 1944. (A.H.B./IIM/a1/4a App.).

on this point it was recommended that two of the 3-flight squadrons in No. 4 Group should be formed into three 2-flight squadrons, with the proviso that the manning and crewing of the units should be proportioned to those of the 3-flight units, and that the progress of the two sizes of squadrons should be followed.

The research into the organisation of aircraft servicing, described in this chapter, was of fundamental, though largely indirect importance. Directly, it lent valuable support to the case for the Base system and put into true perspective the relative merits of 2-flight and 3-flight squadrons. Indirectly, it shed light on otherwise obscure but nevertheless important relationships between diverse aspects of Bomber Command organisation. As a result valuable advice on specific points could be given by reference to general principles and the implicit consequences of particular policy decisions were more readily able to be appreciated. Later research also owed much to the present work, for an appreciation of the relationship between flying and maintenance support was essential to the work on the aircrew/aircraft ratio and on the scheme for the so-called statistical control of resources. So long as there is an operational task of the Bomber Command type to plan for, this basic work is likely to remain of substantial importance.

The Aircrew/Aircraft Ratio

In the course of considering early in 1943 whether Bomber Command operational squadrons should be established with 20 aircraft, of which four were held in reserve, instead of 18 aircraft, of which two were held in reserve, it was found necessary to review the question of aircrew establishments. The correct establishments of aircraft, of aircrew and of maintenance personnel and the flying capacity of a unit or force are all bound up very closely with one another as earlier work on the organisation of servicing support for the flying effort had revealed. The nature of the relationship in respect of the balance between aircrew and aircraft was not, however, very clear and Bomber Command O.R.S. undertook an investigation into the matter.

The O.R.S. investigation served three purposes. It threw light on the nature of the connection between the numbers of aircraft, aircrews and maintenance men in operational units and the sorties performed by the units; it provided a method of checking the correctness of the balance between these factors in any

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unit or group by examination of records; and it discussed the need for modification of the currently adopted aircrew/aircraft ratio of 1·1.(1)

The basic principle was formulated that the aircrew/aircraft ratio, i.e. the proportion of aircrew on strength to aircraft on strength, should be such that there was one fit crew to man each serviceable aircraft when the opportunity for large-scale effort arose. This would necessitate an ideal solution in which the ratio went up with an increase in serviceability or with a decrease in crew effectiveness. Such variation of the ratio was not practicable, so that the best compromise was to adjust the ratio to accord with the mean values of the serviceability and crew effectiveness. It can easily be seen that the required aircrew/aircraft ratio was equal to the ratio of percentage aircraft serviceability to percentage aircrew effectiveness. Though the aircrew/aircraft ratio for a given aircraft type in a group as a whole might be correct, the number of serviceable aircraft with crews might still fall short of the actual number of serviceable aircraft because of deviations from the correct aircrew/aircraft ratio in individual squadrons. Since crews and aircraft of squadrons were not interchangeable, a correction factor had to be introduced to ensure that all the serviceable aircraft in the Group were provided with crews. The correction factor for this purpose was obtained by observing the magnitude of the difference between the number of serviceable aircraft and the number of serviceable aircraft with crews in the Group as a whole from past records.

Further, an assumption was necessary as to the operational intensity of which aircrew were capable. With reference to past experience it was assumed that an aircrew could operate on two successive nights but not on three. Moreover, it was considered that the weather offered so small a number of opportunities of flying on any third consecutive night that it was not worthwhile providing the additional crew capital required to seize such opportunities.

On examining from Bomber Command Form G the mean aircrew fitness and the mean aircraft serviceability over a four-months period, it was found that the current aircrew/aircraft ratio was correct for the Operational Bomber Force as a whole under the prevailing conditions. Deviations from the standard ratio were

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(1) 'Investigations into the Aircrew/Aircraft Ratio in Operational Squadrons of Bomber Command'. Bomber Command O.R.S. Report No. 85 dated 7 November 1943. (A.H.B./II/39/1).

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found necessary in the case of certain types in certain groups. It was also found that the ratio deviated from the correct value in the case of certain types in certain groups; different forms of remedial action and their probable effects were discussed.

In order to maintain the required balance it was suggested that a graphical record should be kept at Command H.Q. to show the number of fit aircrews plotted against the number of serviceable aircraft of each type for each group, taking mean values over a week and adjusting the graph weekly, and that a similar graph by squadrons be maintained at each group.

Perhaps the most important aspect of O.R.S. Report No. 85 was the graphical technique used to present and discuss the statistics obtained; the method employed served to illustrate the nature of the connection between the numbers of aircraft, aircrews and maintenance men. A representative point corresponding to a certain aircraft type in a specified group was plotted against rectangular co-ordinates, of which the ordinate was the prevailing aircrew/aircraft ratio and the abscissa was the required aircrew/aircraft ratio appropriate to the aircraft serviceability and the aircrew fitness. The points were considered in relation to the diagonal straight line, the so-called 'parity line', on which the actual and required aircrew/aircraft ratios were equal, and in relation to the family of curves of constant flying capacity. The curves of constant flying capacity were actually lines of constant total of aircraft with crews available in a given period. For large values of the ordinate such a curve was parallel to the ordinate axis; it curved round in the neighbourhood of the parity line to become, for large values of the abscissa, parallel to the abscissa axis; the equation to this family of curves was developed in Bomber Command Internal Memorandum No. 37 dated 19 October 1943.(1) For points on the parity line, aircrew, maintenance personnel and aircraft were balanced; as a point moved up the parity line the flying capacity increased.

A point, not on the parity line, might be moved on to the parity line by altering any one of the three factors, aircraft on strength, aircrews on strength and strength of maintenance personnel. If the point was below the line, the economical course of action was to increase the actual aircrew/aircraft ratio

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(1) 'Equations of the Constant Flying Capacity Curves'. (A.H.B.2 unindexed).

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by increasing the number of aircrews or decreasing the number of aircraft, or to decrease the serviceability, and hence the aircrew/aircraft ratio required to utilise the serviceability, by a decrease in the number of maintenance men. Conversely, if the point was above the line, action might be taken to decrease the actual aircrew/aircraft ratio by decreasing the number of aircrews or increasing the number of aircraft, or to increase the serviceability by an increase in the number of maintenance men. It will be noted that a change in the strength of aircraft or aircrew would affect the flying done and hence the serviceability; hence the point would not move vertically. Which of the courses should be adopted would depend on the relative scarcity of aircraft, aircrews and maintenance personnel, and on whether it was desired to do more or less flying than before, or an equal amount.

The above considerations should not be taken to imply that for a given opportunity cycle there was a linear relationship between serviceability and maintenance manpower strength but merely that the former was an increasing function of the latter. Since serviceability could only approach the limit of 100 per cent by extravagant use of manpower, there would come a stage when serviceability would increase very slowly with increasing maintenance manpower strength. This would have to be considered in deciding whether to alter the strength of maintenance personnel rather than aircrew or aircraft strength in order to achieve balance between these resources.

An account of views expressed when the O.R.S. Report No. 85 was presented to R.A.F. Staff, Bomber Command, is to be found in Bomber Command O.R.S. Internal Memorandum No. 38 dated 21 December 1943.(1) The proposal that a running check on aircrew provisioning on the lines suggested should be kept was rejected because the A.O.A.'s Branch considered that their own methods of watching the position were adequate.

In December 1943 it was proposed that the establishment of aircrews in operational squadrons should be increased from 11 to 13 or 14 per flight of 10 aircraft.(2) The results of the O.R.S. investigations into the probable effects

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(1) 'The Aircrew/Aircraft Ratio'. (A.H.B.2 unindexed).

(2) 'Points for discussion at Air/Admin./Training Conference to be held in A.O.A.'s Office at 1500 hours on Monday 6 December 1943.' Bomber Command O.R.S. Int. Mem. No. 39 dated 5 December 1943. (A.H.B.2 unindexed).

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of this proposal are to be found in Bomber Command O.R.S. Internal Memoranda Nos. 40, 41 and 42 dated 3rd, 4th and 4th December 1943 respectively.(1) The short-term and relatively unimportant advantage secured would be an initial non-recurrent gain in sorties until the inability of aircraft replacements to keep pace with wastage brought the output back to its original level. More important, greater scope would be afforded for concentrating the effort into the most suitable weather periods. For example, three successive nights of large-scale operations instead of only two would be made possible by maintaining an aircrew/aircraft ratio of 1·4 in the Main Force and 1·2 in No. 8 (P.F.F.) Group. This would increase the striking efficiency of the Force and might tend to decrease the wastage rate. Further, reduced frequency of operations by individual crews might, by a reduction in strain and fatigue, assist both in improving the effectiveness of raids and in reducing the loss rate. The action taken was to increase aircrew/aircraft ratio to 1·4.

After the aircrew/aircraft ratio had reached and exceeded 1·4 for some weeks, it was found that the number of aircraft with crews of ten fell short of the number of serviceable aircraft. This was found to be due mainly to wide variations in the ratio from group to group and from unit to unit.(2) A surplus of crews in one unit did not compensate for a deficiency in another and, unless the ratio stood at or near 1·4 in every operational unit, there was a probability that the number of aircraft with crews in operational units taken together would sometimes fall short of the total of serviceable aircraft. Further, cases (which it would be extravagant to allow for) of abnormally high serviceability or low crew effectiveness were inevitable occasionally; this would likewise leave a few serviceable aircraft unmanned.

In 1945, it became necessary to consider whether an aircrew/aircraft ratio of 1·4 was adequate to support both day and night operations.(3) The normal effort required of a squadron was a 'Derby' effort, consisting of 70 per cent of the U.E. aircraft available with crews, provided that this did not involve

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(1) No. 40 - 'Considerations affecting the Proposed Increase of Aircrews from 11 to 13 per Flight of 8 + 2 aircraft'. (A.H.B.2 unindexed).
No. 41 - 'The Aircrew/Aircraft Ratio for Sustained Operations'. (A.H.B.2 unindexed).
No. 42 - 'Loose Minute (Aircrew/Aircraft Ratio)'. (A.H.B.2 unindexed).

(2) 'The Balance of Serviceable Aircraft and Fit Aircrews'. Bomber Command O.R.S. Int. Mem. No. 43 dated 17 December 1942. (A.H.B.2 unindexed).

(3) 'A Note on the Adequacy of 14 Aircrews per Flight when both Day and Night Operations are undertaken'. Bomber Command O.R.S. Int. Mem. No. 44 dated 14 March 1945. (A.H.B.2 unindexed).

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declaring fit any crew, which was training for a special operation or which would have operated twice during the 48 hours immediately prior to the projected operation. Occasionally 'Goodwood' efforts, when all crews not on leave or sick, were required to fly, were necessary. In general, this scheme would not require a more intense effort per crew than was required when the aircrew/aircraft ratio of 1·4 was established, although then only night operations were contemplated. Accordingly, no change in the aircrew/aircraft ratio was considered necessary.

Two other pieces of investigation into this subject deserve mention here. One was done at the time when the aircrew/aircraft ratio permitted not more than two successive nights of large-scale operations and was concerned with estimating the gain in sorties that might result from an increase in the aircrew/aircraft ratio sufficient to permit three-night flying.(1)

The other piece of work was a largely theoretical investigation into the question of sustained effort.(2) A unit with a fixed number of aircraft was considered. After a spell without flying, at the end of which the serviceability stood at 80 per cent, the unit was required to operate as heavily as possible. The rate of arising of unserviceability was to be 25 per cent of sorties despatched and the rate of restoration to serviceability during any day was to be 30 per cent of all the aircraft which were unserviceable at 1800 hours on the previous day. It was assumed further that no limitation on effort was imposed by shortage or fatigue or aircrews. It was shown that these assumptions lead to a close approximation to the states arising in practice in an actual squadron, both as regards serviceability and as regards the equilibrium state after several nights of sustained effort. It was deduced that the assumptions governing arisings and restoration rate of unserviceability provided the closest fit to actual conditions attainable with reasonably simply hypotheses.

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(1) 'Estimate of Increase in Flying Obtainable with the Increased Aircrew/Aircraft Ratio'. Bomber Command O.R.S. Int. Mem. No. 45 dated 17 August 1943. (A.H.B.2 unindexed).

(2) 'Theoretical Study of Sustained Effort by Aircraft'. Bomber Command O.R.S. Int. Mem. No. 46 dated 1 September 1943. (A.H.B.2 unindexed).

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The case in which aircrew provisioning could limit effort was similarly treated in Bomber Command O.R.S. Internal Memorandum No. 46. The assumptions of the previous case were retained except the one regarding aircrew availability. An aircrew/aircraft ratio of 1·15 was assumed with an allowance for non-effectiveness of 25 per cent. Crews could operate on two nights out of three, but not on three successive nights. Half the crews could operate on three nights out of four and all on three nights out of five but none on four nights out of five. On this basis the total sorties performed in a period of seven days' sustained effort, the distribution of the effort and the excesses or deficiencies of aircrew available relative to aircraft available were estimated.

In the work outlined in the earlier part of this chapter, a valuable basic principle was laid down and light was thrown on the relationship between flying effort and the provision of aircrew and other resources but the problems were treated in an ad hoc manner as they arose. In the work described in the preceding two paragraphs, some attempt has been made at a theoretical approach and this may well form the proper starting point for future research.

Statistical Control of Resources

In April 1944, the shortage of manpower was once more emphasised as the main factor limiting the expansion of the Air Force in a letter from the Air Council to various Commands, including Bomber Command.(1) It was necessary that the flying hours obtained should be closely related to the technical manpower used to produce them; by this means any inefficient or uneconomically manned units could be immediately detected. A memorandum by the Air Staff, describing the principles underlying the relationship of maintenance organisation to flying effort, accompanied the letter. Attention was drawn to the success of these principles in affording by their application large economies in manpower in both operational and training units and it was suggested that Operational Research Sections should investigate applications of the principles in their own Commands. Later, representatives of D.D. Science and D.D.O.(P), Air Ministry, visited Bomber Command to discuss the problem. In consequence Bomber Command O.R.S. undertook an investigation of flying output in relation to maintenance resources in the operational units of Bomber Command.

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(1) A.M. File C.S.2240Z/S.6. Letter dated 17 April 1944.

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At the time of the investigation Bomber Command operational units were distributed among Nos. 1, 3, 4, 5, 6, 8 and 100 Groups. It was decided not to investigate No. 100 Group, which was concerned with radar countermeasures, in view of the peculiarity of its task. The other groups were mostly organised into bases, each of which controlled two or three or four stations. The stations in No. 8 Group and some stations in Nos.3 and 4 Groups were outside the Base system; most of them were self-accounting directly to the corresponding group while others were of sub-station or satellite status and under the control of a parent station. Each station housed one or two squadrons, each holding twenty or thirty aircraft; normally a squadron in sole possession of a station held thirty aircraft and each squadron, sharing a station with another, held twenty aircraft.

Bomber aircraft, operational at this time, were Lancaster I, II and III, Halifax II, III, V and VII, Stirling I and III and Mosquito IV, IX, XVI and XX. Halifax II and V, Stirlings and Lancaster II were going out of operational service. A few Hudson III and IIIA, Stirling IV and Lysanders were also in operational service for special duties in No. 3 Group.

The maintenance personnel on each station were organised into a Repair and Inspections Squadron (R. & I. Squadron) and a Daily Servicing Section (D.S.S.). The D.S.S. carried out daily inspections and remedied petty unserviceability while the R. & I. Squadron carried out minor inspections and performed major repairs. Each base had a Base Major Servicing Section (B.M.S.S.) which carried out major inspections on all aircraft in the base and initial checks on aircraft as they arrived in the base.(1) The R. & I. Squadrons of stations in Nos. 3 and 4 Groups of parent or independent status did the major inspections on their own aircraft and on those of their satellites or sub-stations, if any. All the major inspection work on aircraft in No. 8 Group was done in two Group Type Major Servicing Sections, one for Lancasters and one for Mosquitos.

The first step in the investigation was to collect information about the flying hours and sorties performed by various units and about their strength in aircraft, aircrew and maintenance personnel. Operational and non-operational

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(1) Minor and Major Inspections were done periodically on a basis of flying hours. Minor Inspections were done after 50, 100, 150, 200, 250, 300 and 350 flying hours and Major Inspections after 400 flying hours; the cycle then repeated itself.

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flying hours were available by squadron weekly on a flying hour return made to the Engineer Branch at Headquarters; other sources were available but considered less reliable. Sorties were obtained by squadron monthly from the monthly news of the various groups. The aircraft holding of each squadron day by day was obtained from Form Q and the aircrew strength of each squadron day by day on Form G. The maintenance personnel strength of each station and of each major servicing section was given for the end of each month on Form 1753. This information for each base or station of independent status (including any sub-stations or satellites) in Nos. 1, 3, 4, 5, 6 and 8 Groups for May and June 1944, is tabulated in Bomber Command O.R.S. Report No. S.214 dated 16 February 1945.(1) The existence of Base Major Servicing Sections made it difficult to take as unit the station rather than the base as a whole; for rough comparison of flying output in relation to manpower backing between stations within a base the manpower backing of the B.M.S.S. might be divided among the stations of the base in proportion to the flying hours performed by each in the period under review and such a procedure had to be adopted in the case of No. 8 Group.

It was thought that it would also be necessary to take account for each unit of the amount of flying each of its aircraft could do before its next periodical inspection. If q was the number of hours an aircraft was due to fly before its next major inspection, the set of values of q for all the aircraft in a unit formed the Major Stagger Chart for the unit. The Minor Stagger Chart could be drawn in the same way by plotting the flying hours to the next minor inspection. It might be that one unit performed more inspection work than another in a given period and therefore in comparing their flying outputs in relation to maintenance manpower over the period it was necessary to examine the change in the stagger state of the two units. Further one unit might be in a better position to take advantage of operational opportunity than another with a less suitable stagger state.

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(1) 'A Method of Approach to the Problem of Manpower Utilisation in the Operational Units of Bomber Command'. (A.H.B./II/39/1/1).

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Stagger charts were not convenient for analytical purposes and might be replaced by the Minor and Major Inspection Potentials, P_1 and P_2 respectively. Definitions and a full account of the properties of these functions are to be found in a paper by D.D. Science III/2 dated 12 August 1944.(1) They were defined first for individual aircraft; the Major and Minor Potentials of a unit were the respective sums of the Major and Minor Potentials of each of its aircraft. The Total Potential of a unit was defined as the sum of the Major and Minor Potentials of the unit. The higher the Total Potential of a unit the more flying it could do for the expenditure of a given number of manhours. Calculation of Potential required knowledge of the average manhours expended on the Major and various Minor Inspections and the position of aircraft in the Flying Hours Cycle of Inspections. The former was known sufficiently well by the Command Engineer Branch but the latter could be found only by examining the Forms 700 for each aircraft on every unit under consideration.

Since the collection of necessary data was such an extensive undertaking, it was decided to make a preliminary quantitative examination of the effect of Potential in a few units with a view to discovering whether failure to take account of it would lead to serious error. The existence of many other complicating factors necessitated care in the choice of units for investigation, which fell on Nos. 13 and 14 Bases.(2) Accordingly a representative of O.R.S. visited No. 1 Group to make a detailed examination of the working of Nos. 13 and 14 Bases and to collect the necessary information from the Forms 700. At the same time the whole problem in hand formed the subject of discussions between O.R.S. and the Command Engineer Branch with the A.O.C., the Base Commanders and various Engineer Officers at Group, Base and Station level in No. 1 Group.(3)

With the background of these discussions and in the light of the data examined for a great many units, it was possible in O.R.S. Report No. S.214(4) to lay down principles and sketch a procedure for rationalising the manpower situation in the operational units of Bomber Command.

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(1) 'Planning and Control Indices in the R.A.F.'

(2) 'The Flying Hours per Man Efficiency Index in Nos. 13 and 14 Bases'. Bomber Command O.R.S. Int. Mem. No. 47 dated 14 September 1944. (A.H.B.2 unindexed).

(3) 'Report on visit to No. 1 Group to discuss Flying Hours per Man'. Bomber Command Int. Mem. No. 48. (A.H.B.2 unindexed).

(4) A.H.B./II/39/1/1.

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Provided the average capabilities of the personnel on different stations were the same (and over an aggregate of sections this might be expected generally to be true), a necessary but not sufficient condition for the maximum utilisation of manpower was that the work done per man on each unit should be the same. If one unit achieved more work per man than others, then it was clear that maximum effort was not being obtained all round and manpower was being wasted.

The work which a unit had to perform on each of its aircraft might be divided into work which had to be done whether the aircraft flew or not, work such as bombing up and seeing aircraft off which depended on the number of sorties performed and the work at periodical inspections which depended on the number of flying hours performed. The load on the maintenance personnel due to these three factors was represented by the indices 'Aircraft on Charge per (Servicing) Man', 'Sorties per (Servicing) Man' and 'Flying hours per (Servicing) Man'. The load due to the first factor was comparatively small. Since the number of sorties performed was usually a fair indication of hours flown and vice versa, the load might be represented almost equally well by either of the last two factors. Accordingly either 'Sorties per Man' or 'Flying Hours per Man' might be taken as the primary index of the utilisation of maintenance manpower and recourse had to the other two indices as a matter of routine.

Accordingly, if the 'Flying Hours per Man' of a unit was lower than the maximum it was reasonable to suspect wastage of manpower and an investigation into the cause was worth while. Explanations of differences might be used as a guide on how to bring the effort in relation to manpower of all units up to that of the best.

It might be observed of a unit with a low 'Flying Hours per Man' that it was required to participate in fewer operations than other units. This might be because it was equipped with an aircraft type which was unsuitable for certain kinds of operations. If this were the reason for the low 'Flying Hours per Man', then a reduction in manpower was indicated. If there was no such explanation for the lowered operational opportunity of a unit, then it might be brought to the attention of the Group that the flying programme of the unit would be increased and to the attention of the Command that a corresponding increase in

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the effort of the Group might be expected. This would be of real importance when a peak effort was required of the Command.

A poor performance on the part of a unit might be due to the fact that the unit had not sufficient aircraft to take advantage of operational opportunity when it arose. An increase in the number of aircraft on strength or a decrease in personnel was then indicated. If the trouble was due to an insufficient number of aircrew to fly the aircraft then increased efficiency would be obtained by increase in aircrew or decrease in aircraft and ground personnel. Airfield capacity (of runways or working or domestic accommodation) might be the deciding factor as to which of these courses was adopted.

Again, a poor performance might be due to the layout and conditions of the airfield (and, in the case of a Base, the disposition of resources within the Base). If nothing could be done to improve the conditions of such airfields, it might be worth while to consider which units to locate there. The choice should fall on units from which little flying was required; least manpower would then be affected by these conditions and therefore least wastage of manpower would result from them.

If no explanation of a low output in relation to manpower in a unit was forthcoming, then some defect in the organisation or inefficiency in the unit was to be suspected. The unit would then form a suitable object of investigation for an Air Ministry Manpower Research Unit or similar organisation.

In some of the circumstances described in the preceding paragraphs a reduction in the manpower of a unit was recommended as the appropriate measure. If the circumstance, for example, lack of operational opportunity, was temporary, likely to last, say, less than four months, then a removal of men would be inadvisable. Instead of that, the unit might be required to take over some of the periodical inspection work of more hard-pressed units.

It was proposed that the Command Statistical Section should collect the following statistics for each unit monthly:-

(a) Operational and non-operational flying hours.
(b) Operational and non-operational sorties.
(c) Mean Aircraft strength.
(d) Average of the ratio Fit Aircrew/Serviceable aircraft.
(e) Servicing manpower strength.
(f) Numbers of Major and Minor Inspections and Acceptance Checks performed.
(g) Numbers of Aircraft missing or Cat. E.
(h) State of Inspection stagger.

A suitable new or already existing Command Section should be made responsible for the interpretation of the statistics and for the determination of any changes required in the disposition of manpower and other resources. This section would advise such changes to the appropriate Headquarters Branch for the necessary executive action.

The O.R.S. and the R.A.F. Staff, Bomber Command, were by no means in full agreement in this matter. The exchange of views, consequent upon the submission of Bomber Command O.R.S. Internal Memorandum No. 32 dated 25 November 1942 (1) in draft form to the Air Officer i/c Administration is documented in Bomber Command O.R.S. Internal Memorandum No. 49 dated 8 January 1945. (2) The R.A.F. Staff considered that the imponderable factors would assume major proportions and that in the interval, during which the analysis of performance took place, the changes, if any, that could be recommended would be out of date. The O.R.S. proposals and the R.A.F. Staff comments were published side by side in Bomber Command O.R.S. Report No. S.214 dated 16 February 1945. (3)

It was agreed that a preliminary trial of the scheme should be carried out. Statistics (f) and (h) of the above paragraph were to be obtained from units only in the particular cases where a knowledge of them appeared essential to a full appreciation of the situation. The Command Statistical Section were to provide the statistics and Admin. Plans and O.R.S. were to combine in interpreting them. The trial had not got under way by the end of the war in Europe and thereafter the scheme was abandoned.

Statistical Study of Aircraft Inspections

Besides research into the problems of how best to meet the programme of work necessary to support a given flying effort, work was also undertaken with the aim of reducing the actual volume of work associated with a given amount of flying. Such was the aim of the Bomber Command O.R.S. work on aircraft inspections. Aircraft received a routine daily inspection and, in addition, a more thorough periodical inspection every so many flying hours. Most periodical inspections were of the type known as minor inspections but every eighth periodical inspection was of the more complete type called major inspections. Bomber Command O.R.S. work on aircraft inspections was mainly concerned with the study of periodical inspections.

(1) A.H.B.2 unindexed.

(2) 'Manpower Utilisation in the Operational Units of Bomber Command.' (A.H.B.2 unindexed).

(3) A.H.B./II/39/1/1.

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In September 1943, a report on inspections was received from Coastal Command O.R.S. who had arrived at the conclusion that more time was being spent on inspections than was justified by the decrease in repairs and failures which the inspections brought about.(1) Their report suggested that the expenditure of less time on inspections and a little more on repairs would yield a dividend in flying hours per maintenance man. Bomber Command O.R.S. forwarded this report to the Engineer Branch with the suggestion that it might be valuable to investigate in Bomber Command the distribution of repairs arising on the most important aircraft types, say the Lancaster I and III and the Halifax III, then working to a Minor Inspection Cycle of 50 hours, with a view to determining whether an extension of the periodicity would be safe and practicable.(2) The ensuing exchange of views is documented in Bomber Command O.R.S. Internal Memoranda Nos. 51 and 52 dated 1 and 17 October 1943 respectively.(3) The Engineer Branch was not convinced of Coastal Command O.R.S.'s theory of minor inspections but asked O.R.S. to undertake further investigation.

Briefly the problem undertaken was to determine the probable effect of extending the periodicity of minor inspections of Lancasters in operational units beyond fifty flying hours. These inspections absorbed a large number of maintenance manhours and the lengthening of the minor period would consequently be a considerable saving. If the increase could be effected without a disproportionate increase in the number of repairs arising and especially in the number of operational failures, the manpower saved could be diverted to increase serviceability and operational effort elsewhere.

For the purpose of the investigation the period between successive inspections was divided into classes of ten flying hours, 0 - 10, 10 - 20 etc., and the number of repairs arising from flights in these classes was ascertained from Forms 700. All the Forms 700 available from the Lancaster squadrons of Nos. 1, 5 and 8 Groups were examined and over 5,000 entries were used in compiling the necessary data. Certain precautions were necessary to exclude the effect of extraneous factors; in particular, rectifications performed after air test had to

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(1) 'Inspections'. Coastal Command O.R.S. Report No. 241 dated 21 July 1943.

(2) 'Notes on Coastal Command Paper on Inspections (C.C./O.R.S. Report No. 24)'. Bomber Command Int. Mem. No. 50 dated 19 September 1943. (A.H.B.2 unindexed).

(3) No. 51 - 'Bomber Command File S.30634/O.R.S., Mins. 3 and 4'. (A.H.B.2 unindexed).
No. 52 - 'Aircraft Inspections' (A.H.B. unindexed).

be separated from repairs arising from flying performed between inspections as the former properly belong to the inspections themselves.

It was found that the repair rate (that is, the number of repairs per flying hour) remained substantially constant throughout the minor inspection cycle. There was some evidence that the repair rate declined through the cycle but this was not very strong. At any rate it was clear that an increase in the periodicity of minor inspections would not lead to a disproportionate increase in repairs in the later stages. Furthermore, the number of operational non-enemy action failures was highest in the ten hours following a minor inspection and then decreased until the next minor.

A full account of the methods used in and results obtained from this investigation is to be found in Bomber Command O.R.S. Report No. 97 dated 17 January 1944,(1) which recommended an experimental extension of inspection periodicity to 75 hours in a few selected Lancaster squadrons, in which repair and failure rates would be carefully checked by a Time-Recording Party. The Engineer Branch was in full agreement with the report and the proposed experiment was put into effect in two Lancaster squadrons at Waddington in No. 5 Group.

A Time Recording Party recorded the manhours on repairs between inspections and the manhours spent on minor inspections on the Lancasters, working to a 75 hour cycle. It was found that the number of manhours expended on repair towards the end of the 75 hour period was on the average rather less than the number expended towards the beginning; this phenomenon was believed to be due to the disturbance caused by a minor inspection. Further, the number of manhours spent on a minor inspection and on the rectifications arising from it was no greater when the inspection was performed at 75 hours than when it was performed at 50 hours. A report on this investigation is to be found in Bomber Command O.R.S. Report No. 105 dated 10 August 1944,(2) which recommended that the minor inspection period of all operational Lancaster aircraft should be extended from 50 to 75 flying hours, with a proportionate extension of the major inspection period and that a similar experiment should be undertaken with operational Halifax aircraft.

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(1) 'The Incidence of Repairs and Failures related to the Number of Hours flown by an Aircraft since its last Periodical Inspection'. (A.H.B./IIM/a1/4a App.).

(2) 'The Experimental Extension of the Minor Inspection Period for Operational Lancasters from 50 to 75 Flying Hours'. (A.H.B./IIM/a1/4a App.).

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The Engineer Branch was satisfied that the proposed extension of inspection periodicity was justified for all operational Halifax and Lancaster aircraft (1) and this measure was put into operation without experimental work on Halifaxes. This meant a manpower saving of some 10 per cent of Repair and Inspection squadrons on operational units. If the measure had not been possible, the Command Engineer Officer considered that an increase of maintenance personnel would have been necessary to meet the increased flying programme which Bomber Command was then fulfilling.

A similar investigation was carried out for Wellingtons. The manhours on repair between minor inspections were recorded by an A.M.M.R.U. at No. 26 O.T.U. and were related to flying hours. The relationship between crash rate and flying hours since the last minor inspection was investigated by examining Forms 700 from all Wellington O.T.U.s. No firm conclusions with regard to the optimum periodicity of minor inspections were drawn from the investigation but the interesting result that the crash rate was independent of hours flown since the last inspection, at least as far as 40 hours, suggested itself. For further information, reference should be made to Bomber Command O.R.S. Internal Memorandum No. 54 dated 11 September 1945. (2)

A further question which arose with regard to inspections was whether flying hours was the most suitable basis for their periodicity. It was pointed out that parts of an aircraft which deteriorate solely by weathering should be inspected at intervals of a fixed number of days, while others which deteriorate mainly as a result of the stresses imposed on take-off or landing should ideally be inspected on a basis of number of flights. (3) Parts which deteriorated in proportion to the flying hours performed should continue to be inspected on a basis of flying hours. It was felt in Bomber Command that such a compound system of inspections would unduly complicate the work of the servicing staff, and would not be easily understood by personnel carrying out the inspections. Consequently there would be more room for error than with the current system. Further a squadron commander would be much less certain how many aircraft could be at his disposal in the near future, and the staggering of inspections would be

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(1) 'Bomber Command File S.30634/O.R.S. Mins. 14-16'. Bomber Command O.R.S. Int. Mem. No. 53 dated 31 August 1944. (A.H.B.2 unindexed).

(2) 'Periodicity of the Minor Inspections on Wellington Mark III and Mark X Aircraft'. (A.H.B.2 unindexed).

(3) 'The Waste of Manpower and the Inadequacy of Inspection resulting from basing Periodic Inspections solely on Flying Hours'. Coastal Command O.R.S. Report No. 261 dated 23 November 1943.

made very difficult. In order to weigh up the advantages and disadvantages of the two methods of basing the periodicities of inspections O.R.S. examined the variability of flying hours, calendar days and number of landings between successive minor inspections.

The method employed in and results obtained from the O.R.S. investigation are described in Bomber Command O.R.S. Report No. S.170 dated 7 August 1944.(1) Information was drawn from all the Forms 700 available in respect of No. 4 Group Halifaxes and covered upwards of 200 minor inspection periods. Pronounced variations from normal were found in the number of days elapsing and the number of landings taking place between successive minor inspections. It was, however, considered that these variations would introduce neither undue risk on account of the under-inspection of the components affected nor serious waste of manpower due to over-inspection. The disadvantages of complication inherent in the compound basis were held to outweigh its advantages and the retention of the flying hour basis of inspection periodicity was recommended. The Engineer Branch, whose views are to be found in Bomber Command O.R.S. Internal Memorandum No. 55 dated 4 August 1944(2) was in full agreement with O.R.S.

The Work of Recording Parties

As the work described hitherto on securing greater efficiency and a higher level of manpower economy in Bomber Command progressed the need for information on which to base decisions for action became increasingly important. Measures which could be produced by pure thinking had been explored. The coming invasion involved transfer of men from the R.A.F., and it was more than ever urgently necessary to consider further measures to safeguard the operational efficiency of the Command.(3) An examination of maintenance manpower questions in Bomber Command resulted in the conclusion that a great many technical tradesmen were being employed on station duties or work outside their own trade which should normally have been the responsibility of non-technical personnel. A possible explanation was that the domestic and administrative trades were seriously under-manned. Further conclusions reached were that work should be undertaken to

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(1) 'Frequency of Periodic Inspections. The Relation between Flying Hours, Number of Landings and Lapse of Time'. (A.H.B./II/39/1/1).

(2) 'Bomber Command File S.30634/O.R.S., Min. 11. (A.H.B.2 unindexed).

(3) 'A Study of Maintenance Manpower in Operational Squadrons of Bomber Command'. Bomber Command O.R.S. Int. Mem. No. 36 dated 4 June 1943. (A.H.B.2 unindexed).

eliminate aircraft which were uneconomical to maintain and further to improve the more suitable types.

Means were therefore considered of releasing more technical manpower and relieving the load on servicing wings and echelons, caused by a given amount of flying. The conclusions reached in Bomber Command O.R.S. Internal Memorandum No. 36, and particularly those referring to station duties, formed a basis for investigation. It was hoped by the elimination of unnecessary duties to relieve skilled servicing personnel of the chief obstruction to an increase in their productivity, and to study in greater detail the use made of aircraft time. Ignorance of the scale and frequency of extraneous duties was a serious gap in knowledge at Command and Air Ministry level; so also was ignorance of the details of the mean manpower expenditure required to complete various types of work. Such information was of importance to the establishment branches at Air Ministry in deciding on future manning of sections. It was therefore decided to investigate all these problems in relation to both technical and domestic sides of station life, for it was realised that each had important repercussions on the working of the other.

Unfortunately, existing records and returns were quite inadequate for purposes of reference. Form Q, for example, failed to account for any of the activities of aircraft (and consequently of groups of tradesmen) lasting for less than a whole day, and many serious causes of delay and waste of manpower were not evident. This inadequacy of records, together with the obvious undesirability and perhaps impossibility of attempting to obtain useful information in sufficient quantities from units themselves, made the use of Recording Parties essential.

The difficulties to be overcome were similar in all the Home Commands. Accordingly, recording units were formed under Air Ministry direction to work within the Commands. The units were to be under the immediate supervision and scientific control of the Command Operational Research Sections, but co-ordination of their activities and major decisions concerning their use were the responsibility of the Time Recording Parties Panel. This committee, consisting of representatives from Command O.R.S.'s, Time Recording Parties and Air Ministry departments, met once monthly under the chairmanship of D.D. Science.

/ Agenda

Agenda were supplied by the O.R.S.'s and the Parties, and reports were to be sent to D.D. Science for distribution to departments concerned. The Panel served as a useful link between the Scientists and the Service Departments, and also promoted the interchange of ideas and methods between the various O.R.S.'s and Recording Parties. The Parties investigating aircraft servicing and technical manpower consisted of N.C.O. technical tradesmen, and those concerned with administrative and domestic questions consisted chiefly of clerical airmen and airwomen. The administrative parties were given the name 'D.A.D.O.' Parties (Domestic, Administration, Defence and Organisation).

Logically the first step in use of the Time Recording Parties should have been the establishment of the Panel. Actually this was not so, and for the first few months the parties were used entirely at the discretion of the Command O.R.S.'s. They were eventually to investigate the problems foreshadowed in para. 2 and the first terms of reference for the party for Bomber Command were drawn up.(1)

The first work undertaken by the Recording Party in Bomber Command was largely exploratory though it had a definite purpose which it accomplished with complete success. The Party investigated the manhours spent on repairs to operational Lancaster aircraft at various stages of the flying period between minor inspections, with the intention, if possible, of revising the Inspection Periodicity. This work is discussed fully in the previous section on Statistical Study of Aircraft Inspections. The nature of the work demanded a full record of the activities of all personnel in the R. & I. Squadron and Daily Servicing Section of the station. This record, which classified the activities of the various trades under the headings, Productive Work in Trade Capacity, Other Active Duties (actually diversions), Stand-by, and Part-Day Absence, gave a good impression of the utilisation of technical manpower, and indicated where (if anywhere) manpower was either not being fully used or was in short supply:-

During this investigation the stages in the collection of information were as follows:-

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(1) A.M. File S.97292/S.M.1(a). Letter dated 22 December 1943.

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(a) Interrogation of individual tradesmen by recorders concerning their activities. Each recorder covered the activities of upwards of twenty tradesmen, and was expected to visit each at half-hourly or hourly intervals.

(b) Booking down against the name of each tradesmen his activities and their durations. For this purpose a task code was designed to represent to the necessary degree of detail every occupation likely to be met with.

(c) Summation of the time spent on various activities by each trade as a whole for each day. This was done at Command Headquarters by statistical clerks.

(d) Similar summation over the full period of recording, grouping under various headings and division by the number of days for which the recording lasted. The effect of this was to give an impression of the activities making up an average working day for any type of tradesmen.

After the investigation the methods both of recording and analysis were reviewed in consultation with S(O. & M.). It was hoped to introduce a certain degree of mechanisation into the analysis, and to make individual recorders responsible for preparing their own information for the sorting machine. In the discussions with S(O. & M.), the suggestions for mechanisation were not adopted, and it was decided that existing methods were the best that could be devised in the circumstances.(1)

Consideration was given during the last experiment to the technique to be adopted at the next station (No. 26 O.T.U.), and the following conclusions were reached. By virtue of its size (the Recording Party consisted of 24 technical and 12 D.A.D.O. recorders) an A.M.M.R.U. could record, though not in great detail, the daily activities of all technical and administrative personnel of a unit simultaneously, and from the recorded information a good general impression of the state of employment of the unit could be obtained. Alternatively by concentrating recorders in single sections in turn a much more detailed impression could be gained, and much closer study could be given to anomalies which would otherwise escape attention. Then by studying the balance of station duties between trades, the state of employment, the magnitude and causes of stand-by, and the proportion of personnel absent from the unit, an impression

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(1) 'A.M.M.R.U. Methods'. Bomber Command O.R.S. Int. Mem. No. 56 dated 14 June 1944. (A.H.B.2 unindexed).

could be gained firstly of whether any redistribution, elimination, or more equitable sharing of station duties could release more technical men for the task of supporting the flying programme, and secondly of whether the existing strength was adequate to the task to be performed. In addition a great deal of data useful in the estimation of establishments could be collected, including the manhour expenditure to be expected on various jobs and the number of men required to complete them in any given time.

Aircraft utilisation could also be recorded. This would take the form of half-hourly spot readings of the serviceability and repair state of all the aircraft on the unit, and could conveniently be done in conjunction with manpower recording. The use of a code would again be necessary. The incidence of petty unserviceability between inspections could be investigated in order to decide on the best periodicity for the aircraft and their role (e.g. Wellingtons used for operational training). This method could incidentally give a useful index of the relative realiability of different types of aircraft, or, (if compared with similar information from other units using the same aircraft) an idea of the quality of servicing or the effect of the operational or training role. Further developments might involve collecting overall times for various repairs and examining their frequency on a basis of flying hours, sorties, and calendar time. It was also possible in conjunction with meteorological data to assess the use made by a unit of 'fit for flying' days.

The next experiment, at No. 26 O.T.U., included most of the work and methods mentioned in the last two paragraphs, and it was here that the D.A.D.O. Party was used for the first time. Many useful statistics collected by both parties were forwarded to Air Ministry.(1) The periodicity of minor inspections for Wellington Mark III and Mark X aircraft was investigated, but no extension could be recommended.(2) Serious and unforeseen difficulties became apparent during the investigation. It was decided as a preliminary measure to bring the unit up to full establishment. The immediate result was about four hundred postings in and out, with extensive changes in the balance of many trades. Apart from imposing an abnormally heavy burden on some of the administrative sections during

(1) '33 Manhour Surveys in the R.A.F.' D.D. Science III/12 dated 1 September 1945.

(2) Bomber Command Int. Mem. No. 54 dated 11 September 1945. (A.H.B.2 unindexed).

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the initial stages of the investigation and reducing the efficiency of all sections through employing personnel unfamiliar with their new surroundings, such a measure was harmful in that it might have endangered the unit's ability to complete its task. It was, however, extremely valuable as an indication of the unsuitability of the actual establishment and pointed unmistakably to the need for general revision of all establishments by connecting them realistically with the task of the unit.

A further difficulty was the ban on privilege leave which was in force at the time. This had the effect of increasing the available strength of the unit and of inflating the average weekly amount of trade work done by each man. So although the ban had no measurable effect on the normal demand for station duties it considerably impaired the usefulness of the manpower statistics collected and rendered any estimate of the degree of understaffing or overstaffing of the unit extremely unreliable. It was concluded that no comprehensive manpower survey could yield extensive dividends unless conditions such as the rate of posting and the granting of privileges were not interfered with in any way. Difficulty in checking the daily sheets submitted by recorders was also experienced because of the location of the scientific staff and statistical clerks at Command H.Q. It was impossible to obtain any essential information omitted by the recorders, and it was decided that for the next investigation the statistical clerks should travel with the Recording Party.

The Recording Party moved to No. 41 Base, Marston Moor, in September 1944, and the lessons learnt during the previous investigation were put into practice. Considerably changed methods and technique were employed, particularly by the D.A.D.O. section of the party, and a different method of presentation of the results was adopted.(1) A routine was developed for calculating an establishment from the statistics obtained. This routine varied according to the working conditions of the trade, but was similar in all cases. Since the fulfilment of the task depended on the manhours of trade work performed during the period, it will be seen that the recorded trade time must not be altered unless the task was not completed. In such a case it should be adjusted according to the proportion of the task completed. The maximum attainable ratio of trade time to section time for any trade had to be decided with reference to the performance of

(1) 'Utilisation of Manpower in the Servicing Hangars of No. 1652 H.C.U. under the New Servicing Scheme. Bomber Command O.R.S. Report No. 132 dated 25 June 1945. (A.H.B./II/39/1).

other trades of the same group working under the same conditions, to the minimum requirement for non-trade time, to equal sharing of diversions, and to the maximum possible limitation of stand-by time. To section time had to be added time for additional duties such as guards (outside working hours), giving duty time. The ratio of duty time to available time depended on the length of the working day specified by the Air Ministry. To find the required nominal strength, the available time had to be divided by a factor depending on the leave quota, the weekly allowance of free time, and the average time spent on courses, etc.

Before attempting any revision of existing strengths it was important to consider whether the flying task of the unit was fulfilled and also whether the inspection stagger state was such as to ensure a smooth flow of work for the servicing personnel. If these conditions were not fulfilled the benefits derived from investigations by Time Recording Parties were considerably limited, and there could be no question of recommending alterations in strength on a basis of the recorded information. The results of bad stagger were evident to a very marked extent in the recording of work done in the Base Major Servicing Section of No. 41 (renumbered No. 74) Base.(1) In this case it was impossible to make any use of statistics collected, and the only results of the investigation were certain qualitative comments and criticisms of conditions of work.

It was also necessary to consider the duration of recording of any particular trade or section. If, as in the detailed recording at No. 26 O.T.U. and to a certain extent at No. 74 Base, small sub-sections were recorded for only a week, the probability of the working load and the leave distribution not being representative of average conditions was large. The probability of an uneven distribution of absent time could be reduced by recording for a sufficiently long period(2) but abnormalities of working load could only be revealed by a qualitative report. For this reason, conferences of recorders were convened at Marston Moor at the conclusion of each phase of recording, with agenda designed to reveal any peculiarities not evident from the recorded information and also adequately to qualify this information and to supply a suitable background. It was, however, essential to sort with the greatest of care such opinions and comments as were received in order to eliminate prejudice as far as possible. An example of the

(1) 'The Base Major Servicing Section of No. 74 Base, Marston Moor'. Bomber Command O.R.S. Report No. 143 dated 11 October 1945. (A.H.B./II/39/1).

(2) 'The Connexion between Nominal Strength and Minimum Duration of Recording in a Section'. Bomber Command O.R.S. Int. Mem. No. 57 dated 13 September 1945. (A.H.B.2 unindexed).

results of such a conference can be seen in the comments on working conditions in one of the reports issued at Marston Moor.(1)

Two interesting new methods were used at Marston Moor by the D.A.D.O. party. One was the method of deriving establishments by recording and analysing both hours of work and working pressure. The other was a method of treatment for sections performing a certain number of invariable and routine tasks. Both methods can be seen in the Marston Moor Report.(2) The pressure method, although ingenious, had certain disadvantages. The arithmetical relations between the various numbers on the pressure scale were fixed arbitrarily and were not necessarily accurate. A decision had to be made regarding the proportions of the working day worked at various pressures in a section working to saturation. The length of the working day had also to be fixed in the event of no standard having been prescribed. These were important possible sources of error, to which had to be added considerable variations between the interpretations of the pressure scale by different recorders. In spite of these disadvantages the recording of working pressure obviously gave a more reliable indication of the work of a section than did the recording of manhours alone.

The second method consisted of determining the establishment of a section on a basis of, say, the mean number of forms or documents handled by it and the average number of manhours required to complete all the work necessary on each form. The method was, of course, applicable only to a section which handled large numbers of a very limited range of documents. In a Pay Accounts section, for example, maintaining pay ledgers involved a certain amount of work which varied according to the number of personnel on strength, while further work varied according to the number of postings in and out incurred in opening and closing these ledgers. The advantage of the method was that if manhour figures for the same types of work done on different stations were reasonably constant, the establishment of a particular type of section might conceivably be estimated for any station merely by the use of a formula. In establishing such a formula it would be the task of experts to determine all the possible variable factors, and time recording would be used for finding the constants.

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(1) 'The No. 1652 H.C.U. Handling Flight'. Bomber Command O.R.S. Report No. 133, Section III, dated 18 August 1945. (A.H.B./II/39/1).

(2) 'A.M.M.R.U. Investigation at Marston Moor - D.A.D.O.' Bomber Command O.R.S. Report No. 129 dated 28 May 1945. (A.H.B./II/39/1).

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Although the Recording Party went to Marston Moor aware of the errors which had been made in earlier investigations its work was gravely hampered by unforeseen administrative and servicing developments. The introduction of a completely new system of servicing and the gradual re-equipment of the whole base with new aircraft of a different mark interfered with both the extent and the usefulness of the results concerning technical manpower. The outcome was that on the technical side much greater importance had to be attached to qualitative comment. No such handicaps were encountered by the D.A.D.O. Party. The whole investigation did, however, produce some useful results, and demonstrated that there was scope for some reduction in strength in the H.C.U. Base and that the Base System as a whole was subject to great disadvantages, the chief of which was that a Base was too small a unit to effect all of the economies for which it was designed.

The termination of the investigation at Marton Moor (March 1945) by no means exhausted the possibilities of this type of work, but no further large scale experiments were contemplated, and both use and control of the parties reverted to Air Ministry. A great deal of very useful information collected had been absorbed and used both by the O.R.S.s and by the Air Ministry. Planning data for the estimation of more rational establishments were provided, and a wealth of information on conditions at station level had been amassed which could not have been obtained in any other way. The large-scale experiments had, however, failed for a variety of reasons to provide quite such comprehensive results as were expected of them. The reasons fall into two broad classes: difficulties in the administration and use of the parties themselves and difficulties in using the information collected by them.

The formation of a Recording Party of men with ability, experience and trustworthiness took a long time, and only when a party of such men had been formed could the work be of maximum value. The effect of extensive posting was disastrous, and the importance of complete screening could not be exaggerated. Personnel of the Bomber Command Party were screened from all except oversea posting, but the only result was an increase in the rate of this posting. In this way the Party lost many of its best men at Marston Moor, and through lack of suitable replacements or in some cases through lack of any replacement at all, its efforts at comprehensive large-scale recording were frequently hamstrung.

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The mass of information collected in a large-scale recording with general terms of reference was extremely unwieldy, and the task of arranging, analysing, and adequately reporting it was of such magnitude that it could not be completed quickly enough for the result to be of maximum use. Much of the qualitative comment was, moreover, of a purely local nature because of its peculiarity to one particular station it could not be applied extensively to any other. Many recommendations made as a result of a large-scale investigation were often extremely difficult to put into effect even if the conditions which originally gave rise to the recommendations still obtained when the report was published. Further, the great difficulty of making individual recorders see a purpose in their work and understand how it fitted into a general plan reacted unfavourably on morale and made accurate information difficult to obtain.

These difficulties are a useful guide to the form which might be taken by future Recording Parties. These parties should be small and mobile and should either travel from station to station collecting and interpreting as rapidly as possible information both of general and particular application or should work with some clearly defined aim in view. Investigations of a more specialised nature were under consideration when hostilities in Europe ceased. A routine for examining quantity and pressure of work and also organisation was developed for use with the D.A.D.O. parties,(1) while the attention of the technical parties was to be concentrated on the relative merits of various aircraft types from the point of view of ease and economy of maintenance. It was also intended to study the relative reliability of aircraft and the re-arrangement of individual items in inspection schedules.(2) It is certain that in this field and in the estimation of rational establishments for special sections in a form in which they can be of general application lie opportunities for the effective use of Recording Parties in the post-war years.

Miscellaneous Investigations

In addition to the full-scale and, in general, long-term investigations into problems of manpower, organisation and aircraft servicing, Bomber Command O.R.S.

(1) 'Notes on Future Approach to Manpower Research'. Bomber Command Int. Mem. No. 58 dated 16 November 1944. (A.H.B.2 unindexed).

(2) 'Suggested Technique for an Investigation into the Nature and Extent of Unserviceability arising on Different Types of Aircraft'. Bomber Command O.R.S. Int. Mem. No. 59 dated 15 October 1944. (A.H.B.2 unindexed).

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undertook a number of smaller investigations mainly for the provision of planning data. Of these investigations, those which concerned the following subjects deserve mention and are described here:

(a) Manpower Requirements for 'Window' Launcher.
(b) Signals Servicing Survey.
(c) Flight Refuelling.
(d) Planning of Scale of Operational Effort.
(e) Engine Supply Requirements.

Manpower Requirements for 'Window' Launcher

In the early months of 1945 an operational trial of the Fairey Mark I 'Window' Launcher was carried out at R.A.F. Station, Little Staughton. This machine was designed for use in disseminating conducting strips of aluminium foil from aircraft on operational trips for the purpose of confusing enemy radar. Simultaneously with the operational trial the manpower requirements for the Launcher were investigated.

The operations to be performed in loading the launchers were :- withdrawal of bundles of 'Window' in transit cases from store, conveying the 'Window' to aircraft, loading the launcher with 'Window' and returning transit cases to the store. This work and the servicing of the moving parts of the launcher mechanism were done by a specially established 'Window' party. The remaining additional work caused by the new installation arose when it was necessary to remove parts of the launcher in order to service faulty radar boxes; this work was done by the riggers.

The object of the manpower investigation was to determine the size of the 'Window' party required for the job and the amount of additional work which the riggers would have to do. This object was successfully achieved by suitably modified use of the standard recording methods[1] with the service of three N.C.O. recorders for nine days.[2] It is noteworthy that this was perhaps the first occasion on which the manpower requirements for a new piece of equipment were investigated thoroughly at the trial stage and further that these requirements could be determined in a comparatively short time.

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(1) See previous section - 'The Work of Recording Parties'.

(2) 'The Operational Trial of the Fairey Mark I Automatic 'Window' Launcher'. Bomber Command O.R.S. Report No. 134 dated 3 July 1945. (A.H.B./II/39/1).

/ Signals

Signals Servicing Survey

Towards the end of the European war, the Signals Branch at Bomber Command set up a Signals Servicing Committee to report on the organisation required for servicing airborne radar equipment in a heavy bomber force. In the course of its enquiries, this committee made a critical examination of the existing signals servicing organisation at a very large number of R.A.F. units. In order to supplement the information compiled in this way at first hand, a signals servicing questionnaire was sent out to Group Headquarters, Base and Stations within Bomber Command. O.R.S. advised on the formulation of the questionnaire and made a statistical analysis of the replies.(1)

Flight Refuelling

At the request of the Operations Branch, O.R.S. undertook, in January 1945, some work on flight refuelling of potential usefulness in planning for the Far East theatre. The work involved estimating for certain stated conditions how the maximum possible weight of payload carried by a bomber to be re-fuelled once en route would vary with the position of the refuelling point.

In the first piece of work,(2) the bomber was assumed to have a Basic Weight of 41,500 lb. and a Maximum Permissible All-Up Weight (A.U.W.) of 68,000 lb. and was to fly 1,500 miles to its target and 1,500 miles back to the same base during an operational sortie. The weight of the payload was given by the condition that the sum of the weight of the payload, fuel and any overload fuel tanks should equal the difference between the Maximum Permissible A.U.W. and Basic Weight at the time when most fuel was aboard. With these conditions and knowledge of the fuel consumption of Lancasters Marks I, II and III, a diagram was produced which gave the weight available for payload and any overload tanks for varying positions of the refuelling point.

In the second piece of work,(3) two cases were considered. In the first a diagram was produced similar in essentials to the one mentioned above but giving information for sorties of various lengths. In the second case a diagram was produced which in its turn was essentially similar to the one produced in the first case except that allowance was made for the fact that the Maximum Permissible A.U.W., while it could not exceed 68,000 lb. before take-off, could rise 70,000 lb. after take-off.

(1) 'Report on the Servicing of Radio Equipment used in Heavy Bomber Aircraft by Bomber Command Signals Servicing Committee'. Bomber Command File S.32430 (1 June 1945).
(2) 'A Problem in Flight Refuelling'. Bomber Command Int. Mem. No. 60 dated 13 January 1945. (A.H.B.2 unindexed).
(3) 'Extension of Problem in Flight Refuelling'. Bomber Command Int. Mem. No. 61 dated 28 January 1945. (A.H.B.2 unindexed).

Planning of Scale of Operational Effort

In planning the scale of effort and the aircraft and manpower resources required to back a given scale of effort it was necessary to know how many sorties each aircraft would fly during its life and how much periodical inspection work would arise. One of the determining factors in both these questions was the casualty wastage rate. As an aid to planning for Tiger Force, accordingly, O.R.S. undertook, at the request of the Nucleus Planning Staff, a study of the variations in the sortie output per aircraft and in the arising of periodical inspections when the casualty wastage rate took different values.

It was necessary, in order to obtain numerical results, to specify certain conditions, for example in respect of the periodicity of inspections and the relative amounts to be performed of operational and non-operational flying (for which the wastage rate would be different). The conditions assumed were those likely to obtain in Tiger Force.(1) The number of sorties flown for every major inspection performed was calculated for various casualty wastage rates and the number of, and manhours expended on, minor inspections to back a flying programme of any fixed number of sorties were each compared for various casualty wastage rates with the corresponding figures at zero casualty wastage.

Engine Supply Requirements

Another investigation, undertaken by O.R.S. for the Nucleus Planning Staff, had the object of obtaining an estimate of the number of engines required monthly per 100 U.E. aircraft operating under conditions likely to arise in the Far East. In particular, estimates were required for cases in which operational sorties of duration 7 hours, 9 hours and 13½ hours were flown.

The numbers of Merlin engines (fitted to Lancasters of Bomber Command) returned to maintenance units for reasons of unserviceability were compared with the average flying hours per sortie, month by month, over a period of six months. From this it was possible to estimate per returning (engine) sortie the number, c, of engines likely to be returned by the force to the repair depot for reasons of unserviceability in the three cases of different sortie lengths.

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(1) 'The Effect of Wastage on Sortie Performance per Aircraft and on the Arisings of Major and Minor Inspections'. Bomber Command O.R.S. Report No. 138 dated 30 July 1945. (A.H.B./II/39/1).

/ Assuming

Assuming the probable policy with regard to engine replacements and the disposal and replacement of major-expired and written-off aircraft, formulae were developed for the number of replacement engines required per (engine) sortie in terms of the engine unserviceability rate, c, and the wastage rate. With the help of information about the probable flying intensity, engine unserviceability rate and wastage rate, the engine provisioning requirements could then be estimated.(1)

(1) 'Estimation of Engine Requirements for V.L.R. Sorties'. Bomber Command O.R.S. Report B.236 dated 16 May 1945. (A.H.B.2 unindexed).