TRAINING OPERATIVES FOR MACHINE SHOPS

A WORKS INSTRUCTOR'S HANDBOOK

PREPARED BY
THE NATIONAL INSTITUTE OF
INDUSTRIAL PSYCHOLOGY

2/- NET

LONDON
SIR ISAAC PITMAN & SONS, LTD.

NATIONAL INSTITUTE OF INDUSTRIAL PSYCHOLOGY
Aldwych House, London, W.C.2.

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FOREWORD

THIS Handbook is designed to assist those who are called upon to undertake the training of workers in Engineering Machine Shops. It summarizes in simple terms the experience gained by the National Institute of Industrial Psychology in dealing with the problem of training in many different industries; the methods advocated have proved in practice to be effective. A training system which takes due account of the psychological aspects of learning, and which has been carefully systematized to ensure that it covers all that the beginner should be taught, results in the learner mastering the task in a very much shorter time than is possible by a more haphazard method. The advantages from the point of view of war production of the rapid training of novices to a level of proficiency where they can take their place beside the more experienced workers are apparent, but there is another aspect of the question of training which is also of great importance.

Recruits to industry are easily discouraged and disheartened during their early experience of the factory environment, and lack of progress at learning the work is an important factor in this respect. In many cases they are expected to learn by watching experienced operatives, who may from time to time give them a few words of explanation and advice. The skilled operative is not necessarily a skilful teacher, while his teaching must suffer by reason of the fact that he is engaged on productive work: in some cases the learner is regarded as a positive nuisance, who is hampering production. Even when the operative is genuinely anxious to instruct the novice, this method has serious disadvantages; for example, a skilled worker often adopts quite a different method when working at a much lower speed in order to demonstrate to the novice. Unsatisfactory training resulting in slow progress on the part of beginners produces in them, all too often, a sense of frustration and despair; the work, they think, is too difficult or too complicated for them to master. Some may seek to change their employment, while in the case of those who remain this attitude easily leads to the acceptance of a comparatively low standard of quantity or quality of work as a reasonable result of their efforts.

The systematization of training is not sufficient by itself; the success of a training scheme depends very largely upon the instructor. He needs qualities of patience and understanding: he must be able

to encourage and to be firm, and, although technical competence is necessary, his qualities of temperament and his knowledge of the best means of dealing with people in the situation which exists between learner and teacher, are more important.

The Institute hopes, therefore, that this publication will help instructors not only to plan their training schemes in a systematic manner, but also to gain more insight into the personal problems of the learner—to recall in fact memories of their own training period, and of difficulties which seemed important to them then but which faded quickly as skill was attained.

The Handbook was prepared by Dr. Isabel Blain and Mr. Dermot Straker under supervision of the Director, Mr. C. B. Frisby, and acknowledgments are gratefully made to J. B. Brooks and Company, Ltd., Hoovers, Ltd., and Standard Cables and Telephones, Ltd., who provided facilities for studying the wide variety of work carried out in their machine shops under war-time conditions.

B. SEEBOHM ROWNTREE.

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TRAINING OPERATIVES FOR MACHINE SHOPS

I. INTRODUCTION

EXPERIENCE in training industrial workers has proved without any doubt the value of thorough systematic instruction. The length of the "learning period" may be reduced by as much as nine-tenths, with increased efficiency and with reduction of waste, by the adoption of a well-planned scheme of training. In other words, good systematic training can very largely help to make up for lack of experience. Such a scheme need not be so time consuming as to be impractical in emergency; on the contrary it is recommended as a means for more quickly and satisfactorily bringing to a stage of efficiency and effective productivity in your shops men and women who were previously quite inexperienced in your work.

II. THE SYSTEMATIC APPROACH TO TRAINING

The characteristics of a good training scheme are that it is planned, comprehensive, includes detailed instruction on avoiding errors, and alternates practice with explanation. First you analyse the job and note down all the things it is necessary to know in order to perform it well—information about the materials, the machine, the movements required for controlling the machine, and so on; then you list the possible mistakes and the way to avoid them; finally you gather together all the hints you have picked up in your years of experience about efficient working methods, safety precautions, etc., and make a note of them. You arrange this material in order, fit it in to a definite time-table and it constitutes a manual which will be of great help to you in training new workers. A specimen manual, for use in training capstan operators, will be found as an Appendix at the back of this handbook.

Some instructors produce excellent results without a manual; but if the programme of training is not written down there is the danger that some important, though perhaps small, point may be overlooked, especially in times of stress; and that might result in error or accident which would have a serious effect on the learners' progress. Good training not only reduces this risk and cuts down

the amount of faulty work produced, but it may accomplish in one week what formerly required ten.

Time and Place of Training

If possible training should be carried out in a special place away from the machine shop. Beginners are apt to find the constant activity of the shop distracting and tiring at first. Besides, there would be a risk of their picking up from the workers there practices dangerous for novices, or methods different from those chosen best ones in which they are being trained; and they would almost certainly be discouraged if they saw how slow they were in comparison with experienced workers. If a separate place cannot be arranged, it is better to use a corner of the shop than the middle.

In any case, actual productive work should be used for training whenever possible; this is very important because it urges learners on to better progress by giving them the feeling of doing valuable work.

Programme of Training

The amount and scope of training which you give will naturally depend on the needs of your particular firm, on how much operators are expected to know, for example, about gauging, and on how much learners already know. You will be able to adapt to your own needs the general principles we give, which are drawn from a wide experience of training in many firms.

Learners will not, of course, be skilled workers as soon as they have finished their course of training, and they should not be encouraged to think they will be; but they *should* know enough of what to do, and what not to do, to make them *useful* workers in the machine shop, at once, and they should understand this quite clearly. Certainly they should need much less supervision than if they had begun work directly in the machine shop. If newcomers to your works already have machine shop experience, try to run through the whole programme with them more quickly than you would with those who are complete novices, but not missing out any points. Try to avoid training them in the same group as entirely inexperienced people.

This handbook is to help you to help beginners to learn quickly and easily how to operate their machines. It is intended to give you a basis for planning your programme of instruction, whether for an individual or a group, and you will find that it repays to make sure that no point mentioned here is omitted from your training.

III. HINTS ON TEACHING

Teaching is harder work than machine operating. It requires great patience, sympathy, concentration and perseverance. These hints are intended to help you to do this difficult job with success. Most of them are common sense, but they are all important, so don't overlook any of them. Your success as a demonstrator or trainer will depend on how carefully you learn the job of demonstrating.

You are already skilled at the jobs you are going to teach. You know a great deal more about them than you realize. Remember that things which have become easy for you are difficult for the new recruit.

Relations with Beginner

Many learners have never been inside a factory before. To them a factory may seem a dirty, noisy place full of complicated and dangerous machinery. Your first job is to overcome their fears by explaining to them that jobs which appear very difficult can be learned quite quickly if good attention is paid to the instructions, and that work is seldom dangerous if it is properly carried out. (If you can remember the haphazard way in which you probably received your own introduction to factory life, you will realize how much you can do to help new workers to settle down quickly.)

Always encourage learners, put them at their ease, try to draw them out of themselves. Never laugh at their mistakes; and *never* be sarcastic. Each time you say a discouraging thing you are destroying the effects of your own previous efforts and sabotaging the country's war effort besides. It has been proved that rebuke or ridicule given in public does more harm than good; that sarcasm in front of other people, seven times out of ten, causes worse work; but that *praise openly awarded*, while it may lead to carelessness, *will nine times out of ten result in improved work.* If it becomes really necessary to reprove a worker, make an opportunity to do it privately, either when no-one else is about or in such a manner and tone of voice that other people cannot guess what you are doing.

Planning and Carrying Out the Programme

Your programme of instruction should be planned so as to cover all the essential information about how to do the job, and about emergencies which may arise in it, why they occur and what action to take if they do occur. It should include explanations of all the main terms which are used in the job. You need to keep a very open mind. The fact that something has always been done in a certain way does not prove that this is the best way; you must analyse

the jobs carefully and determine what *is* the best way. To help learners to become efficient in the shortest time you must teach them the best methods from the very beginning. *You should explain first the easiest things from the learners' point of view*, and progress gradually to the more complicated parts of the job. You will need to think out what are the most important things to know, the *key facts*, and *teach them with particular care and emphasis.* To make sure you cover every point it is best to write them all down in a systematic way. (The appendix shows how this might be done for capstan operation.) Your plan should ensure that the learners' practice alternates with your own talks and demonstrations.

Having prepared a good plan, try to stick to it. If questions are asked about something you are going to explain later, answer in an encouraging way, but without being distracted from your immediate subject and purpose; you may commend the questioner for having thought of the point or for the keen interest shown, but beware of letting other members of the group lose the connecting ideas in your instructions.

Assume that most learners know nothing at all about the work. Explain everything fully—even simple things like what a drill is. *Give talks in only small amounts*—twenty minutes is long enough at a time. State only a few facts at a time. In order to make your talks interesting, and to help people to remember what you have said, you must illustrate your meaning with stories and examples. Every point you want to make will need to be repeatedly driven home; very few people "take a thing in" the first time they are told, so that you must explain over and over again, but using different words and a variety of examples. Often it will help if you use a blackboard to write up new words—you should print them—and be sure your own spelling is correct! (If you can't have a blackboard, print the words beforehand in large capitals on a piece of cardboard or on a large sheet of paper.)

Always it is a good thing to let learners handle the things you are talking about; e.g. when you speak about drilling, give them a drill to examine; and afterwards pass round parts which were machined by the tool you have been describing. In every case give practical demonstrations on the machine in the course of your talk if possible, or immediately after it. Always, when possible, stop the machine while you talk.

You must talk slowly, for many words will be new to learners, and at first they will not take them in quickly; and you should make frequent short pauses. Remember, however, that some people learn

more quickly than others, and try to arrange your talks so that the quick ones will not get bored while you repeat and revise enough to get the duller ones to understand and remember what you have been saying. *Keep on repeating* until you know that everyone understands; and then repeat again, once more often than you think is necessary.

Allow time for questions, and *encourage people to ask questions* by showing appreciation of the interest and intelligence which prompt them, and by answering them as fully and clearly as you can. *Never* say "That's a silly question," nor show by your manner that you think it is. Even if the person who asked it is too dull to notice your attitude the brighter people may do so, and it might put them off asking a really sensible question later. Instead, your response should be, "I'm sorry I didn't make that clear," or "I'm glad you raised that point," and give them the answer. Even if the question *is* rather silly, try to find something to say about it so that the learner is not discouraged from asking further questions.

Demonstrating

So as to make a good job of demonstrating how to operate the machine, first of all observe carefully your own movements and those of other good workers as they do the job, and determine which are the best movements. Then slowly and thoroughly *teach the learners the right movements from the very beginning*. It is best to have them stand on the operating side of the machine while you do this. Demonstrate even such simple things as where and how to hold the controls, how to move the hands, where to stand, and the correct stance; show them any knack that you can. Emphasize the key points, and always *give reasons* when you give instructions. Teach learners to listen to the machine sounds, and to notice and interpret alterations in sound and vibration. Let them practise the movements before any work is put in the machine; this helps to give them confidence when material is actually put in, and so reduces the amount of spoilt work and the consequent discouragement.

Do not wait for learners to make mistakes and then correct them; it has been definitely proved that *learning is quicker*, and quality of work better, *if probable faults are described before they occur*, and at the same time instructions are given on how to operate so as to avoid such faults. Keep in readiness a collection of faulty pieces so as to illustrate each fault that may arise. If a learner does make a mistake, explain how it happened, and show how to prevent this happening again.

Supervising Learners' Practice

Keep the quantities of work small, so that with the completion of each lot the beginner may get the feeling of having accomplished something. It is very discouraging to learners to be given a whole day's work or even a whole morning's work at once; so divide the work, and at first give them in one lot only as much as will last, say, from half an hour to an hour. Set possible objectives for the completion of the work, but never hurry beginners; they cannot all learn as quickly as the fast workers you have known, and you may discourage them and delay their progress by saying too much about other people's speed; although the competitive spirit may at times result in increased effort and progress, it must be made use of with great care and tact.

Insist on careful, correct work from the beginning: speed will come naturally later on if the right movements are learned and the essential points understood.

Show them where to stack completed work, and tell them what to do when their supply of material runs out.

Don't let learners hang about if they have to wait for work, or for the machine to be set up. Take them to watch a good operator, and point out to them the things to notice particularly; but do not allow them to watch too long. *Keep them interested and occupied*, for example, by showing them other processes on a part they are making. (Not only is it discouraging for people to have nothing to do, but it is wasteful of their time, and also gives the impression that you, or your department, or your firm are not pulling your weight in the national effort. Learners form habits of work to fit in with the general atmosphere of the place they work in, and if they think there is any slackness or inefficiency they are not likely to give of their own best effort.)

Always keep a check on the quality of the learners' work. Frequently test them by asking them to explain or to demonstrate to you some point you have made earlier. Insist on the importance of precise accuracy; show them as soon as possible, if any fault has occurred, how to avoid it in the future, and explain why work of that quality cannot be passed. Above all, remember to commend them when they improve on their previous standard of quality or quantity of work.

Your job is to get learners on to useful production work as soon as possible. Therefore see that they get ample opportunity for practice, and for having explained to them points that they do not understand.

Your teaching is more likely to be effective if they are "settling down" well, so you should help with this in any way that you can; e.g. by seeing that places are provided for their coats in the cloakroom and that they are taken to the canteen for the first few days until they have "found their feet" in the organization.

After making obvious progress in the first few days, some learners will appear for a spell not to get any better at their work, or even to get worse. Do not let this experience disappoint you, for it is a natural and common occurrence, and not necessarily due to a shortcoming in the training. The period of "staleness" will be followed by more progress, and you will soon see the results of your efforts.

Preparing Yourself to Instruct

You may find some of this is rather difficult to do at first, so you must prepare by giving yourself some practice. Plan short talks on easy subjects, and practise making your points slowly and in good order when you are at home, on your way to work, or at any odd times when you have a few minutes to yourself. Topics you might practise on are, for example—

1. Tools (*a*) the tool itself (describe each important tool in turn); (*b*) how to use it; (*c*) what it does—its action on material; (*d*) how to take care of it; (*e*) safety precautions in using it.
2. Safety as related to (*a*) movements; (*b*) clothing; (*c*) the need for attention to work; (*d*) particular machines.

Remember the need to enliven your talk by illustrations; it will be all the better if some of them can be humorous. With experience, this part of the job will soon become easier.

IV. WHAT TO TEACH

Efficient Working Methods

Not all operators will take naturally to the most efficient methods of working; therefore you will need to teach them. You yourself would not keep your tools in an awkward place, nor stoop to the floor to pick up each component or put it away when you had finished with it; but operators in their enthusiasm to make progress in their new job will not think it worth while taking time to plan their workplace unless you tell them to.

You should keep the following points in mind, and illustrate them as frequently as you can—

1. All unnecessary stooping and reaching should be avoided.
2. Tools should always be conveniently placed and always kept in the same place.

3. Supplies of materials and of finished articles should be stacked in a convenient position, and each component should have its own proper place.
4. Both hands should be kept occupied as far as possible; often the left hand is allowed to idle while the right operates a tool or control, but the left hand might, for example, be preparing for the next part of the operation or possibly picking up the next piece of material to be worked upon. Both hands should not be used on the same control unless for a special reason, such as very fine precision in movement or to get greater pressure.
5. Movements should be simple, easy, and rhythmical. The best and fastest worker seldom looks the quickest; and hurried movements usually produce bad work.
6. The best sequence of movements should be worked out and the job always done in the same way.
7. The workplace and machine should be kept clean and tidy.
8. When seating is provided it should be adjusted so that the worker naturally adopts a good posture while working. Footrests of suitable height should be provided. (This is not pampering workers; it does result in a decrease of fatigue, which in turn leads to improved standards of work and increased production.)

Stopping and Starting a Machine

It is most important to make sure that learners know how to stop and start (particularly stop) any machine *before* they begin to do any work on it. Switches, levers, pedals, etc., should be demonstrated and explained. Learners should practise using these controls without work in the machine. At a later stage special controls, such as reverse and change speed, should be demonstrated and practised in the same way.

Cleaning

How and when to clean the machines, and how much operators are supposed to do, should be taught as carefully as how to operate them. Sometimes this is neglected, with the result that machines are not properly cleaned and get into bad condition; and there is the risk that operators will fall into dangerous habits.

1. The machine should be thoroughly cleaned down at the appointed time. This is an important job and must not be skimped.
2. The correct lubricant should be used at each point.

3. Swarf, etc., should be frequently cleared away; a brush or cloth should be used, never the hands.

4. Swarf or chips of different metals should be put in the place appropriate for each metal.

5. Cloths used for cleaning should never be put amongst the swarf.

6. Care should be taken to keep stops and gauges free from adhering particles of metal.

Gauging

What you teach about gauging will depend in part on the type of gauge that operators will have to use, the limits worked to, and so on.

Describe the limits and tolerances allowed, explaining what is meant by these words; point out that in making certain things it may not matter if they are a little bigger or a little smaller than the specified size, but that in the work learners are about to do, making components for precision instruments, aircraft parts, or whatever your own products are, it is essential that the size should be reproduced exactly. Explain that in this work you do not measure to the nearest inch, or half an inch or even a sixteenth of an inch, but that you measure in thousandths of an inch called "thous"; (that is about the thickness of a cigarette paper, or half the thickness of a hair); the plan you work to always gives the exact size and specifies that the parts must not vary from it by more than a certain amount (e.g. ·275 in. ± ·001). Point out that to make sure the parts do fit the specification they must be measured frequently, and the importance of this being done by all employees exactly in the way that they are told to do it. The more frequently gauging must be done, the more important the part.

Show, if you use them, samples of plug gauges and gap gauges, go and not go gauges, micrometers, verniers and any type of special purpose gauge which is in use.

Point out that instruments made to such fine measurements are expensive to produce, so care must be taken not to lose or damage them; and they are very easily damaged even although they look quite strong. They should always be kept in the same special place, and should *never* be put in beside the work. They must not be allowed to fall, or in any way get knocked about; the least accident to them must be reported so that a check can be made to ensure that they are still accurate to the given limits.

Further, learners should keep at hand as a rough standard a sample component which has been inspected and approved.

Booking of Work: Method of Payment

Explain carefully how to book work (and how to enter waiting time). Demonstrate clearly how to fill in any necessary forms or other records.

Tell learners and if possible point out to them who is responsible for providing new work and collecting completed work; tell them what to do with waste and rejected work.

Explain how work is paid for—e.g. so much per hour; or piece work, which is so much per number or per weight completed. If there is a bonus system, describe how it works and give examples to illustrate your explanations; be sure you teach clearly enough so that learners can work out their own bonus. If only good work is paid for, inform them that this is so; and tell them whether they must do repairs themselves and whether they are paid for doing them. If the firm keeps some days' pay in hand, explain to newcomers how this works and what effect it will have on their first week's pay packet. (Describe in passing how pay is distributed.)

Explain what is done in case of absence or late-coming, and how overtime is paid for (and incidentally how to collect back pay if they are absent on pay day).

V. SAFETY

Be sure you point out to new operators everything they must do and avoid doing so as to promote safe working conditions for themselves and other people. Let them realize there is no danger if everyone follows the instructions you give; and that taking needless risks does not show courage but foolishness.

Safety hints fall into three main groups, namely: general, personal, and more specifically with regard to machines and equipment.

General Precautions

1. The foundation of safety is *tidiness*. Show learners the importance of keeping their tools and materials in their proper place and of keeping the floor tidy around the workplace; otherwise someone might trip and fall and in so doing not only incur injury himself but cause disturbance which might in turn lead to others being hurt by the machinery.

2. *Carefulness* cannot be overstressed. Naturally, learners see in the workshop a great deal that is strange and interesting to them; you must insist that they give all their attention to whatever they are doing, that they watch where they are going, and do not gaze around them. (You should be sure to provide opportunities

for their curiosity to be satisfied, or your instruction on this point is likely to be disregarded!)

3. *Teach beginners to use the proper gangways and passages;* you must not let them use short cuts.

4. Learners need to have it pointed out to them that they *should not lean on machines;* it is a dangerous habit; for example, a machine part might be set in motion either accidentally or by someone out of sight, and serious damage to person or clothing might result; leaning becomes a habit very easily, so don't allow beginners to neglect your warning.

5. It is necessary to emphasize that *on no account must driving belts be touched.*

6. *Lifting and carrying.* Inexperienced workers often try to move things which are too heavy for them; and particularly if they are enthusiastic over their new job and their part in the war effort it may be necessary to restrain them and insist that *for certain loads they must get help.* They should be shown, too, how best to lift and carry heavy weights—holding them as close to the body as possible, and if it is necessary to bend, bending the knees rather than the back.

Loads should never prevent workers from seeing where they are going. Loads which must be piled up should always be piled in such a way that there is no risk of their over-balancing or spilling; and there should never be projections which might catch on some person or object in passing.

7. The dangers of practical joking, skylarking, and horseplay in the shops should be vividly described.

All of this is common sense to you, but to the people new to the machine shop nothing is so simple that you can afford to take it for granted. After their first few days on production employees need particularly careful supervision; at that time their feelings of confidence at work will be increasing so rapidly that they may be tempted to take risks.

Personal Precautions

1. Rings are a source of danger; it is wise to insist that if they are worn they should be covered with sticking plaster.

2. Bandages on the hands should always be well covered with fingerstalls, or if necessary a whole glove. It is very easy for an uncovered bandage to be caught by revolving machine parts.

3. However, gloves should not be worn without express permission or instructions. They, too, are apt to catch in the machine.

4. Slight cuts or blisters should be attended to at once by the

authorized person or in the First Aid Room; that is the only reasonably sure way to prevent sepsis from setting in.

5. If goggles are provided, insist on their being worn.

6. If special soaps or skin preparations are provided, encourage their correct use—they are for the operator's own protection. Hands should be cleaned before eating; but unauthorized degreasing agents should not be used (e.g. methylated spirit, paraffin) as they may cause skin irritation.

7. Loose ties, cuffs, bows or frills, are unsuitable wear; they might get caught in a machine and cause a fright, even if no injury resulted. A plainly cut neat overall or dungarees are best. It is best to wear elbow length sleeves or to roll them above the elbow so that they cannot get in the way.

8. Women should never wear shoes with high heels or without toes. An unprotected toe is more liable than a covered one to injury from, for example, falling tools. The floors may be uneven and oily, and it is worth taking care to avoid falls and twisted ankles. It is best to wear flat-heeled or low-heeled shoes with soles of ordinary leather or very rough crêpe; hard rubber soles should be avoided.

9. Women must keep their hair completely covered in a cap, turban or strong net; otherwise a strand or curl might get caught in the machine and torn out.

Proper Use of Machine, Tools, and Equipment

1. Make sure the learners not only *know* how to stop the machine but *can* stop it without having to take time to think.

2. Guards must be used wherever they are provided; you should see they are kept in good working condition.

3. All work should be done keeping the hands in sight.

4. Learners need to be reminded that they must keep their eyes on their work.

5. See that individual lights are kept properly adjusted so that no deep shadows are thrown on the working area. Point out to learners the value of this.

6. Learners should be told not to attempt to gauge while the machine is running.

7. Parts being machined should not be handled any more than is necessary.

8. Tools should not be touched while they are cutting; and the ends of revolving bars should not be touched, or a nasty cut to the hand may result.

9. Machines must always be stopped for cleaning or the removal of waste, and usually for oiling.

10. Learners should understand that if anything goes wrong with the machine they should not attempt to put it right themselves, but should call the setter or person in charge.

11. Any control handles or hand tools which are in any way cracked or damaged should not be used, but should be reported immediately to the setter or supervisor.

12. Air jets should always be directed downwards and away from the body.

13. No worker should ever attempt to mount a belt by hand when the machine is running; this is a most dangerous practice.

VI. CONCLUDING NOTE

As you read through the foregoing pages you may have felt that you would never be able to do all they say, either for lack of time or because you thought you did not know enough. In practice you probably do (or would) pass on most of the information which has been outlined; if you begin to make a systematic note, as was suggested on page 8, of all the things which learners should be told, you will be surprised to discover how much, in fact, you do know. Your first rough notes can be made in odd moments, and the small amount of time that will be required to piece them together into a systematic programme will be amply repaid by your own increased assurance that useful information is less likely to be overlooked, and by the improved efficiency and faster rate of learning of the trainees.

APPENDIX

SPECIMEN MANUAL FOR CAPSTAN OPERATING

APPENDIX

SPECIMEN MANUAL FOR CAPSTAN OPERATING

I. GENERAL OUTLINE

During training, learners should be taught how to work all the lathe controls and how to use all the tools they are likely to meet in the machine shop. Always begin by showing how to stop and start the machine. It is a good plan to give learners their first experience of machine work on a drilling machine, first with plain drilling and countersinking and then with taps; a drilling machine gives excellent practice in getting the feeling of cutting, and in acquiring sensitivity of touch. They should then progress either to a simple operation on a centre lathe, or to a second operation involving the use of the cross slide only, on a capstan lathe. The turret should only be introduced when the cross slide and collet are already familiar. The object of this plan is to acquaint learners gradually with the more complicated machinery, so as to ensure that they do not have too much to pick up at one time. (Incidentally, observation of their approach to drilling and their success in learning it should indicate whether they have the makings of good capstan operators; this may save time being wasted in training unsuitable people on the more complicated and expensive machinery.)

While under the supervision of the instructor, capstan learners should, where possible, have experience in the use of the following tools: parting tool, at least one forming tool on the slide, drill, centre drill, spade cutter, at least one box tool, and die. Tapping might be introduced later, as it is a more difficult operation for learners to master. Experience of an operation which requires the locking of the turret (i.e. an operation with a knee tool) and of one which involves using the change-speed mechanism should, where practicable, be included at this stage. Short runs on a variety of parts should be arranged.

A definite programme of instruction, fitting into a fixed time-table, should be drawn up. It is impossible to lay down a standard time-table which would apply in every case, but for your guidance the following rough outline for the first day is suggested.

First Morning

Talk—about the firm, its products, the type of work to be undertaken, etc. . . . . 20–30 minutes.

Break . . . . . 5 minutes.

Instruction and demonstration—on drilling . . 30–40 minutes.
Cover the points outlined in Section II, A, 1 (Drilling and countersinking), omitting i (*g*) and ii (*b*) (pages 25, 26).

Practice . . . . . 1½ hours.

Revision and further instruction . . . . 30 minutes.
See that the technical terms you have used are understood and remembered; bring in the points omitted in your earlier talk about changing drills and about countersinking; cover the points in Section II, A, 2 (Tapping, page 26).

First Afternoon

Talk and demonstration introducing the lathe . 30–40 minutes.
Cover the points outlined in Section II, B (Lathes (pages 26, 27). Explain that in the drilling machines seen in the morning the material was held steady while the tool revolved and was driven through the work, but in the lathe the work is made to revolve, not the tool.

Practice—in use of controls for collet and cross-slide, without work in the lathe . . . . 30 minutes.

Instruction and demonstration—lathes . . . 30–40 minutes.
At this stage you should cover the points outlined in Section IV, A (Operating the Lathe—General Instructions; pages 29, 30), certain more detailed points about the collet and slide (Section IV, B, 2 and IV, B, 3, omitting i and iv; page 30) and those points about efficient working and safety contained in Sections IV, C, 1, 2, 4, 5, 7 on pages 31, 32, and IV, E, 1, 2, 3 on page 32.

Practice—use of collet and cross-slide only, but with work in the lathe . . . . . 1½–2 hours.

Revision. Explain faults which have occurred; cover points outlined in Section V, A, 1, 2, 4, on pages 32, 33. Show samples of good work, and samples of different metals . . . . . 30 minutes.

Second and successive days, proceed in similar manner, introducing first simple, then more difficult tools on the turret; and gradually increasing the number of tools whose order of use must be memorized, etc.

II. INTRODUCTORY DESCRIPTION OF DRILLING MACHINES AND LATHES

Your aim in this part of the training should be to explain briefly and simply how the cutting tools of the capstan lathe work. The following notes should be helpful, though not every part of this section will apply to every firm. At the end of this explanation you should provide some practice in drilling.

A. DRILLING MACHINES

1. Drilling and Countersinking

(i) *Explain* that—

(*a*) A drill is a tool for making round holes (show a drill);

(*b*) It has two cutting edges which must be kept sharp (i.e. correctly ground) and the right shape (i.e. cutting edges at the right angle) (show, illustrate by diagram);

(*c*) It has two flutes up which the swarf runs (show);

(*d*) These flutes must be kept free of swarf, hence the need for clearing the drill;

(*e*) Cooling agent (coolant) may be required in order to counteract the heat generated by the friction of metal against metal;

(*f*) The work may be held in a jig or fixture;

(*g*) Countersinking is like drilling just a very short distance with a large drill in order to give a smooth bevelled edge to the hole.

(ii) *Demonstrate*

(*a*) How to *stop* and start the drilling machine;

(*b*) How to change drills (if the operator will be required to do this);

(*c*) Rapid approach of drill to work;

(*d*) Slow cut with even pressure;

(*e*) Adjustment of pressure according to the material to be cut and the size of the drill;

(*f*) The need for using rhythmical, not jerky movements;

(*g*) The need to hold work firmly, especially when no jig or fixture is used;

(*h*) The importance of aiming straight;

(*i*) How the operator should watch for the drill getting blunt (e.g. by noticing a change in the nature of the swarf, and by change in the feeling of the cut); inform how long drills should last approximately on different jobs;

(*j*) That drill must be kept cleared (the feeling of the cut tells when this is necessary);

(*k*) That swarf must be kept off the table.

(iii) *Safety*

(*a*) See section on safety in instructors' handbook, page 17. Insist especially that no rags, bandages, loose sleeves or hair should be allowed to come near the machine.

(*b*) If drill stops revolving, hold work, stop machine.

(*c*) If drill seizes (i.e. if work revolves with drill) don't touch work, but stop machine.

(iv) *Broken Drills*

Point out that—

(*a*) It is not a crime to break a drill, though, of course, learners must be careful and try not to do so.

(*b*) The setter should be informed whenever a drill breaks.

(*c*) The bits of broken drill, and the work with the broken drill in it, should be kept separate from all other work.

2. TAPPING

(i) *Explain* that—

(*a*) Tapping is not hitting, but is putting a screw thread into a hole, e.g. in a nut; the tool which is used is called a tap;

(*b*) Lubricant may be needed;

(*c*) Taps need clearing just as a drill does.

(ii) *Demonstrate*

(*a*) Method of operation;

(*b*) Clearing.

(iii) *Safety*

As for drilling.

(iv) *Broken Taps*

As for drilling.

B. LATHES

(i) *Explain* that—

(*a*) A lathe is a machine for making round parts.

(*b*) A capstan lathe is a special lathe with which one operator can perform a number of different operations one after the other.

(*c*) Although it looks complicated it is usually fairly simple to operate, but it does need to be treated carefully.

(ii) *Demonstrate*

(*a*) How to stop and start the lathe.

(*b*) Simple operation of centre lathe.

(*c*) More complex operation on capstan lathe.

(iii) *Explain and demonstrate* that—

(*a*) Most capstan operations are performed with a drill, die or forming tool.

(*b*) The parting tool may be a special sort of forming tool.

(iv) *Show*—

Samples of work made on lathes; choose pieces of various shapes and sizes, and made from different materials.

III. TERMS AND MATERIALS

1. Technical Terms

The following terms are among the more common ones which capstan lathe operators may have to know. The relevant ones should be explained briefly, whenever possible with a practical demonstration.

A list of the terms used in your particular training course should be kept where learners can refer to it easily when they wish.

Automatic bar feed;
automatic traverse;
box tool, roller box tool, four-way box tool;
centre punch;
chuck, collet;
clearing, easing, relieving;
coolant, lubricant, suds oil;
countersinking;
cutting edges;
die, chasers;
drill, broach, centre drill, reamer;
filing;
fixture, jig, vice;
forming tool;
front and rear tool;
gauge;

headstock, tailstock;
knee tool;
knurling;
lead screw;
parting tool;
pip;
slide, cross-slide;
stops;
swarf, waste, chips;
tap;
tolerance, limit;
tool post;
turret, capstan, hexagon head;
turret handle, crossbar handle, star handle.

2. Controls

Make a list of the controls with which operators in your firm should be familiar, and the main points about them; for example,

start and stop mechanisms—power and clutch;
reverse mechanism;
change speed mechanism in normal and reverse directions;
turret handle—normal and reverse movement;
how to skip a tool, working to a stop, always bringing the same pressure against a stop, avoiding abrupt contact with component and abrupt break through;
cross-slide—both directions, working to readings, working to stops, avoiding sudden break through;
collet handle—how best to bring weight to bear, to ensure fast locking;
locking chuck;
locking turret;
automatic traverse, turret—how to engage at varying speeds;
automatic traverse, cross-slide—how to engage at varying speeds.

3. Materials

Describe the materials which are commonly cut on capstan lathes in your shops; possibly, for example,

aluminium;
brass;
copper;
ebonite;

iron;
phosphor-bronze;
plastics;
steel.

Learners should be told simple ways (weight, colour, etc.) of distinguishing those which they are likely to come across. They should be told something about their uses, and see specimens of work in the various materials. Their properties as they affect cutting tools should be described (e.g. rate of cut desirable, frequency of clearing, length of life of tool).

IV. OPERATING THE LATHE

A. GENERAL INSTRUCTIONS

Here your aim is to increase the learners' *general* knowledge of the lathe, so that they will be well prepared to learn the details you must teach them later. By following this method you will make sure that when you come to explain the more complicated things, learners will probably be able to understand them quite easily; but if you tell them too much detail at an early stage they will find it very hard to "take it in," and they are likely to be afraid that they will never be able to understand and remember everything; that would hinder their learning even more.

1. Explain that work must always turn towards the cutting edge of a tool and never away from it, or damage to the tool might result.

2. Point out that the speed of the cut depends on the material being cut, and on the amount of material being removed. Explain the importance of cutting at the right rate; how too fast a cut leads to faulty or broken work, while too slow a cut may blunt a tool. It is difficult to begin a cut again, once having stopped; so steady, even movement should always be continued right through to the end of the cut. Angular bars must be cut more slowly than round bars.

3. Usually the slide should be returned after each cut to a position in readiness for its next cut; but it may need to be specially placed to clear the turret tools.

4. Describe how often it is necessary to clear away the swarf.

5. Give practice in control of collet, slide and turret without work in the lathe.

6. Tell learners that in the early stages of their experience they

must call the setter as soon as a fault occurs; but that later they should do a second part, and call the setter only if the same fault is repeated. Emphasize that the setting of the lathe must be left to the setter, and that operators should never interfere with the adjustments.

7. Show the importance of keeping all stops and slides clear of swarf.

8. Constantly keep in mind and recall to the learners' minds the hints on efficient working and safety which are contained in the handbook (pages 14 to 16 and 17 to 20).

B. SPECIAL INSTRUCTIONS

1. Coolant

(i) Explain that setter usually instructs when coolant is needed and how fast a flow is required.

(ii) Show learners how to adjust rate and direction of flow.

(iii) Explain that if joints work loose, setter should be asked to adjust them.

2. Collet and Chuck

Show that—

(i) Collet must be fully closed before operating.

(ii) Collet must be half closed before positioning bar.

(iii) Key must be removed from chuck before operating.

3. Slide

(i) If lever-operated, slide should be held central while turret is in use.

(ii) Rapid approach, slow cut.

(iii) If wheel-operated, show how to use fingers of both hands on rim of wheel to get delicate control while cutting.

(iv) If working to a scale reading, show how eyes can be helped by marking wheel with chalk.

4. Turret

(i) If lever-operated, demonstrate how to keep lower arm parallel with bed of lathe to get fine control. Lean body sideways to get very fine control while cutting.

(ii) For very fine control, if handle is of crossbar type, show how to lean over it with hands on opposite spokes. Use both hands on same spoke to get increased pressure on large drills.

(iii) To approach turret to work, if control is of crossbar type, demonstrate how to take hold of right-hand spoke only, and to operate with a swing.

(iv) Describe how the need for clearing the drill can be felt in the operation of the lever or crossbar handle. Tell learners not to force the drill through the work, but to ease pressure just before breaking through.

(v) Rapid approach, slow cut.

(vi) Where it is possible, show method of reversing rotation of turret and of skipping one or more tool places (when maximum number of tools is not set up).

(vii) Show how to lock turret and explain that this is sometimes necessary to give rigidity, e.g. when a knee tool is used. The turret must be unlocked before changing to the next tool. (It may be necessary to correct the turret before making the next cut.)

5. Bar Feed

Demonstrate and explain the following points—

(i) Fully open collet before moving bar forward.

(ii) Half close collet before bringing stop up to bar.

(iii) Do not push bar through an unnecessary distance. A sight can usually be obtained from some fixed part of the lathe to act as a guide until the movement becomes familiar.

(iv) Push the bar a little too far, then push it back with the stop. Fully close collet before taking stop back.

(v) Feed from back or front of headstock according to the type of work and length of bar.

(vi) Don't touch the end of the bar while it is revolving.

(vii) Keep face of stop clear of swarf.

(viii) When the feed is not automatic, it is essential if working with angular or large bars to stop the machine before positioning the bar.

(ix) If the chuck is key-operated, insert the key in the easiest position. Always remove the key before starting the lathe.

6. Special Tools

Give instruction in use of special tools if learner will be expected to use them. This might well be done at a later stage in training.

C. EFFICIENT WORKING

With reference to the operation of a capstan lathe the general principles set out in the handbook would apply as follows—

1. Supplies of materials and finished parts should be stacked as close to the lathe head as possible.

2. Tools should not be moved further back than necessary.

3. After completing an operation the next tool should always be left in position for the next operation.

4. If the lathe needs to be stopped at the end of the cycle, switch off before unlocking the collet.

5. If it is necessary to switch off, do so while returning the parting tool.

6. Swing the turret control handle so as to make use of momentum.

7. Use both hands to finger the slide wheel while cutting.

D. CLEANING

Show how to apply all the rules laid down in the handbook section on cleaning; show, for example, how it is necessary frequently to clear the cross slide of swarf.

E. SAFETY

In addition to the general safety points mentioned in the handbook in the section on safety, you should explain the following necessary precautions which apply specifically to the operation of lathes.

1. The chuck should be securely closed before starting the machine, or the part to be tooled may fly out and do damage.

2. If the chuck is operated with a key, it is most important that the key should be removed before the machine is started up, otherwise it may fly out and cause damage.

3. Usually materials in the chuck should not be touched until the lathe has stopped—there is a danger of getting cut or burned.

4. Learners should be warned against catching their hands on the tools of the revolving capstan.

V. FAULTS, THEIR CAUSES AND THEIR REMEDIES

A. COMMONER FAULTS

The following are the more common faults that learners will make. Prepare and keep at hand sample faulty pieces; explain with illustrations how each fault arises, and coach learners thoroughly in the precautions to take so as to prevent the fault from occurring.

Fault	Cause	Remedy
1. Work too long	Collet not half shut	Half shut collet
	Turret not up to stop	Bring turret up to stop
	Pressure too light on stop	Keep even pressure
	Setting wrong	Call setter
	Collet too tight	Call setter
	Swarf on stops	Clear stops
	Swarf on turret tool	Clear tool
2. Work too short	Collet not half shut	Half shut collet
	Pressure heavy on stop	Keep even pressure
	Setting wrong	Call setter
	Collet too loose	Call setter
	Swarf on stops	Clear stops
	Swarf on turret tool	Clear tool
	Excessive pip	Bring parting tool up to stop
3. Work wrong diameter	Too rapid cut	Cut more slowly
	Heavy or light on stop	Keep even pressure
	Turret not locked or incorrectly locked (knee tool)	Lock turret correctly
	Scale incorrectly read	Read scale correctly
	Setting wrong	Call setter
	Swarf on stops	Clear stops
	Too little coolant	Use more coolant or direct it better
4. Burred edges	Blunt tool	Call setter
	Too rapid cut	Cut more slowly
	Uneven movement	Move more evenly
	Wrong speed of lathe	Use right speed or call setter
	Too little coolant	Use more coolant or direct it better
5. Uneven surface to work	Uneven movement	Use even movement
	Incorrectly ground tool	Call setter
	Too rapid cut	Cut more slowly
	Too little coolant	Use more coolant or direct it better
6. Wrong depth of hole in work	Turret not up to stop	Bring turret up to stop
	Uneven pressure	Keep even pressure
	Drill slipped back	Call setter
	Collet not tight	Call setter, or lock collet correctly
	Swarf on stop	Clear stop

Fault	Cause	Remedy
7. Wrong length of thread on work	Tool slipped	Call setter
	Turret not up to stop	Bring turret up to stop
	Chipped tool or die	Call setter
	Die loose in holder	Call setter
	Swarf on stop	Clear stop
	Swarf in die box	Clear die box frequently
8. Stripped threads on work	Die out of adjustment	Call setter
	Die forced back	Let die run back
	Die not followed up	Follow die up
	Too little coolant	Use more coolant or direct it better
9. Wrong diameter of external thread	Turret locked	Unlock turret
	Swarf in turret tool	Clear tool
10. Stripped or over-sized thread	Turret locked	Unlock turret
	Too little coolant	Use more coolant or direct it better
11. Broken drill or tap	Drill or tap blunt	Call setter
	Tool bearing pressure	Call setter
	Not clearing drill or tap	Call setter
	Too little coolant	Use more coolant or direct it better
12. Broken material	Too rapid approach	Approach tool more slowly
	Too rapid cut	Cut more slowly
	Blunt tool	Call setter
	Faulty bar	Call setter
	Collet not closed	Close collet
	Too little coolant	Use more coolant or direct it better

B. CONTINGENCIES

The following less usual things may go wrong—

1. Broken Tools

Learners should be told to call setter and to make certain that bits of tools, and work with broken pieces of tool in it, are kept away from the rest of the work and from the swarf.

2. Tools Used in the Wrong Sequence

Learners should usually be told to put aside all work where a tool sequence has gone wrong. They must be shown how to start

again at the beginning of the cycle. This usually means starting with a parting tool.

3. Turret Indexing Out of Step

Learners should either be shown how to put this right, or should be instructed to call the setter.

4. Change in Form of Swarf, Especially in Drilling

Learners should call setter at once.

5. Unusual Noises

Learners should call setter at once.

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