THE DEVELOPMENT OF A UNIVERSAL MACHINE TOOL

BY

J. W. J. BURDEN, ESQ.

THE REQUIREMENT

In 1943 it became abundantly clear that the increased equipment and amenities to be installed in combatant ships of the Royal Navy, would necessitate a revised allocation of space to those services and amenities already existing.

For a long time it had been suggested in some quarters that certain machine tools, although necessary for maintenance, were not extensively used in ships, giving the impression that they could be dispensed with and the machine shops consequently reduced in size. On the other hand the view held at the Admiralty was, and still is, that all machines have an insurance value and the premium paid in space is small, if a vessel can be self-maintained to a high degree of preparedness with the occasional assistance of these machines.

With these conflicting views, therefore, it seemed very desirable to carry out a survey of the use actually made of the machines and, while admittedly very

rough, this survey showed that, considering the lathe as 100, the usage factors of various types of machines were :—

Drill	..	80
Tool Grinders	..	20
Universal Grinder	..	10
Universal Miller	..	60

Consideration was then given to the possibility of omitting certain items, but it was found, particularly in the larger types of vessels that, with the various self refit policies, this presented a greater risk than could reasonably be accepted, particularly in wartime. In addition, these larger vessels are expected to lend assistance to smaller escort craft as opportunity arises or as necessity in war demands.

It was at this stage in the enquiry that the possibility of a combination machine came in for serious investigation. If a machine could be produced to give three or more actions and, at the same time show a reduction in space, some reduction in the areas of the common machine shops could be accepted without any corresponding reduction in the standard of maintenance method previously enjoyed by the Fleet.

There have been many attempts to combine various types of machines, but they have all had the disadvantage of restricting the use to only two actions at any one time, the machine was invariably a basic unit to which various attachments were secured. Experience has shown that such expedients were used only in dire emergency. The basic requirements, therefore, for such a machine resolved themselves into the following :—

(*a*) That at least three of the basic production methods (say, mill, drill and turn) should be possible at any one time.

(*b*) The methods should be undertaken with the minimum assembly of accessories.

(*c*) The machine should save a considerable space over the individual machines.

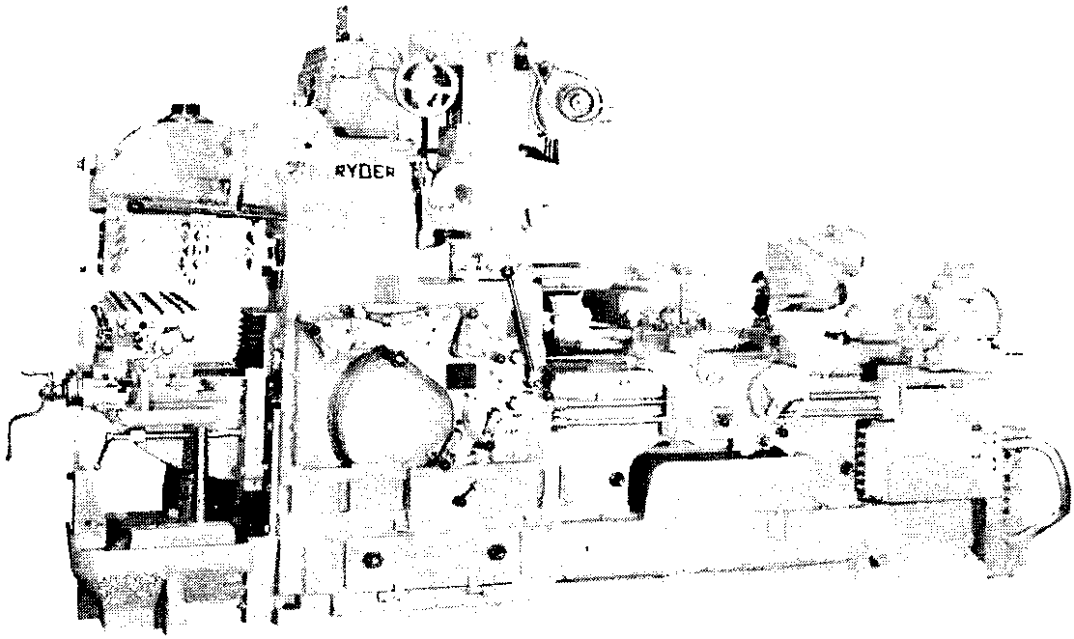
(*d*) The machine should incorporate as much 'standard' equipment as possible. This would not only reduce cost but would incorporate equipment with which the users would already be familiar.

(*e*) That two sizes of such machines were required and that the capacity of each unit incorporated must be commensurate with the other units.

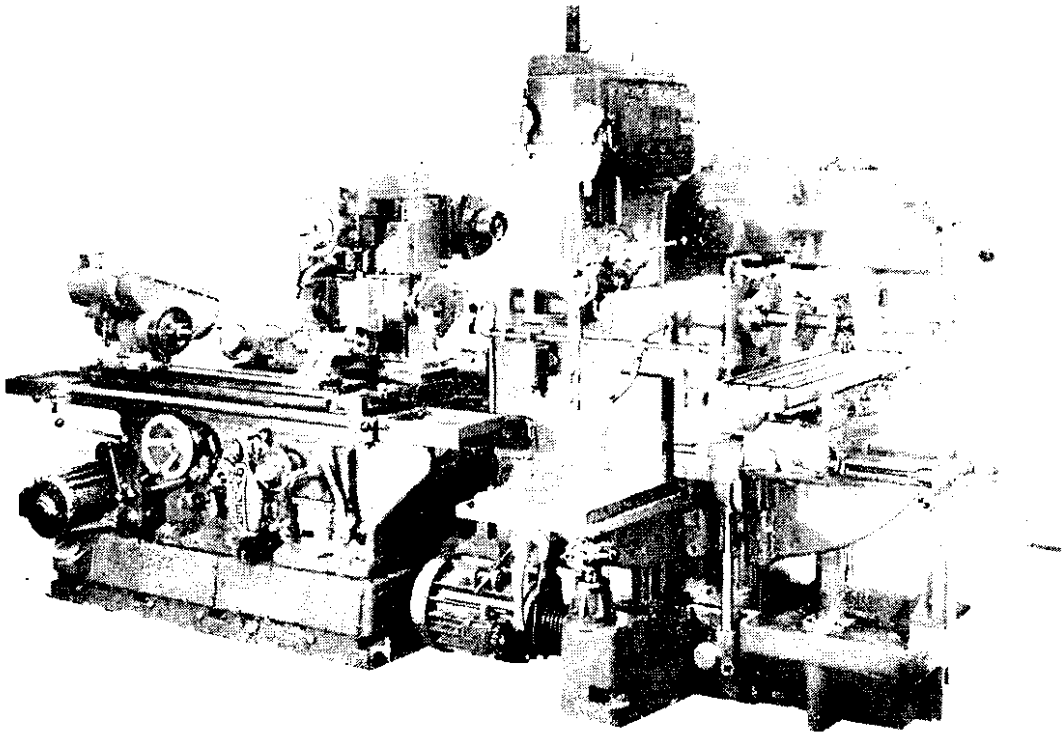
Taking these criteria, and having regard to the usage factors previously obtained, it was found that a combination of the following machines would give the most favourable utility value, as well as the greatest saving in weight and space :—

Lathe
Drill
Tool Grinder
Miller
Universal Grinder

These machines are all basically different, each requiring its own particular manufacturing techniques and, as was to be expected, there was nothing in the commercial sphere which came anywhere near meeting the requirements. It was therefore necessary for the Admiralty to design a suitable machine or at least to set out a basic design for the guidance of the firms who might develop it under contract.



The Lathe, Miller, and Grinding Wheel Head in its Stowage Position



The Drill and Grinder with Wheel Head Rigged for Grinding

THE UNIVERSAL MACHINE TOOL (LARGE)

The projected design was referred to manufacturers but, because of full order books, only two firms showed their willingness to co-operate in the production of these interesting machine tools. These were Messrs. Thomas Ryder of Bolton and Messrs. Adcock & Shipley of Leicester. This proved a distinct advantage because one design could be allocated to each firm, thus ensuring

that the machines would be developed along independent lines. The contracts were placed early in 1944 and both firms applied all their knowledge and experience to the task, the result of which has been two extremely fine machines of high quality, finish and accuracy.

THE UNIVERSAL MACHINE TOOL (LARGE)

The development of the large machine was allocated to Messrs. Thomas Ryder, Turner Bridge Works, Bolton, and provides four essential machines in one unit with the following capacities :—

(*a*) *Surface Sliding Screw Cutting Lathe*

Height of centres 6½ in. Swing over saddle 8¼ in.
Swing-in gap in front of face plate—22 in diameter and 5 in length.
Distance between centres 30 in (to be increased in production models).
Spindle speeds, number 9, range 21 to 533 per minute.
Rates of feed, number 12, sliding ·005/·04 inches per revolution surfacing ·0025/·02 inches per revolution.
Threads available through gear box 3½, 4, 5, 6, 7, 8, 10, 12, 14, 16, 20, 24, with change wheels 1¾ to 72 t.p.i. ·8 to 9 m.m. pitch.

(*b*) *Universal Milling Machine*

Working surface of table	40 in × 10 in.
Longitudinal feed	23 in.
Cross traverse	7 in.
Vertical traverse	13 in.

Speeds of horizontal spindle, number 9, range 21 to 533 per minute.
Longitudinal feeds, number 4, range ½ to 10 inches per minute.
Table swivels 45° either side of centre line.

(*c*) *Sensitive Drilling Machine*

Maximum size hole drilled in mild steel	1¼ in.
Stroke of spindle	6 in.
Distance from spindle to column	12½ in.
Maximum distance from table to spindle nose	31 in.

Spindle speeds, number 9, range 85 to 1,220 per minute.
Spindle automatic feeds, number 4, range ·0055 to ·0162 inches per minute.
Size of table 20 in × 15 in.

(*d*) *Universal Grinding Machine*

Maximum swing over table	10 in diameter
,, grinding length	24 in.
,, width of surface grind	8 in.
Vertical movement of wheel head	14 in.

Work speeds — Number 4, range 84 to 356 per minute.
Table speeds — Number 4, range 6·5 to 69 inches per minute.
Wheel head feed — ·0001 to ·001.
Maximum angle table swivels — 5° either side of centre line.
Size of external grinding wheel 10 in × 1 in.

More general features of the machine are :—

(*a*) The lathe, drill and milling unit can be operated independently or simultaneously. When operating the universal grinder the lathe and

drill cannot, of course, be used but the milling unit may be, providing its operation causes no appreciable vibration.

(*b*) The lathe and milling units are driven by a single 6 h.p. motor but apart from this, they are completely independent of each other. Clutches are provided on both units for an instantaneous stop and reverse, and to the feed mechanism for protection. All the normal interlocks are provided. An interesting feature of the milling unit is the strong box casting of the overarm, which incorporates a built-in vertical milling spindle and thus provides considerable depth between the vertical spindle and table, a feature unobtainable in the standard machines which use the horizontal drive for the vertical attachment. The vertical spindle is driven from the main horizontal spindle through a gear chain. A safety cover is provided for the horizontal spindle when the vertical attachment is in use.

(*c*) The drilling unit is gear driven by an independent motor. The gear changes are by levers and speeds can be selected instantly from the plates. The auto-feed and sensitive cut-ins are all operated from the same levers and are extremely sensitive.

(*d*) The universal grinding unit has its own independently reciprocating table which gives this unit the continued accuracy usually associated with the standard type of machine. For the grinding operation, the wheel head is mounted on a special cross slide which is attached to the bed of the lathe. This cross slide is accurately positioned over a vertical drive from the front of the grinding unit, through which the wheelhead feed is obtained. The change over from lathe to grinder takes about 10 minutes, but care must be taken not to damage the lathe bed or cross slide base by entrapped 'chips', etc. Apart from the assembly of the wheel head the operation of the machine proceeds exactly as a standard type. The wheel head is independently motor driven, as is the reciprocating table motion gear box.

(*e*) Two independent coolant systems are provided, one for the lathe, miller and drill, and the other for the grinding unit. Both units are built into the fabricated base of the machine, are fluid tight in a seaway, and are capable of being cleaned.

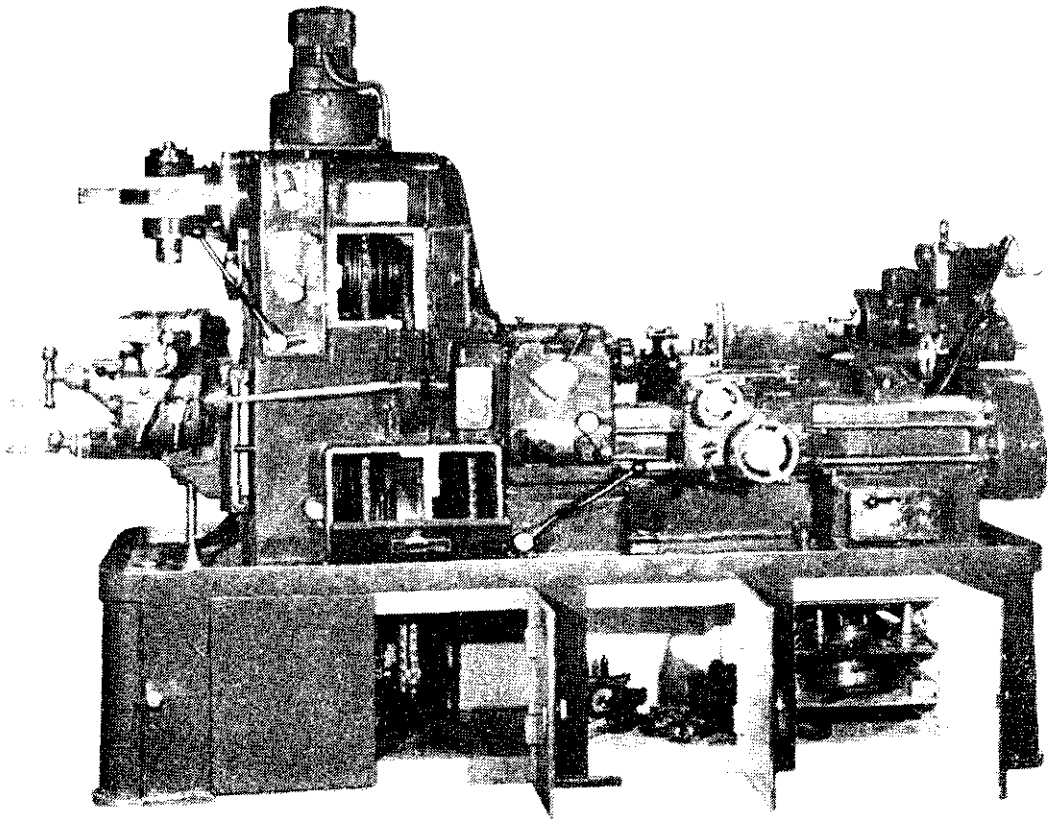
(*f*) There are seven motors fitted on the machine, each with its own push button switch control and contactor control gear. The control gear is fitted on an independent unit outside the machine.

THE UNIVERSAL MACHINE TOOL (SMALL)

The development of the small machine was allocated to Messrs. Adcock & Shipley of Ash Street, Leicester, and provides similar units to those on the large machine but of smaller capacities, details of which are :—

(*a*) *Surface Sliding Screw Cutting Precision Lathe*

Swing over bed . .	. . 8 in.
Distance between centres	. . 18 in.
Spindle speeds . .	. . Number 8, range 58 to 1,020 per minute.
Rates of feed . .	. . Number 8, range ·005 in to ·019 in per rev. per minute.
Screw cutting . .	. . 4 t.p.i. to 100 t.p.i. and equivalent in mm. pitches.



THE UNIVERSAL MACHINE TOOL (SMALL)
THE LATHE AND MILLER ARRANGED FOR VERTICAL MILLING

(*b*) *Milling Section*

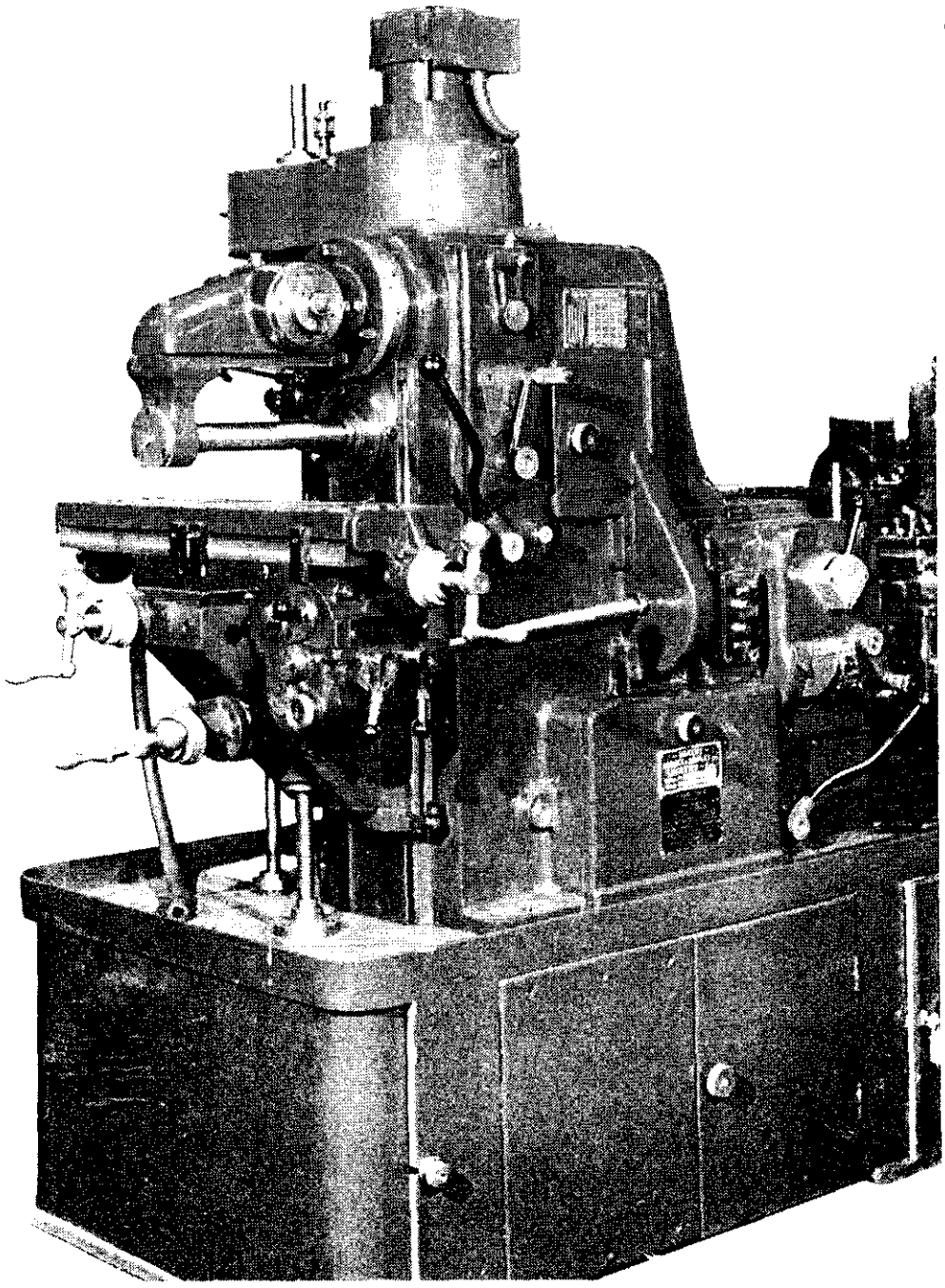
Working surface of table (inside suds well)	..	18 in. × 7 in.
Longitudinal traverse	..	10 in.
Cross traverse ..	..	5½ in.
Vertical traverse ..	..	10 in.
Horizontal table feeds	..	Number 6, range ·004 to ·047 in./rev. of spindle.
Horizontal spindle speeds	..	Number 8, range 48 to 970 rev/min.
Vertical spindle speeds	..	Number 8, range 77 to 1,575 rev/min.
Spindle centre to table	..	0 in. min. 10 in. maximum.
Spindle centre to overarm	..	3⅜ in.

(*c*) *Drilling Section*

Maximum size of hole drilled		½ in (No. 1 morse taper).
Spindle traverse ..	..	3½ in.
Distance spindle to column face		7½ in.
Maximum distance spindle to table ..	..	13¼ in.
Speed of drill spindle	..	Number 6, range 420–5,000 rev/min.
Working surface of table	..	12 in. × 12 in.

(*d*) *Grinding Section*

Maximum swing over table	..	7 in.
Distance between centres	..	10 in.
Wheelhead vertical adjustment		5½ in.



THE SMALL MACHINE WITH THE MILLER ARRANGED FOR HORIZONTAL MILLING

Maximum height of wheel centre above table ..	8 in.
External wheel speeds ..	3,400 and 5,100 rev/min.
Internal wheel speeds ..	13,500—19,000 rev/min.
Number of workhead speeds	3
Range of workhead speeds ..	116, 224, 425 rev/min.
Table traverse speeds ..	13 in to 105 in per minute.
Size of main grinding wheel ..	6 in × $\frac{1}{2}$ in × $1\frac{1}{4}$ in.
Maximum angle table will swivel	45° clockwise; 15° anti-clockwise.

(*c*) *Tool and Twist Drill Grinder*

The wheel head is secured to the bed of the machine on a special seating and when in this position, the motor spindle can be used for general small tool and twist drill grinding.

The general features of this machine tool are similar to the larger one with the following main differences :—

(*a*) The drive to the lathe and milling spindles is by ' V ' belts through a countershaft. Each spindle is independent of the other and each has its own clutch drive. These units are operated by a single 3 h.p. motor sited in the base of the machine ; also the overarm is built for both horizontal and vertical milling.

(*b*) The drill head is individually motor driven, the six speeds being arranged by ' V ' belt.

(*c*) The grinding wheel head is secured directly to the bed of the lathe and connection to the feed drive is by spur gear pinion. This is a much simpler arrangement than that adopted in the large machine. The feed mechanism of the wheel head is extremely sensitive and with the special fine adjustment control, can give a genuine 1/10,000 advance per division. The table traverse to the grinder is independently motor driven through an infinitely variable unit, adjustment to which can be made while the table is working.

(*d*) Independent suds and soda systems have been provided but in this machine there is a common tray, and to avoid mixing the two separate coolants, a ball type changeover drain valve is provided which operates micro switches fitted in the circuit of the coolant motors. The coolant tanks are fitted at each end of the base of the machine and can easily be removed for cleaning. The base of the machine is of fabricated construction and houses all the switches, contact gear and certain of the accessories.

Both machines have been provided with a comprehensive range of accessories which may be reduced or added to as experience dictates. To facilitate this, the machines have been designed to utilize standard fittings. The bayonet type back plate has been adopted on both lathes ; this ensures accuracy over an extended period of use and, in the case of the large machine, enables an easier change over with the heavier type chucks.

Referring to the criteria mentioned above, it can be stated with confidence that nearly all have been met. Universal grinding is the only action which needs the machine to be quiescent, to avoid the well known shortcoming of any grinder its susceptibility to vibration. To offset this, however, it is hoped that the heavier body castings will impart greater rigidity than that found on the existing standard machines, when used on board ship. This rigidity has shown up remarkably well during trials to date, and there is very little vibration even if the lathe, miller and drilling units are used at the same time.

It is hoped to save about 50 per cent of the floor area usually required for the independent machines which, together with some saving in weight on A.C. current ships, for which the prototypes were specially designed, should go a long way to give efficient self-maintenance within the restricted spaces now allocated.