PAPER

LATHES: A COMPARISON.

By Edgar Thompson.

The subject of this paper is probably the most commonly used machine tool in any engineering works, and as such is usually the first machine to be installed. Every engineer has some knowledge of a lathe, which is composed of a bed of various lengths, with a tool carriage capable of movement by mechanical means, a movable head with a stationary spindle, and a fast head with a spindle revolving at a variety of speeds and rotating the work with it. From this basic design many improvements have been brought about to meet the increasing demands for greater production; and so great has been this demand, with its resultant development, that we now have the province of lathe manufacture split up into three distinct classes, namely, Centre or Engine Lathes, Capstan and Combination Turret Lathes, and Automatic Lathes. These will now be considered in the order given.

CENTRE OR ENGINE LATHE.—This type of lathe is an indispensable unit in any engineering workshop, and shows to its best advantage where the class of work to be machined is of a variable nature, and where the quantities are so small in number that it would not be economical to prepare a tooling set up. With such a widely used machine as a Centre Lathe, it is only natural to find such a large preponderance of firms manufacturing Centre Lathes as compared with any other machine tool. This leads to a highly competitive spirit among manufacturers, who realise the necessity to keep abreast with the times. As a consequence, we find many interesting features which are quite distinctive, some of these being essentially connected with the firm’s own individual design, and others bearing a national character.

In comparing these features, it will be helpful to bring the main items of the Lathe under sub-headings:—Beds, Aprons, Gear Boxes, Loose Heads, Fast Heads.
Beds: One of the most striking points of comparison of the bed is the national difference in the raised Vee type and the square or flat way type. The use of the raised Vee is the recognised practice amongst all American manufacturers, and is the design generally used amongst the German and Swiss manufacturers. The British manufacturers, however, are equally firm in their preference for the square bed. Although there are such decided opinions shown in this connection, there is unquestionably some justification for their respective points of view, for each type of bed shows an advantage in accordance with the class of work to be machined. Taking the American type of raised Vee first, this usually takes the form of two Vees on the back shear and one Vee on the front shear. The two outer Vees are the guides for the carriage, and the inner Vee acts as the guide for the loose headstock. One advantage of this design is the freedom of movement of the carriage, thus giving ease of operation and less fatigue to the operator. The principal advantage, however, lies in the alignment of the carriage in its relation to the headstock, as this alignment is so important in obtaining accuracy.

Now, assuming that a Lathe with this type of bed has been in regular service for a few years, any wear taking place due to the constant travel of the carriage along the bed would naturally be on the Vees of the bed or carriage, which would gradually become lower. But though it is actually lower after years of wear, the Vees retain the alignment, and thus keep the carriage square to the headstock. In making reference to the inner Vee for the loose headstock, it is only necessary to add that this also is for alignment purposes.

The Swiss type of bed is of different design. They place reliance upon only one Vee for the alignment, the bed having underslung carriage guides which are situated below the gap of the bed, but project out to allow for the movement of the carriage. Thus the distance between the guide and carriage support is considerably wider, and gives a width across shears proportionally equivalent to what could be obtained only on a larger lathe using the type of bed previously mentioned. Another advantage obtained from a bed of this section is that, due to the low position of the shears, a longer bearing support can be given to the carriage, which support is given irrespective of whether the lathe is of the gap or straight bed type; and if of the former type there is no necessity for a bridge piece to be fitted. Therefore, it will be recognised that where the class of work to be machined is of such a diameter that a gap is necessary, great advantage can be obtained by having a full guide support to the carriage when the tool is cutting on work close to the faceplate.
The British type of bed is of the square section, and the advantage to be gained from this is the greater robustness obtained, also the greater facility for taking heavier cuts due to the carriage having a bearing surface across the full width of the shears, and thus obviating any possibility of spring, which may arise under the strain of heavy cutting when the Vee type of bed—with its resultant bridge—is being used for heavy duty work. In support of this view, it is interesting to note that one of the best-known manufacturers of lathes in the United States recently introduced a new design of bed where provision is made for the carriage to have a bearing on the horizontal surface of the bed, and also on the inside vertical surface of the shear, and in their announcement of this alteration they particularly draw attention to the feature that "this extra horizontal surface gives a solid support to the bridge just where it is needed." In pre-war days much criticism was given to the Square Bed Lathe, particularly so from an operator who had also the experience of having worked on a Vee Bed Lathe. This criticism was due probably to a large extent from the extra fatigue experienced as a result of the friction produced through the necessary fine adjustment of the gib or strips when requiring accuracy. Since the war, however, there has been a change in the design of the type of bed, with the introduction by all the British manufacturers of the type now known as the Narrow Guide Bed, so named as a result of the guide for the carriage being transferred from the outside vertical surface of the rear shear to a guide which is machined into the front shear. It will be readily seen what an improvement this new design is when compared with the old.

For instance, the guide is now close up to the forces propelling the carriage, namely, the feedshaft or guide screw, and consequently the twist or cross wind of the carriage is reduced to a minimum, as is also the power or effort required to move the carriage along; and so noticeable is this difference that on an 8-inch to 9-inch centre lathe, after giving the carriage a start with the rack and pinion, it is quite possible to then push the carriage by hand the full length of the bed. Another advantage of this design is that when locking the carriage for surfacing work the pressure is applied on solid metal as compared with the action of springing the shears in when the guide was on the outside shear.

Summing up the national characteristics of bed design—the British preference is definitely for the gap type, the American is equally decided in his preference for the straight type, the German is adaptable to either, and the best Swiss manufacturer supplies the gap bed without any provision for the fitting of a gap piece or even the half gap. These divergences have probably
been the result of the demand of the purchaser, and relative to the question of mass production.

Aprons: A divergence of design is noticeable in the choice of position of the hand wheel for operating the rack and pinion traverse for the carriage, the British placing it on the right hand side, while the American and Continental makers place it on the left. This is done according to whether a straight or gap bed is used.

Another example of the variation in apron design is in the provision of a feed reverse, which in American and Continental design is usually obtained from the apron by means of a double bevel gear sleeve and wheel, whereas the British supply this reverse motion from either the gearbox or headstock.

With regard to the provision of power feeds for sliding and surfacing motion, various manufacturers adopt different methods, and it is noticeable that the leading manufacturers are always striving to obtain further improvements. For instance, an American company which specialises in lathe manufacture has recently changed its design of engaging the feed motion from a multiple plate clutch to a friction disc type, operated by means of levers in place of handwheels.

Other well-known British and American manufacturers utilise the sliding gear method of engaging whichever feed motion is required. This is operated by means of a sliding shaft in the apron, which moves a gear into either of the following three positions:

1st, to connect up with gears for sliding or longitudinal feed;
2nd, free position, in which position screw-cutting motion can be operated;
3rd, to connect up with gears for surfacing or transverse feed.

The foregoing methods of supplying power feeds in conjunction with the various drives from the feed shaft are the most commonly used types amongst lathe manufacturers. But there have been some interesting developments introduced by British manufacturers in connection with the application of power feeds, in which connection both the sliding gear and friction type of drive have been superseded. Reference is here made to the use of the Dropping Worm Box. Previously this component has been used in supplying the power from the feed shaft to the friction discs or sliding gear shaft.

One instance is where the manufacturer has incorporated in his apron design the method termed the gate method, which is a longitudinal slot opened out at the ends and situated in the front of the apron through which the handle of the dropping feed box passes, and thus by moving the feed box into either
extreme end it is then in position for engagement with either the sliding or surfacing gears, which is done by an upward movement of the handle, the feed box being held in position by means of a spring loaded catch.

The advantage of this design is that the operation is a one-handed movement and instantaneous, thus obviating the engaging or releasing of any friction handwheels or the sliding gear after the feed box has been engaged. The releasing of the feed box is also instantaneous by a downward movement of the handle of the spring loaded catch, which thus allows the feed box to fall and become disengaged. Another design of feed change is the use of the dropping feed box, which again is a one-handed operation. But in this case the feed box contains two worms, one for sliding and one for surfacing, and a half turn of the handle in either direction will slide the required worm into position ready for engagement with its mating worm wheel. Then an upward movement of the same handle gives the necessary engagement for whichever feed motion is desired.

Coming to the Nut Box, the usual mode of operation is by a vertical movement of the two half nuts. But our British manufacturer, by making the half nuts move horizontally and machining off the lower portion of them, was able to provide brackets to support the guide screw in a perfectly horizontal position. This obviated the need for bearings on the apron, and consequent wear on the external surface of the screw due to the traverse of the carriage.

Now usually the half nuts have a distinct clearance between their faces when clamped up, and also a clearance is left at the bottom of the thread to allow for taking up future wear. But recently one lathe builder has adopted the practice of clamping the nut box halves face to face, and then machining out the thread. Thus there is no provision for wear, and in time backlash would develop. This is of no importance, however, for in any particular operation the screw is always pressing against the same face of the nut. The advantage of the design is that full face contact is retained on the side of the thread, a condition essential to accurate production. In the older type of nut box a shoulder tends to form which when closing the box tends to bind on the guide screw, and leads to inaccuracy.

Gear Boxes: The method of transmitting the range of feeds to the apron is by means of gears usually carried in a box and operated by clutches, sliding wheel or spring key, or a combination of these, the gears in the box being driven by a train of gears from the spindle and arranged so that the feed of the tool is a definite amount of travel per revolution of the spindle. In this section there are distinctive points of view in regard to its utility when comparing the British with the American and
Continental makers. For instance, the British manufacturer as a general practice only supplies a quick change screw-cutting gear box on the smaller type of lathe, with height of centres not exceeding $10\frac{3}{4}$ inches, whereas the American or Continental manufacturer supplies this type of gear box to all sizes of centre lathes. The screw-cutting gear box was introduced, of course, to reduce production costs by saving the time taken in selecting the necessary change wheels and assembling the same on the studs and swing plate. There does not appear to be any standard fixed amongst the manufacturers in regard to the number of changes in pitch which can be effected through the gear box, and under those conditions it is only natural to find such a great variation, with an American manufacturer supplying probably the highest number of changes, 61, and covering a range of from 1 to 64 threads per inch; this large number is effected, as in all cases where a large number of changes is obtainable, by altering the ratio of gearing by transposing gears in the train from the spindle to the gear box. Provision is also usually made on this type of box for using change wheels in the event of having to cut metric or some very odd pitch.

Up to the present I am unaware of any British or American manufacturers who have designed a gear box through which, by change of levers only, metric or English threads can be cut from the one guide screw, though a gear box capable of doing this can be obtained both in Germany and Switzerland. As, however, in many works, a screw-cutting gear box is not essential, the British manufacturer usually makes what is termed a standard gear box, from which can be obtained four and in some cases six rates of feed, which, with the advantage of having the guide screw driven from the gear box, enables the same number of changes in pitch to be obtained when screw-cutting by movement of the feed change lever. This arrangement has proved very useful in many works, due to the fact that the four or six pitches of thread respectively may be cut with the use of one train of gears from the spindle. With this method fewer change wheels are required for cutting a full range of threads, and the cost of this type of gear box is not as expensive as the full screw-cutting gear box. There are British firms which also have the reverse motion in the gear box operated by a sliding clutch. One firm introduces in this reverse motion a single-tooth clutch for facility in reversing the carriage when screw-cutting, without having to release the nut box; this is a very useful feature, particularly when cutting a very coarse or odd pitch.

**Loose Headstock**: Regarding the loose head, there are very few changes in design, and practically the only variation from the standard design is in the spindle, where there are two types
in use, one in which the thread is cut on the spindle and passes through the handwheel, and the second type, where the spindle is bored out for the adjusting screw and nut.

The latter type is in general use in America and on the Continent, and is very much favoured in the smaller sizes of lathes in Britain because of its sensitiveness and also for the greater purchase on the handwheel.

The former type has claimed for it that the spindle bearing is always the full length of the barrel, and thus gives better support when in an extended position.

Fast Headstock: There are three types of headstocks generally used, namely, the cone driven type with back gear, the cone driven type having back gear and friction clutch, and the all gear head. The plain cone driven type is useful and economical where there is not sufficient work to keep a lathe fully employed, or in cases where the work to be machined does not require much gauging for size. The cone driven type with friction clutch has a distinct advantage over the former, particularly in that class of work where the machining time is of short duration or in cases where the work is of such an accurate nature as to require constant gauging for size in the various lengths and diameters. This advantage is due to the great amount of time saved through being able to stop and start the spindle without the necessity of stopping the countershaft, and when one realises the number of occasions a lathe is stopped and started in one day’s work it can be readily understood where a saving of time can be effected. Another time-saving feature is the facility given to the operator by means of this clutch of being able to “Inch” the spindle round, when setting up work in the chuck or on the faceplate.

The all geared headstock has advantages over both the previous types mentioned: First, no overhead countershaft is required; and second, the correct cutting speed can be obtained with greater ease by means of the gears in the headstock, than with the belt change required on the cone driven lathes, and consequently there is less temptation for the operator to retain a cutting speed which may be unsuitable for the work to be machined.

With regard to the number of speeds obtainable from the all gear head, there is no standard design amongst the various manufacturers in this connection, but amongst the designs available it is possible to obtain headstocks with a range of speeds from 8 to 24 in number.

A feature of some manufacturers in their design is to incorporate the use of double friction clutches in the headstock of lathes up to 10½ inch centres, by means of which the operator
can effect a more rapid change of spindle speeds; but on lathes of heavier capacity all spindle speeds are usually obtained through a positive gear drive.

The design of an all gear headstock is also particularly suitable for a motor drive, and there are many types of drives in this connection, some being of the direct gear drive from the motor, some with motor enclosed in the cabinet leg under the headstock, and another by use of a hinged platform suspended from an extension at the rear of the cabinet leg. There is also the Continental drive, by means of a flanged motor, which gives an exceedingly neat appearance.

**Surfacing and Boring Lathes.**—This type of lathe is one which can be said to be a British production, and in many works has proved itself to be one of the most serviceable machine tools. Its construction differs from the centre lathe by having a powerful headstock on a raised portion of the bed, and having in some instances a hexagon turret mounted on the slide of the carriage, the function of the machine being for the surfacing and boring of work held in the chuck or fixed to the faceplate. When passing through any large engineering works it is quite a usual sight to see centre lathes fully occupied on what is commonly called chucking or faceplate work, and in many instances where the headstock has been raised on packing blocks to give the necessary height for swinging the work. It is in this class of work where a surfacing or boring lathe is particularly suitable. These machines are usually provided with a triple geared head, or the all gear headstock, but there is a third type of headstock manufactured in Britain, namely, the variable speed headstock, which is particularly suitable for surfacing work. The variation of speed is obtained by means of sliding cones, over which a special belt with bevelled edge runs. The cones are adjusted according to the speed required by means of a worm and quadrant operated by a handwheel at the near front side of the headstock. The strong feature of this particular design is the automatic increase or reduction of spindle speed in relation to the traverse of the tool slide which is obtained through bevel gears, one mounted on the cross slide screw and the other on a shaft which passes through the carriage to a position underneath the handwheel operating the worm and quadrant. The shaft is then connected to the worm spindle by means of sprockets and chain. As an example, if work of say 24 inches diameter is mounted in the faceplate, and requires machining across the full face, the cutting speed could be beneficially increased towards the centre of the work in comparison with the cutting speed at the outside diameter, and by the action just described the desirable change of speed is supplied automatically.
LATHES: A COMPARISON.

CAPSTAN LATHES—GEARED AND UNGEARED.—This is a type of machine developed to meet the demand for increased production by the specialist in the machining of parts by decreasing the tool handling time and by the use of stops for the various feeds. Generally speaking, there are two classes, the Ungeared and Geared type.

The Ungeared Capstan is usually of simple design, and manufactured in sizes up to 5-inch centres, with a direct drive from countershaft to spindle pulley, wire feed for bar stock, a hand-operated cut-off slide, and a slide on bed which in turn carries the capstan slide. In making a comparison of the various types it is noticeable that the flat bed is the most commonly used by British and American manufacturers, whereas the Continental manufacturers use the Vee bed. In regard to the capstan slide, these are generally of the hand feed type, with an automatic method of revolving the turret at the end of the return stroke. Several Continental makers supply a vertical turret, though others supply the horizontal turret. The latter is the most popular type, but this is probably due more to the common practice of using the horizontal type than in any weakness of design in the vertical type.

The Geared Capstan Lathe is designed for heavier work than the machine previously described, and in this connection we find all gear headstocks becoming more popular, also the introduction of power feeds, a recent improvement being the supply of power feeds to the tool post saddle. A further improvement has been made in connection with this saddle, which formerly was supplied with single tool posts on the front and rear of the slide. The front single tool post is now supplanted in favour of the square turret, and the rear single tool post is replaced by a two-way post, both of which are decided improvements in facilitating increased production due to the time saved in tool handling. There are two kinds of saddle used on this type of machine, namely, the sliding saddle and the chasing saddle, the choice of which is dependent upon whether the purchaser requires to do screw-cutting or not. If screw-cutting is necessary, then a chasing saddle will be selected, and in this type of saddle there is a noticeable feature adopted by reputable makers, which is the simultaneous withdrawal of the cutting tool from the work, and the nut from the leader screw by the one movement of a lever.

The screw-cutting motion is by means of a lead screw and nut, the lead screw being driven from the gear box. The ratios of gearing vary according to the manufacturer's individual design, some having three, other four ratios; but, according to the number supplied, so are the number of pitches possible to
be cut from the one lead screw. If a full range of screw-cutting is to be done then it is necessary to have additional lead screws supplied. The leader nut is usually of the revolving type, with two or three pitches, cut to suit the same number of lead screws.

With regard to the capstan slide the number of power feeds vary according to the design of the individual manufacturers; the highest number of feed changes is probably given by a British manufacturer who in his design provides for ten changes of feed.

Combination Turret Lathe.—This type supplies the demand for a machine capable of dealing with a greater variety of work than can be dealt with in the capstan lathe, and is manufactured in various sizes, ranging in height of centres from 7 inches to 13 inches approximately, according to the class of work to be machined. Generally the features which, apart from the size of the machine, give a larger scope to the combination turret lathe are: First, that the turret is located on the carriage itself, thus giving a range of travel in the one movement which is only limited by the working length of bed, whereas on the capstan lathe the length of turret travel is governed by the length of stroke obtainable from the turret slide in relation to the auxiliary slide upon which it is mounted, this auxiliary slide being moved along by hand to the required position and then securely locked to the bed. Second, quick power traverse is usually supplied to the turret saddle, this being an essential feature in the reduction of floor to floor time, and is more applicable to a turret saddle than the capstan slide, with its limited stroke. The combination turret lathe, with its larger scope, also lends itself to a greater variety in design.

With regard to the turret, there are two kinds in use, namely, the Hexagon and the Flat Turret. The hexagon turret is most serviceable for use in work where drilling and boring are required, and the flat turret is particularly serviceable on the class of work suitable for the use of multicut tool holders and bar work, especially so where provision is made for a transverse movement of the turret.

In the recognition of the varying uses of the hexagon and flat turret, one Continental manufacturer provides for the interchangeability of both these types of turret. The quick power traverse, as previously stated, is an essential feature for two reasons: First, in the reduction of production cost due to the facility given of being able to run the tool up to the work at a fast speed before engaging power feed; and second, in running the carriage in either direction by means of a lever as compared to the hand traverse through rack and pinion.
Lathes: A Comparison.

The preference given to the flat way bed by British and American manufacturers has already been referred to; but there is one feature yet unmentioned—that is in connection with the hard wearing properties of the bed. Much criticism has been given at various times to the soft and open grained metal used in the American bed as compared with the hard and closer grained metal of the British type. This has led the American manufacturer to develop a chilled bed, in which process a close grained construction was obtained; and some firms have even gone beyond that stage by supplying the flat way bed with a steel surface by means of steel plate secured to the top of the bed, one firm making a special feature of dovetailing this plate to the bed. The Continental manufacturer retains the raised Vee bed, an interesting design of which is supplied by one firm in giving extra support to the various carriages used.

Automatic Lathes.—In this section we have two types, one for bar work and one for chuck work. As the name signifies, these machines are fully automatic in all their motions, and as such are the most highly productive machines manufactured under the category of lathes, and it is essential in the economical running of machines of this type that the work must be of a repetition character, and in large quantities, to allow for the time spent in setting up the tooling equipment to be proportionately distributed over the number of parts to be machined. The most commonly used automatics are those for the production of parts from the bar; and so great has been the demand for more intensive production that up to the present time we have single spindle, four spindle, and six spindle automatics, the latter machines being used for heavier bar stock.

The general method used in supplying the necessary automatic travel of tool slides and carriage is by the use of rollers and cams, and according to the various shapes of the latter so is the feed, dwell and quick return governed in speed by its relation to the cam shaft, provision usually being made by the manufacturer, of a gear box to enable a suitable speed to be obtained in accordance with the nature of the material to be cut. With regard to the automatic for chuck work, this type of machine is of a totally different design to the bar automatic, and in outward appearance has a great resemblance to the centre lathe with the all gear head gear box, carriage and loose head. The function of this machine is to obtain increased production on work held in the chuck or between the centres. To obtain this result provision is made for multi-tooling with full automatic travel of tool slide. Both American and Continental manufacturers have designed a bed to carry front and rear carriages, each carriage having independent feed and control mechanism, and with quick power traverse for facility in running up to the work and also the rapid withdrawal after the
cutting operation. The tool slide carrying the series of cutting tools is also provided with a quick return motion; but in the method of supplying the necessary feed motion to the tool slide the American design is by use of a screw, and the Continental type by use of gears and racks. An additional feature of the American machine is the supply of an air-operated spindle in the loose head for quick location of the work to be machined.

Mr. John Wilkins said Mr. Thompson had contributed a most interesting lecture. A comparison of the machines illustrated with those of 20 years ago revealed a remarkable difference. The machinery of to-day not only tended to much greater output, but the work had to be much more accurate. He moved a hearty vote of thanks to the author.

Mr. H. E. Grove, in seconding the vote, said he had been intensely interested in the wonderfully ingenious machines shown, and to the stage of perfection they had reached. The lecturer was to be congratulated upon the amount of work he had performed in preparing his lecture.

Mr. Westwood said he had thoroughly enjoyed listening to the lecture, which had been a technical treat. He complimented the author on the clarity of his slides. He tendered his thanks for the invitation to be present.

Mr. G. H. Gough said the lecture had been extremely lucid. It was a very difficult subject to explain in detail. Modern tools were very complicated, but each complication had its use.

The President said he wished to express his appreciation of the very valuable paper and of the work involved in its preparation. The paper had dealt with such a broad field that it had covered the subjects of a dozen individual papers.

Mr. Edgar Thompson, in reply, said the lathe was the most highly perfected machine tool and the most commonly used. The lathe was only one type of machine tool, and the paper given had by no means exhausted the subject. There was sufficient material for a paper on Miscellaneous Lathes alone.
DISCUSSION
LATHES: A COMPARISON.
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Mr. J. Williams said high speed steel had been the chief cause of the revolutionary changes in the design of the lathe; but there were other causes, for instance, mass production. Of course the heavier cuts required by the latest high speed steel necessitated much more rigid construction. He thought that was the reason for the changes that had taken place.

Mr. Edgar Thompson, in reply, agreed that the introduction of high speed steel had had a great deal to do with the changes in design of machine tools. Recently there had been introduced alloys which were nearly as hard as the diamond. The introduction of these cutting compounds would probably mean still further change in the design of machine tools. With reference to the question of mass production, there was a growing tendency to cut out the elaborate machine tool. Where great numbers of parts had to be machined the tendency of the manufacturer to-day was to bring in a single purpose machine, thus obviating the elaborate and expensive design. It was more economical, as far as possible, to keep the tool occupied with one operation.

At 10.15 p.m. the meeting terminated.