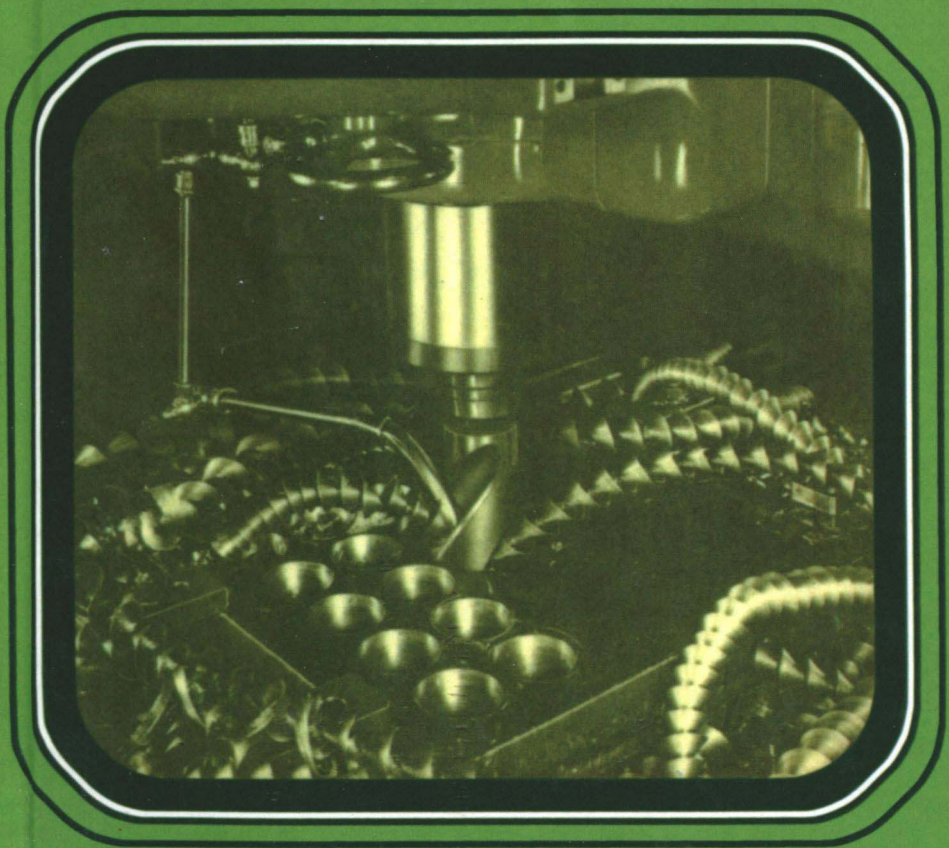
Workshop technology

Part 2

Fourth edition

W. A. J. Chapman



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Part 2

SI UNITS

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Preface to first edition

The First Part of *Workshop Technology* has made so many friends that I have every confidence in offering this, its second volume. Here will be found all the aspects of machine-tool work that the reader should require for his basic knowledge of workshop engineering, together with chapters dealing with the elements of accuracy, measurement and gauging. The two parts together provide a complete introduction to the technique of the workshop itself and contain elements of all the knowledge a student should require whilst serving an apprenticeship, or learning period in the shops. Although primarily written in detail for the inhabitants of the workshop, the general terms of the text include nothing but important fundamentals in the knowledge of any mechanical engineer, so that its reading should be of help and interest to any student of engineering.

The text covers most of the work necessary for the City and Guilds Intermediate and Final Examinations in Machine Shop Engineering, and the Ordinary National Certificate in Workshop Technology. Students taking this subject in Higher Certificates should also find the books helpful with parts of their syllabus. A thorough insight into the elements of workshop technology requires a knowledge of many related and contributory processes. In making these two volumes a fairly complete guide to the workshop itself it has been necessary to plan the additional text into a third part which I hope to complete in due course.

I have again received help of great value from various firms and institutions, and a name appended to a diagram reproduced often represents assistance much in excess of the mere permission to use the illustration. I should like to offer my sincere thanks for such co-operation, and assure those concerned that if the book fulfils the purpose for which it has been written, their trouble will have been worth while. Finally, I must again compliment the Publishers, and their draughtsmen, on the quality of their work in the face of such difficult circumstances.

W.A.J.C.

Stafford 1945

Preface to fourth edition

This book with its companion, *Workshop Technology, Part 1*, continues to play its part in the education of workshop engineers. Since the last revision, seven years ago, considerable progress has been made towards the recognition of our need to establish craft, in the workshop, as something worthwhile, and as an asset to our national well-being. Two important advances have been the establishment of the Industrial Training Boards and the clarification of the functions of craftsmen and technicians. Having now set up in the ways and means for producing our greatly needed supply of what I still prefer to call 'workshop engineers', it is now possible to look to the future with a greater degree of confidence.

The purpose of this present revision is to convert the text to the SI metric system of units and conventions and to bring the book up to date in its ideas and illustrations. The two books are now so well known that it seems invidious to state that they will prepare for this or that course of study or examination. I feel it sufficient to say that they will be useful textbooks for any system of education where technicians and craftsmen are concerned. In the past they have been used as much by readers outside the workshop as by those on the shop floor. I hope that they might still perform this useful service.

Once again I should like to acknowledge my appreciation for the help I have received from numerous firms and individuals. This time, with the changeover to SI it has been necessary to worry these people rather more than usual. The Publishers, as usual, have extended their customary encouragement and enthusiasm for the revisions and deserve my grateful thanks.

W.A.J.C.

Hatfield 1972

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Appendix

1 Accuracy, interchangeability, gauging

Whatever may be the reader's work, if it has any connection with engineering construction, he must on many occasions have need to apply the fundamental rules of accuracy. In the workshop these rules are an essential part of the technique, and when the problem of checking surfaces arises the workshop engineer needs all the ingenuity and skill his mind and hands can muster. In addition, the action of checking work, whether his own or that of someone else, places him in the position of a judge, and for this reason he must exercise extreme honesty of mind and purpose, a process which, if the work is his own, may sometimes cause misgivings! The use of measuring instruments involves a delicacy of manipulation and touch which can only be acquired from experience. The inspection of accurate work is a job which cannot be hurried, and to make haste slowly is a lesson which is not often learned until after many delusions and disappointments. Let the reader be not discouraged, however, but let him remember that the most experienced of us have passed through the experiences he may sometimes find to be a test for his patience.

Accuracy

A satisfactory component must have its important surfaces true with respect to form, relationship and dimensions. Trueness to form means that cylinders will be round, parallel and straight; flats will be flat, etc. Trueness to relationship implies that surfaces which should be perpendicular will be within a close approach to 90°, and so on. The degree to which perfection in accuracy is attained and achieved will depend, of course, on several factors, the chief of which are as follows:

1. **The grade of the product.** We look for and expect adherence to perfection in a Rolls Royce car than in one made to a lower price under mass-produced conditions.
2. **The classification of the product.** Greater accuracy is necessary in a

high-efficiency aero engine than in one of a lower type operating under less arduous conditions of service. Slow-moving agricultural machinery need not be made to such fine tolerances as high-speed reduction gearing and so on.

3. The function of the surfaces concerned. The surfaces making up any component serve one or more of the following functions when the component is in use:

(*a*) Fit and work (move) against a corresponding surface on a mating component, often whilst carrying a load.
(*b*) Fit against a mating surface without any relative movement taking place.
(*c*) Serve as one of the surfaces necessary to make up the form of the component, and when the component is in use either clearing other surfaces or mating components, or being just an open, joining face of material.

In general, the degree of accuracy necessary is highest in (*a*) and lowest in (*c*), although, as we shall discuss presently, condition (*b*) may demand higher accuracy than (*a*) on certain components. The conditions under (*c*) include the various clearance and non-fitting surfaces found on every component. These may vary from such examples as (i) working clearance on a piston between the rings (a few hundredths), or (ii) a bolt hole (clearance from 0·20 mm upwards) to the rough unmachined surface of a casting which only 'fits' the atmosphere ('atmospheric fit').

4. Conditions imposed by, and dependent on, operating factors. For most components there are conditions which influence the accuracy required, or the possible departures from it. As an example we might consider the head tube of a bicycle frame—the tube through which the spindle tube of the front forks passes. The only machined faces here are the spherical seatings upon which fit the head ball races. The inside of the tube is clearance, and the outside is an atmospheric fit, a good finish being necessary, however, to provide an attractive enamelled surface. The conditions necessary for the spherical seatings at top and bottom may be summarised as follows:

(*a*) The spherical radius must be the same as that formed on the ball races or a snug fit will not be obtained, and movement may take place in service.
(*b*) Slight latitude is possible on the top diameter of the seating since

the locknut will accommodate for slight variations in the up and down position of the ball races.

(*c*) The seating should be fairly well centralised in the rather thin tubing or weakness will be caused.

(*d*) The axis joining the centres of the spheres (top and bottom) of which the seatings form part, *must* be in line with the frame when viewed from behind. If this is not so the front and back wheels of the machine will not be in the same plane and the steering will be affected.

(*e*) The above axis when viewed from the side should be sloping as near as possible at the angle decided upon during the design of the machine. A slight deviation from the actual angle may be permissible without detrimental effects, but it must be remembered that a small variation over the length of the tube will have a relatively large effect on the position at which the wheel touches the ground.

Synthesis of accuracy

Before we pass on to the discussion of examples illustrating the points we have just set out it might be well to stress one important point. It is essential to start the work right, and as we proceed to observe the principles which will preserve accuracy. Let us consider one or two simple cases: The only way to achieve a perfect fit between a cylinder and a cylindrical hole is to have them both perfectly round, parallel and straight. They must, of course, have the necessary size relationships to give the fit we require, but we will discuss that later. If we started with a hole not round, or parallel, or with its sides not straight and tried to accommodate a shaft to it, we should never achieve our object. We might delude ourselves into thinking we had done so, but such a delusion would either be the result of our inexperience, or, if we knew better, would be equivalent to acting an untruth. If a true hole and shaft are obtained at the commencement nothing seems easier than making the necessary fit. A similar set of principles operates in the case of machining plane work such as the shaping up of a cube. If we commence by making one face truly flat, and proceed by making a second face truly square with the first we are able to build up the accuracies we are seeking in a systematic manner.

The contribution of a series of accurate intermediate steps in building up to some final desired result is illustrated in Fig. 1, where it is important that the face of the disc attached to the end of the shaft should be perpendicular to the base of the bracket and parallel with the tenon slot (A)

machined in it. This result may be achieved automatically as follows, and no other method would be acceptable by any experienced workshop engineer.

1. Assuming the base to have been machined flat, and the tenon slot straight and parallel, the bracket would be set up so that when the boss is bored the axis of the hole will be perfectly at right angles to the tenon slot sides and parallel with the base of the bracket.

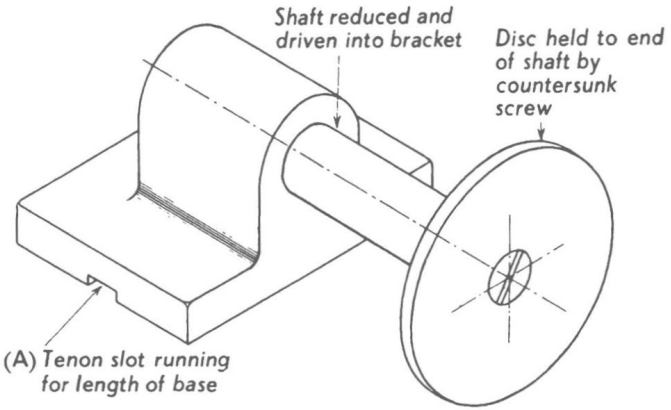

Fig. 1.

2. The bored hole must be perfectly round, parallel and straight.

3. The portion of the shaft which fits in the hole must be round, parallel, straight and a good fit in the hole.

4. The end of the shaft against which the disc fits must be flat (or slightly concave) and true with the fitting portion of the shaft. This can be achieved by facing it on the same *true* lathe centres, using the centre holes upon which the end was turned.

5. The faces of the disc must be parallel.

If these simple elements of accuracy are independently observed the final result desired will be achieved when the parts are assembled. The reader should notice that the diameter of shaft between the bracket and the disc plays no part in the desired alignment but merely serves as a carrier.

As a final example we might refer the reader back to a consideration of the suspension of the front wheel of a bicycle, and its alignment when viewed from front or rear. Assuming that the frame is not twisted and the back wheel to be truly centralised, the front wheel will be in alignment if the following alignments are correct:

1. Ball race seatings in the centre of the frame, and on an axis parallel to the frame, as previously discussed.