O.M.T. "JUST A SECOND"

If it wasn't for cloud, I imagine at this height it might be possible to see the optics factory of Optical Measuring Tools. Quite a large percentage of the output is earmarked for export markets and quite a number of optical instruments have been used in conjunction with rocket research and space satellites.

Space - come to think of it - space and accurate space at that, is a component part of O. M. T. rotary tables and the measuring of that space is dependent, to a great extent, on the high quality of the optical systems.

The opitcal division of O. M. T. is certainly one of the most forward looking. Here are produced lenses, prisms, optical flats, graticules and mirrors, to name but a few items. Although, for the most part, production capacity is taken up by requirements for optical systems for rotary tables and other O. M. T. instruments, there is a constant demand for the supply of what are called 'naked optics'. Specialised production has been the keynote of O. M. T.'s success in the development of optical tables. This specialisation has been the predominant factor which has resulted in the unequalled accuracy of equipment manufactured.

Accuracy has been accomplished through the application of the O. M. T. concept that readings of the rotary and inclinable positions of tables should be achieved by purely optical means. This design feature offers two important advantages:-

First, the inherent accuracy of a table is maintained during years of use, due to the optical system being entirely divorced from the table drive.

Secondly, there is the great ease of setting and reading, particularly with tables incorporating illuminated projection screens.

Quite naturally, the mechanical mechanism of any rotary table must be compatible with the high accuracy of the optical system and providing this is so, as it is with O. M. T. tables, then settings to the often illusive one second of arc are a certainty and not just a possibility.

Now what is one second of arc? Well, imagine a shot-gun target set at a distance of $3\frac{1}{4}$ miles. If it were possible for a bullet to travel that far and hit the target within 25mm of the bull, then the rifle need only be moved by one second of arc to hit dead-centre.

What of a typical optical system which permits such settings? First, an illumination source and lenses.

A rotary scale - which is possibly the heart of the system.

Wedge prisms, which are part of an optical micrometer ....

and of course the all important viewing screen.

Now, the completion of the optical system.

Lets follow a light path through the system in order to see how a reading is projected onto the screen.

The rotary scale is divided into precise 360 degree divisions which will form the basis of measurement. Later, we shall see how these tenth-of-a-thou' wide lines are produced.

From the rotary scale, degree readings are projected through the optical micrometer and graticle which sub-divides the degree into minutes and seconds. The complete image is then projected onto the viewing screen.

The rotary scales start life as a complete glass blank from which the centre is trepanned. Following this, the scales have to be polished to a high order of accuracy for flatness and parallelism. Here, we can see such polishing in operation.

The glass circles are, in effect, optically worked glass annulars and great care must be exercised during this early stage of their manufacture. Segments of glass fill the centres of the circles during polishing to prevent wash away on the inner edge.

Precise checking is maintained to ensure that surfaces are flat, to within 2 hundredths of a thou' and mutually parallel to within 3 tenths of a thou'.

Polishing completed, degree lines and figures are photo-copies, at a later stage, from specially produced photographic masters. Here, such a master is being prepared on an O.M.T. 760mm numerically controlled table employing a compensated tape.

The master glass disc, coated with a high resolution photographic emulsion, is mounted onto the table platen under two projectors. The projection of graduation lines and degree numbers are carried out under red safe-light illumination. First of all, the table is zeroed and this and the succeeding movements will be controlled by punched tape.

After zeroing the first exposures can be effected. One projector projects a graduation line whilst simultaneously the other projects a degree number at a position displaced from the line by 180 degrees. Following this, the table will be advanced by 1 degree intervals, under tape control, until all 360 degree lines and numbers have been projected.

This somewhat complicated looking piece of equipment is for the manufacture of radial diffraction gratings. Produced to a very high order of accuracy, these gratings are used in digital read-out tables - we shall be seeing one later in the Plessey Plant. Linear diffraction gratings, by O. M. T. , are used exclusively in Newall Jig Boring and Milling Machines.

At the other end of the optical system, the graticule forming part of the optical micrometer, which sub-divides the degrees into minutes and seconds, must be produced to the same high order of accuracy. Here, a master graticule is being drawn many times full size, and it is only after careful checking and re-checking that the masters are inked-in and passed for subsequent reduction by photography.

Having been reduced in size by photography, a graticule is here being inspected before the next stage of proceedings.

Held onto a vacuum board, to ensure absolute flatness, the enlarged drawing of the master graticule is scaled down to the required size by photographic means and a master is produced.

In this laboratory, technicians subject graticules and other photo-processed products to very close scrutiny with the aid of binocular microscopes. In the event of there being any blemishes on the glass plates, these are removed by a 'spotting out' process to ensure that the final product is of the highest quality.

From the optical plant - to the headquarters of Optical Measuring Tools where the machining of all castings, final assembly and inspection is carried out prior to a product being shipped to a customer.

Now, which came first - the chicken or the egg? In this particular instance a microscope casting of an 200mm rotary inclinable table is being machined with the aid of just such a table. This casting exemplifies the use of a rotary inclinable table, for a number of different faces have to be machined. By the use of the rotary and inclinable movements it is possible to machine the casting without the necessity of removing it once firmly in position on the table platen.

Apart from the obvious economy in time, which can be effected by the non-removal of the casting between the machining of different faces, further time saving is effected by O. M. T. with the aid of a numerically controlled machine tool which positions the rotary table carrying the casting with a minimum amount of delay.

By the use of punched tape, Optical Measuring Tools are able to keep production costs to a minimum. For, quite obviously, once a paper tape has been proved on a first component it is a guarantee that all subsequent components will be identical.

The ease with which a component can be repositioned for machining, with the aid of a rotary inclinable table, is clearly demonstrated in this particular view. For not only has the workpiece to be moved from the vertical to the horizontal plane but once in the horizontal plane it has to be rotated into the required new position.

While this is in progress, let's consider the wide range of rotary and rotary inclinable tables available from O.M.T. Sizes range from 200mm to 610mm platens in the inclinable range and from 250mm to 1060mm platens in the plain rotary range. To customer requirements the tables can be provided reading direct to one second of arc or alternatively to 2, 10 or 30 seconds of arc.

According to the size of various tables, they are equipped with either micrometer eyepieces or projection screens. On certain tables there is the additional feature of free-rotation of the platen for setting-up purposes. There is also an optical setting device permitting the establishment of an absolute zero for any angular position throughout 360 degrees of rotation.

In addition to the wide range of rotary tables available from O. M. T. are numerous sizes of dual purpose tables and tables utilising a digital display system. Both of these types of table will be seen later in this film.

Dual purpose tables have been developed to meet the requirement of users whose production processes mainly entail the establishment of accurate angular location in the vertical and or horizontal planes. Of particular interest is the increasingly wide use of dual purpose tables with horizontal boring machines. A demonstration of such a set-up will be seen later on a De Vlieg.

In this particular shot a 400mm rotary inclinable table is being used to facilitate the machining of an aluminium casting destined for use in one of the world's largest workshop projectors - which, incidentally, is also a product of O. M. T.

Having securely positioned the casting, the platen is now being inclined to a 45 degree angle prior to machining the flange of the component. In every instance, when a change of angle is effected, table clamps are applied and a double-check carried out for precise positioning.

The 45 degree angle machining having been completed, the component has now been lowered into the horizontal position and rotation of the component effected in order to permit the drilling of a hole in the side wall for setting purposes.

The positioning of this hole is particularly critical and it doesn't take a great stretch of the imagination to envisage the difficulties which would have to be faced without the aid of such a high-precision rotary inclinable table - working to that second again!

To achieve the standards of accuracy associated with O. M. T. rotary tables and to ensure that they are maintained in service, it is essential that the running fit between the table pivot and mating bearing should be of a very high order. In fact, on final assembly, the pivot and bearing will have a clearance on diameter of only 4 hundred thousandths of an inch. Here, we see the lapping of a pivot diameter prior to its mating-up with a table bearing.

Now, the lapping of a table bearing.

In both of these operations, accuracy of fit between mating components depends, to a great extent, upon the operator's skill and 'feel' during the lapping stages. Nevertheless, numerous checks are carried out to ensure the highest quality of product.

Here, such a check is being carried out. First of all, with the aid of an air gauge plug and ring, utilising a pair of master gauges which have been manufactured to the required clearance, the reading on the air gauge head is set to zero. Incidentally, each small division on the scale of the air gauge is equivalent to 5 millionths of an inch.

Zero having been established with the master set, a substitution is now carried out by the checking of a newly lapped pivot and bearing in the air gauge ring and plug. As has been indicated previously, the permissable clearance on diameter of a pivot and bearing is only 4 hundred thousandths of an inch. This pair is O.K. and can go on for final assembly in a rotary table.

Now, to one of the most important inspection operations carried out during the manufacture of a rotary inclinable table. If a table platen is to be inclined and set to within one second of arc it is of paramount importance that the shaft on which the inclinable assembly will move, in relation to the base casting, is not only straight but parallel with the underside of the main base and resultantly with the working surface of the table of a machine tool or surface plate. The check is made by comparing the height of the top of the shaft with stacks of known slip gauges at three positions along its length. This is done with a dial indicator mounted on a long and particularly rigid arm. The indicator is set to zero on the slips, which are then moved away and the component moved under it. The base is moved rather than the indicator stand to obviate any minute errors in the surface plate which would otherwise be magnified by the length of the arm and would show wild inaccuracies.

Any deviation from the height of the slips is shown on the scale of the indicator and is recorded by the inspector. By deducting half of the previously measured diameters at the appropriate positions along the shaft, the accuracy of the centre line can be calculated both for parallelism and straightness.

The maximum combined error permitted is two tenths of a thou' over a shaft length of 20 inches (500mm).

Now, one of the final assembly operations of a rotary inclinable table. This, the inclinable base assembly, carries the pivot bearing we have previously seen lapped and the roller assembly on which the platen revolves. This assembly consists of 27 rollers which are lapped together as a set. The actual size of the rollers is relatively unimportant but the maximum deviation between any rollers in a set is one hundredth of a thou'.

In this tilted position we see the underside of the platen assembly. Clearly indicated is the pivot and the rotary optical scale. This platen assembly is lowered into position and in spite of the minute clearance of 4 hundredths of a thou' is guided easily into place by a pilot diameter ground on the pivot.

Final assembly completed and with it all the various intermediate inspection operations, a table must now undergo final performance checks.

In this instance, a specially designed and manufactured reflecting angle block, mounted onto the table platen, is used in conjunction with an auto-collimator for the checking of the inclinable scale settings in the horizontal, 45 degree and vertical positions.

The angle of the table is set at the appropriate nominal position using its own optical system. The inspector with the auto-collimator reads off any deviation from the nominal in his eyepiece and records his readings.

It is a known fact that when readings are correct in the horizontal, 45 degree and vertical positions, then all intermediate readings will also be correct.

Having checked the accuracy of the inclinable scale, we now go on to check the accuracy of the rotary scale. This is carried out with the same auto-collimator but in this instance an Ultradex polygon, with which can be checked each of the 360 degree divisions, is mounted onto the table platen. It is practice for the setting of the rotary scale to be checked at 5 degree intervals in view of the known accuracy of the scale itself and usual customer specifications.

In addition to the scale setting, the accuracy of repeatability is checked by rotating the table to zero in one direction and taking a reading in the auto-collimator. Then, moving on and coming hack to zero again from the opposite direction a repeat zero reading must be obtained.

Let's see, we were talking earlier of the accuracy of our tables and the meaning of 1 second of arc. It's about an inch over 3 miles, isn't it. I'm flying something like 3 thousand miles from London to New York. If we were flying to an accuracy of 1 second, our error, on arrival at destination, would be about the wing span of this plane. Ah, I remember, we built a special non-magnetic table for use at the Admiralty Compass Observatory for checking compasses. I wonder how they're getting on? When I get back I'll arrange for somebody to go along and see them.

The work which is being checked on the non-magnetic table certainly bears no resemblance to the museum pieces displayed in the entrance hall.

The superstructuré erected over our non-magnetic table is designed to simulate any magnetic field likely or unlikely to be encountered anywhere in the world. Like the table it is, of course, completely non-magnetic.

In this instance, the non-mag table is being employed to check the accuracy of a gyroscope which is mounted on the platen. A detector unit is at the top of the superstructure and is being subjected to a simulated magnetic field. A read-out compass is mounted in the free-standing unit displayed on the right. The technician having previously set the non-mag table to zero checks that the read-out compass is also giving a zero reading.

The table is then rotated through 22 degrees 30 minutes (a sixteenth of a complete revolution) and the compass read-out figure is noted and recorded. This operation is continued for another 15 times to complete a revolution.

Some quite unforeseen difficulties were encountered with this table. Even some bronzes and aluminium alloys were found to be slightly magnetic and believe it or not even the paint was eventually checked. The rollers which are normally of hardened steel were made of fused silica.

Hmm. The Q4, Queen Elizabeth the 2nd, that's the latest transatlantic liner to be launched. They're spending quite a bit of money on that project not only from the point of passenger comfort but also on operating efficiency. We had some influence on the running efficiency by way of the work carried out at the Ministry of Defence Compass Observatory.

Instead of an aero gyroscope, in this case a marine compass is being checked on the O. M. T. non-magnetic table. There is no separate read-out to this type of instrument so the technician sets it directly to the scale on the compass card and checks the reading against the optical scale of the table via the viewing screen.

Set up on a co-ordinate measuring machine, a 400mm dual purpose table, embodying a diffraction grating and digital read-out system, an admiralty gear box casting is being inspected. The table is rotated to line-up the datum axis of the casting with the linear axis of the measuring machine, after which the read-outs are set to zero. Following this the table is rotated to the required angle as specified on the component drawing, the angle being displayed on the read-out screen. How much quicker this is than making plugs to fit holes and measuring angles with a sine bar.

Set up for inspection on a 400mm rotary inclinable table is a memory drum, used extensively in telephone communication systems. Again, the table is set to the required angle of inclination and locked in position. The height of a setting pin in a datum hole is checked, using a height gauge previously set to zero against a bank of appropriate slip gauges. The operation is repeated with other datum holes in the component, zero being read from an electrical comparator.

Talking of inspection, we take our own medicine and use a rotary table in the O. M. T. Test House to check the accuracy of vee jaw blades used in the O. M. T. Horizontal Comparator to check the effective diameter of a screw thread ring gauge. Quite naturally, as this jaw blade is to be used for measuring gauges it is vital that its accuracy be of the highest order. In the inspection of the vee, the table scale is first set to zero and the jaw blade clamped to the platen. A collimator is also zeroed reflecting from one flank of the vee. The table is rotated until the other flank of the vee is reflected in the collimator eyepiece and reads zero.

Here, at the Royal Aircraft Establishment at Farnborough, we see a typical indication that O. M. T. Tables are employed just as effectively on horizontal boring machines as on vertical machines. In this instance, an aluminium casting - actually a mounting for one of the mirrors of the large projector previously referred to - is being machined. The casting is clamped on a dual purpose table which, in turn, is mounted on a 30 inch projection type table. The first operation shows the dual purpose table set square to the spindle of the machine to drill and ream holes for the mirror clamps. On completion, both the dual purpose table and the 760mm table, on which it is mounted, are reset to permit the boring of a hole at a compound angle to the front face of the component.

It is obvious that such a combination of tables is completely versatile when used on a horizontal spindle machine and absolutely any compound angles can be achieved with such a combination.

Although this operation has called for a dual purpose table mounted on a 760mm projection table, it is possible to mount one 760mm table vertically on another of similar size. This provides capacity for precision machining well beyond anything obtainable with the largest optical rotary inclinable table available. For example, the machining of parts of the nose cone assemblies of rockets is much simplified by this set-up.

Ah well, here's another flight nearly over and we'll be arriving at New York in a very short time. It looks as though we shall be on time - had a beautifully smooth flight - today's planes are a lot more reliable than they used to be - thank heaven. In particular, thanks to the complete reliability of the engines and to the maintenance people who look after them. Come to think of it, they're using one of our tables on maintenance at B. O. A. C. Heathrow.

An aero engine is in for overhaul and this is the main casting of one of its auxiliary units. It is worn and needs to be rebored and bushed to restore its original dimensions. Here, it is being accurately centred on the platen of a 400mm rotary inclinable table.

Having centred the casting, the platen is inclined to the vertical position and carefully locked in place using the long links. The operator checks to ensure that no movement has occured during locking.

The operator then clocks a machined face to ensure that the rebored hole will be square to its datum and then clocks the unworn part of the hole to establish its original centre.

Satisfied with his setting, the operator removes the indicator and substitutes a boring and facing head and proceeds with the precision boring of the hole to the required size for rebushing.

Boring of this hole completed, the tool is removed and replaced by the dial indicator. The table is reset to another hole for similar treatment. This merely entails the rotation of the platen whilst still in the vertical position.