CRAFT TRAINING

BY

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A detailed investigation into the craft training in 'fitting and turning' for mechanician candidates has been carried out in H.M.S. *Sultan*, with the object of determining :—

(*a*) Whether training time was being used to the best advantage, and whether any reductions in time could be effected.

(*b*) As a corollary of (*a*), the duration of a reasonable training period.

(*c*) Whether training methods could be improved and, if so, how improvements could be effected.

(*d*) Whether the subject matter being taught met the end requirement or the 'aim'.

Investigations into apprentice training in Industry seemed to show that, in those firms where a systematic training scheme operated, it was fairly general practice for the time spent in actual basic training in a craft not to be more than one year. The remaining four years of the apprenticeship were spent on production work, i.e. in gaining experience in the application of the basic skills It was appreciated that a year's craft training in Industry gave more hours training than a year in the mechanicians' course, since the mechanicians were also attending classes in school and engineering subjects. Against this, however the mechanicians are adults who have volunteered to be trained and who want very much, to improve their status. The penalty of failure is removal from the course, and the loss of excellent prospects of further rapid advancement, quite possibly to commissioned rank. Add to this that they are disciplined men, and it seems reasonable to expect that we can utilize our training time to much greater effect than is possible in Industry.

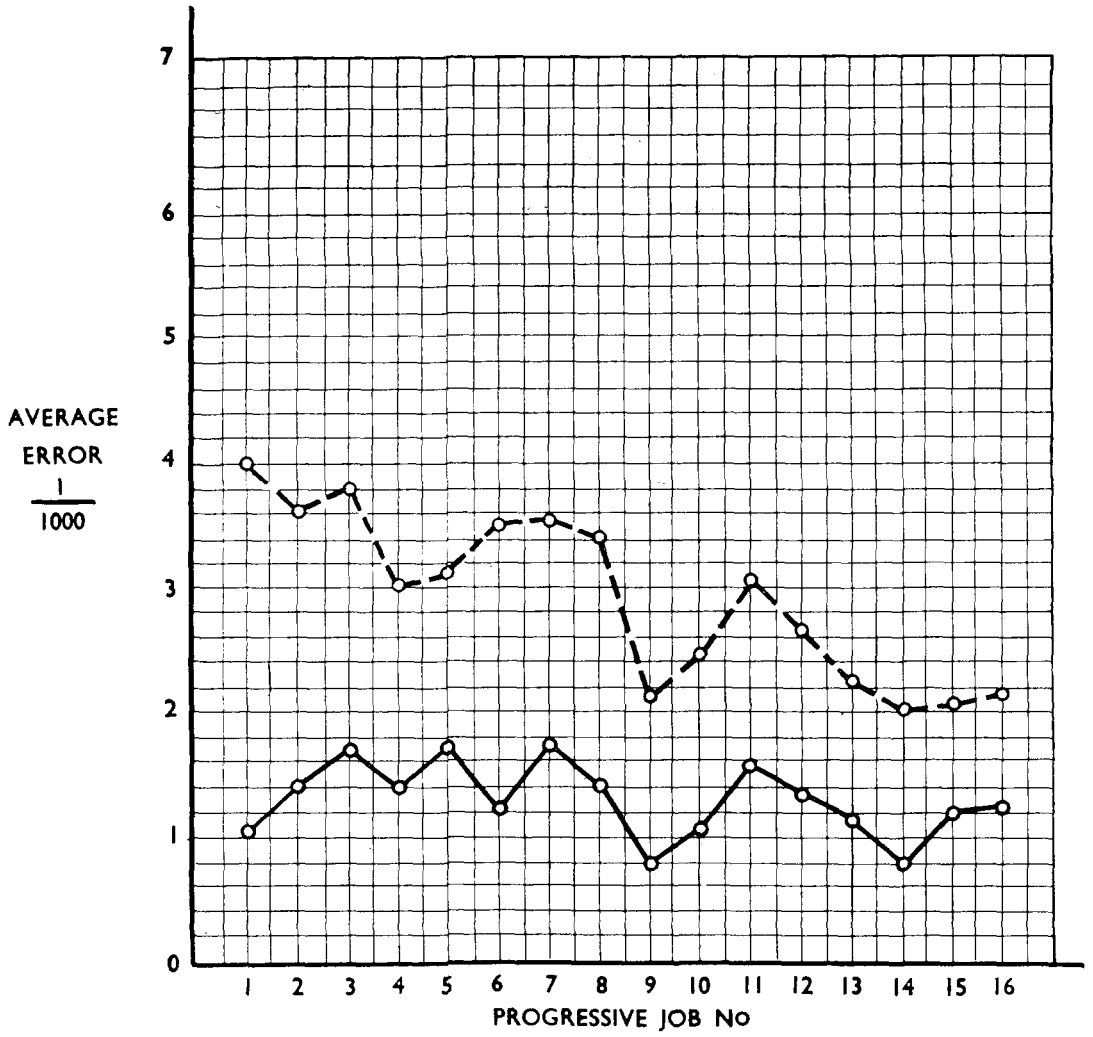
It was therefore felt that the required standards of craftsmanship could probably be achieved in about eighteen months or some 1,150 hours training time. If this could be done, then the time in the last six months of the course devoted to training in practical maintenance would be of even greater value to the trainees, in that they would have the final test job behind them and could concentrate on the maintenance work more effectively.

EVALUATING RESULTS OF TRAINING

A salient point which quickly emerged at the beginning of the investigation was that neither in H.M.S. *Sultan* nor, apparently, anywhere else, could the progressive results of craft training be evaluated in terms of accuracy achieved Even with the application of the Admiralty standard marking scheme, one was left with the question of what was an acceptable standard. In other words, what did a 70 per cent job really mean ? The answer appeared to be—and this had subsequently been proved to be true—anything one cares, or happens, to make it mean.

Consequently, it was felt to be imperative that some system should be evolved by which the merit of any one job, compared with any other, could be accurately assessed. It was only by evolving some such system that a true picture of the progress of the men under training could be obtained.

After much experiment and many modifications, a system, which was called the 'Average Error' system, was devised in H.M.S. *Sultan* to meet these requirements.



A Typical Progress Chart

THE AVERAGE ERROR SYSTEM

The object of this system is to produce a standard and clear presentation of a candidate's accuracy as he progresses through his training.

It is impossible accurately to assess the progress of a candidate unless each successive job that he undertakes is marked to the same terms of reference. To achieve this, some common datum is necessary. In this system the datum is provided by working always on dead dimensions, and allowing no tolerances. If tolerances were allowed, different jobs would have a different average tolerance and it might be that a complicated job could have a smaller average tolerance allowed than a simpler job, in which close tolerances were not required. In such cases the two jobs could not be fairly compared.

It is, in any case, considered that, in training, it is better to train a candidate to work to a definite dimension, because, once he can do this, working to tolerances should present no difficulties.

Although the average error system is simple to apply, it would take rather a lot of space to describe it in detail. Basically, however, it consists of dividing every job carried out into its individual components, listing, for each component, every dimension and geometric qualification of a dimension (e.g. parallelism, centrality, etc.) and deducting one mark for each 0·001 in. deviation from the dead dimensions. Similarly, marks are deducted for every 0·001 in. error in

' fits ' and alternative fits with the job assembled. The total marks lost are then divided by the total number of fits and dimensions and the result is an average error expressed in thousandths of an inch.

From a survey of ' average errors ' over a period, a graph can be plotted which shows, at a glance, the progress of a trainee. It might logically be thought that, as the training progresses, a trainee's accuracy should improve. This, however, is not by any means always the case, because the jobs get progressively more difficult. Thus, if a trainee, in his first job, obtains an average error of 0·001 in., i.e. he is accurate to within 0·001 in. on dead dimensions and in fits, and if he maintains this standard for all successive and increasingly difficult jobs, he is doing very well indeed. A trainee who starts off in his first job with an average error of 0·004 in., however, should be expected to better this as his training progresses. This is illustrated in typical graphs, one of which is shown in the Figure. The full line represents the above-average man and the dotted line the less good candidate. From these graphs it will be seen that a set pattern emerges, and any marked deviation from this pattern can immediately be observed and investigated.

A graph showing the set pattern for a particular class is obtained by plotting the mean average error of all the candidates for each job. Graphs are also plotted for a candidate's average error over a period of a term against his position of merit for accuracy, in that term. From this graph, a mean of the average errors for all candidates can be readily determined which again provides a datum for comparing the relative progress of classes of candidates.

These graphs have been found to be of considerable value and it is hoped that, as training methods further improve, the graphs will reflect that improvement. Indeed, at the moment the graphs indicate very clearly where the training falls short.

A standard time is assessed for each job and a percentage is deducted proportionately to the amount of overtime taken. Similarly, a bonus percentage is awarded for those jobs completed under time which also have achieved a 75 per cent standard of accuracy. A ' maximum ' time is also laid down, after which a trainee is placed on ' extra factory ' to speed up completion.

Each progressive job is designed so that there is a logical sequence in the operations that a candidate has to perform and in the tools which he uses. The emphasis in designing these jobs has been laid on ' fitting ', with an adequate amount of turning and other machine work so that a candidate emerges able to cope with the Admiralty final test job.

THE AIM OF TRAINING

Having established a yardstick by which the results of training can be assessed, it was necessary to consider what is the aim of this training.

This is a much more complex question than it may at first appear. The facile answer might be—' To turn out a tradesman capable of coping with the maintenance and repair work in the Fleet which is normally expected to be performed by an E.R.A. or mechanician.' This, however, begs the real question, because we must be quite clear what types of jobs are to be done, not now, but in two years' time for the mechanician, and four years' time for the artificer apprentice, and we must also know what will then be the required standard of accuracy and use of particular tools.

At present, the training establishments must assume that the aim and requirements are reflected in the types and standards of the final Admiralty trade tests. Bearing this point in mind, it is essential that the greatest care is

exercised in ensuring that this is, in fact, the case. The final trade tests must never be allowed to become mere tricks of manual dexterity with little relation to what the Fleet requires of a craftsman.

The training aim should be kept under constant review, and clear statements of the craft standards required should be issued to the Training Sections. Without such constant review and guidance, it is felt that much of the training may be wasted effort. If craftsmen, on reaching the Fleet, find that they have been either over or under-trained for the tasks they have to undertake, their morale will surely suffer and the training courses will be open to justifiable suspicion.

As a personal opinion, I feel that in the craft field, we are over-training, in that very little use is made in the Fleet of the high standard of craftsmanship achieved in fitting and/or turning. This would seem to be accentuated by the introduction of planned maintenance, with the eventual diminution of break-down maintenance, and the implementation of the policy of repair by replacement. At sea, the only highly skilled fitting and machine work is performed by the workshop staff ; the remainder of the task is principally the assembly of ready-made and interchangeable parts. It is for consideration that our requirement for the future lies more in technical ' know how ', with the bias towards highly skilled operators and maintainers. In this respect, it is considered that to be a highly skilled maintainer does not require an equally high degree of fitting and turning skill. After all, boilermakers and coppersmiths are used as maintainers of machinery. What is important is their technical knowledge of machinery and systems. It is, therefore, considered possible that our training aim should alter considerably in the future, with a lesser emphasis on craft skills and a greater emphasis on maintenance and operating techniques, and with only a comparatively small number of ' super ' fitters and turners borne on much the same lines as we now carry patternmakers and moulders.

Closer Definition of the Aim

It has been pointed out that the only real guide that the training establishments have as to the standard of craftsmanship to be achieved is in the type of standard of the final test job.

If, however, the craft standard required can be more accurately defined, and if, as has already been done by the evolution of the average error system, training standards achieved can be accurately assessed, then the necessity for, or even the desirability of, a final test job at all must be open to question.

Under existing conditions, however, a final test job does have the virtue of rounding off the skill of hand training in a tidy and final manner, and it is considered that for the time being it should be retained, but it is re-emphasized that it must be realistic, must directly reflect the aim of the training, and must give a completely fair assessment of the candidate's true potential.

TRAINING METHODS

Having clarified these ideas as to what the aim of the training is at present—rather unsatisfactory though its exact definition may be in some respects—the methods of attaining the aim, i.e. to produce fitters and turners capable of achieving the standards required by the Admiralty range of test jobs, were tackled.

It is possibly worth mentioning that, with the recent decision that the mechanician should undertake the same Admiralty range of test jobs as the E.R.A. and O.A., the mechanician's training has had to be modified to meet this rather different aim. Broadly speaking, the training problem falls under

two main headings—the human angle and the physical angle, and of the two, the human angle is felt to be greatly the more important.

Human Aspects

To derive benefit from craft training, the trainee must have patience, concentration and the desire to do a good job. These requirements may be more briefly defined as ' interest '. Interest in this type of training is difficult to sustain, and constant encouragement and display of genuine interest in the trainee's progress must come from the instructional staff at all levels. This, in itself, is easier to postulate than to achieve, but it must be achieved, because otherwise, no matter how many ' interesting ' jobs are introduced into the syllabus, the trainee will get bored, and with boredom, his patience, concentration and desire to do a good job will all fall off.

It is considered that, in H.M.S. *Sultan*, this vital interest has been increased most markedly by three main factors :—

(*a*) The fostering of obvious interest by the officers in the work of the trainees

(*b*) The introduction of the ' Average Error ' system of assessing progress

(*c*) The mechanician candidates undertaking the same final test jobs as the artificer apprentices.

It is worth while elaborating on these three points.

(*a*) *The Officers*

The officers referred to are all the officers connected with any aspect of the candidates' training, both engineering and instructor officers. The objects and aims of craft training should be explained to all these officers, so that they can take an intelligent interest in what the trainees are doing. This has been found to pay large dividends, and all officers in *Sultan* are encouraged to, and do, visit the workshops and watch the men at work and discuss with them what they are doing. The effect on morale is believed to be very valuable, in that the trainees feel that what they are doing must be important if officers, not directly connected with workshop training, show they are interested in and want to understand what is going on in this part of the course.

The Workshop Officer himself must spend practically all the working-day in the workshops, watching, advising and always being on the look-out for means to improve training methods, and always available and ready for discussions with his instructors and trainees. He must also have a detailed and personal knowledge of each trainee, and he must be informed of any external influences or pressures that may affect a trainee's work.

(*b*) *The Introduction of the Average Error System*

The introduction of the average error system of marking has had effects far beyond anything at first envisaged. It has probably been the most potent single factor in re-awakening interest in craft training. This is considered to be due to that fact that, for the first time, both instructors and trainees really know what progress is being made, and that this assessment of progress is demonstrably accurate and expressed in a form that is readily comprehensible.

Care is taken, from the commencement of training, that every trainee is fully aware of the standards expected of him, and how his work will be assessed. Every job he does is marked to this system, and afterwards the Workshop's Trade Test Marking Team (see below) explain to each trainee exactly how his job measured up and point out weaknesses and good points. Trainees are

unanimous in declaring that this is of great assistance to them. (It is also believed that this approach will be of lasting value to the trainee when he gets to the Fleet, in that he will, when on production work, know whether a job is up to standard or not, and will be intelligently critical on craft matters.)

Instructors, too, can readily see whether they are getting successful results from their trainees, and can determine in what direction extra effort may need to be directed.

The Workshop's Trade Test Marking Team, consisting of three C.E.R.A.s, is the hub of all information on standards and assessments of training work, and is a vital part of the organization. Job marking, which was previously generally regarded as a black art that only the initiated few could understand, is now enthusiastically accepted as an integral part of training technique.

The average error system also showed up the fact that some of the ' progressive ' jobs were not in fact, truly progressive, in that they were either in the wrong place in the syllabus, or were not achieving what they had previously been thought to achieve. By ironing out such anomalies, morale does not suffer through trainees being given jobs which may be too difficult, or otherwise unsuitable, for that particular phase of their training.

Another rather curious feedback is that, on occasions, a sudden drop in a man's accuracy from his norm, when followed up, reveals that he is labouring under some external stress, previously unknown to the training staff. A statistical aid to divisional and welfare work !

(*c*) *The Introduction of the Artificer Apprentices' Final Test Job*

The introduction of the artificer apprentices' final test job for the mechanician candidates is believed to have boosted morale, in that it has removed any suspicion that the craft standards of mechanicians are inferior to those of E.R.A.s. This has developed a determination in most mechanicians to show that they can, in fact, do as well as the other chap, and has added that spice of competition to the training which, provided it is kept within reasonable limits, is a healthy and useful thing.

Physical Aspects

Dealing now with what may be termed the ' physical ' angle of craft training, certain principles have been arrived at, most of which seem obvious, but the majority of which were not previously applied.

Training to Meet the Aim

The training must be geared to fulfil the aim which at present is, as stated previously, exemplified by the Admiralty standard range of test jobs. No subject matter extraneous to these requirements must be taught, no matter how tempting it may be ' just to give them some idea ' of this or that operation or technique. If it does not appear in the requirements, then it should not arise in any job the fully trained man will do in the Fleet. If some special techniques are required in, say, some particular class of ship, then these should be taught in a pre-commissioning course.

Syllabus

The detailed syllabus must be so designed that there is time allowed for all progressive jobs to be completed by the slow workers. This was not so in the past, and consequently the slower workers had not done the full range of training jobs when they came to tackle the final trade test. The fast workers will, there-

fore, have time to spare in the syllabus. If they are accurate as well as fast, they should be put on to production work when they have completed the progressive jobs in each particular phase of the training. These jobs are also marked in exactly the same way as progressive jobs. For fast, but inaccurate workers, the time should be used in further training on the progressive job system.

Phasing of Training

Following on from above, all candidates should start each new phase of training together. In H.M.S. *Sultan* a phase is of six months' duration.

Time Limits for Jobs

Every progressive job should be given a standard and maximum time for completion. This inculcates, from the beginning, the idea that speed is important, though the marking system demonstrates that accuracy is the over-riding requirement.

Extra Workshop Instruction

Extra workshop instruction (or ' extra factory ') should not be used as a punishment for poor work. If the work is poor, it is usually due to some failure in the training methods, or some extraneous cause, and the reason should be found. ' Extra factory ' is only awarded in *Sultan* if a trainee runs over the maximum time allowed for a job, and he then puts in ' overtime ' to enable him to catch up with the rest of the class. As soon as he has caught up, he comes off extra instruction.

Dead Dimensions

In all progressive jobs, the candidates should work to ' dead dimensions '. Working to tolerances has been tried, but it does not permit the close check on accuracy which is considered to be necessary in the training period.

Marking

All progressive jobs must be marked in such a way as to give a direct check on accuracy achieved, in order to permit true progress, or otherwise, to be assessed.

Assessment of Jobs

In order to be able to compare the results obtained in one job with those obtained in another, each progressive job and test job must be properly assessed as to the allocation of marks to each component and measurement. This assessment is part and parcel of the average error system.

Length of Job

Jobs should not be too long. About sixty hours is reckoned to be long enough. After this, the jobs tends to get tedious and concentration will start to fall off.

Avoiding Waste of Training Time

' Metal-shifting ' in the form of prolonged chipping and coarse filing should be cut to a minimum. Its only advantage is to teach a trainee the use of a hammer and chisel, and once a reasonable standard has been achieved in this,

any further work of this nature reduces time that can be spent on the real art of fitting. Methods of reducing rough work to the minimum include :—

(i) The supply of the best size of material for the job. This also helps in eliminating waste of metal.

(ii) When castings are necessary, in making the casting of a size to reduce subsequent work to the minimum.

(iii) Removing excess metal by machine wherever possible, and without detriment to fitting practice. This also helps in teaching the range of purposes to which machines can usefully be put and, by specifying the limits to which jobs may be taken down by machine, and marking at this point, a further check on machine work accuracy is obtained.

Size of Jobs

Small jobs, with as many ' fits ' as possible, are preferable to those requiring large surfaces to be trued up by hand.

Workshop Practice Lectures

Workshop practice lectures should be tied, as far as possible, to the practical work being undertaken.

Principles of Work Study

The basic principles of work study should be instilled in the trainees throughout the training period. It is felt that this can best be done by demonstrating how time and effort can be saved by reasonable forethought, planning and common sense, e.g. the correct selection of tools, and laying them out for greatest ease of working ; the elimination of waste movements ; and producing, if only mentally, a definite plan for tackling each job.

With regard to work study in general, it is felt that there is a worthwhile field here for further investigation. The Workshop Officer in H.M.S. *Sultan* has recently completed a work study course and several concrete ideas for the use of this science in the craft training field have emerged and are being put into practice. It is probable, however, that a complete survey of this problem by experts would be desirable. The adoption of any devices which will help to produce faster and/or better craftsmen will benefit the Service as a whole.

CONCLUSION

Results to date encourage the supposition that action is proceeding on the right lines and that the basic skills of a fitter and turner can, in fact, be taught to the standards required in about 1,100 hours' training time spread over an eighteen-month training period, provided that :—

(*a*) Training is truly progressive, and always directed to the final aim

(*b*) No subject matter is taught that does not directly contribute to the required aim

(*c*) High grade instructors are employed. This probably entails training the instructors first. All should, at least, undergo the Instructional Technique Course

(*d*) Interest in training is engendered and sustained. (This must emanate from the instructional staff)

(*e*) To assess progress, a system such as the average error system is employed

(*f*) Trainees and staff are at all times aware of the results being achieved, so as to sustain interest and permit faults to be rectified as they become apparent

(*g*) The aim does not radically change.

POSTSCRIPT

It is realized that some of the ideas on general training put forward in this article may be considered controversial. It is felt, however, that it is essential, particularly at this time of economies and reductions, that we ensure our training is directed to what is actually required in the Fleet.

It is well, too, to remember that what may have been an ideal training method fifty, twenty or even five years ago, may no longer meet future requirements. Indeed, it seems certain that, with the far reaching changes in equipment and personnel that can now be envisaged, our training methods and aims must be radically overhauled.