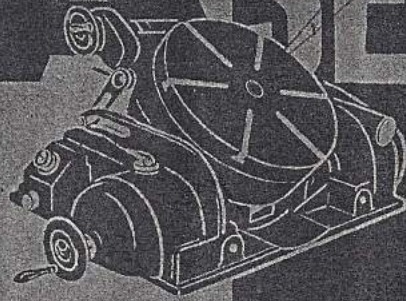


JUST A SECOND



O. M. T. ROTARY AND ROTARY-INCLINABLE TABLES

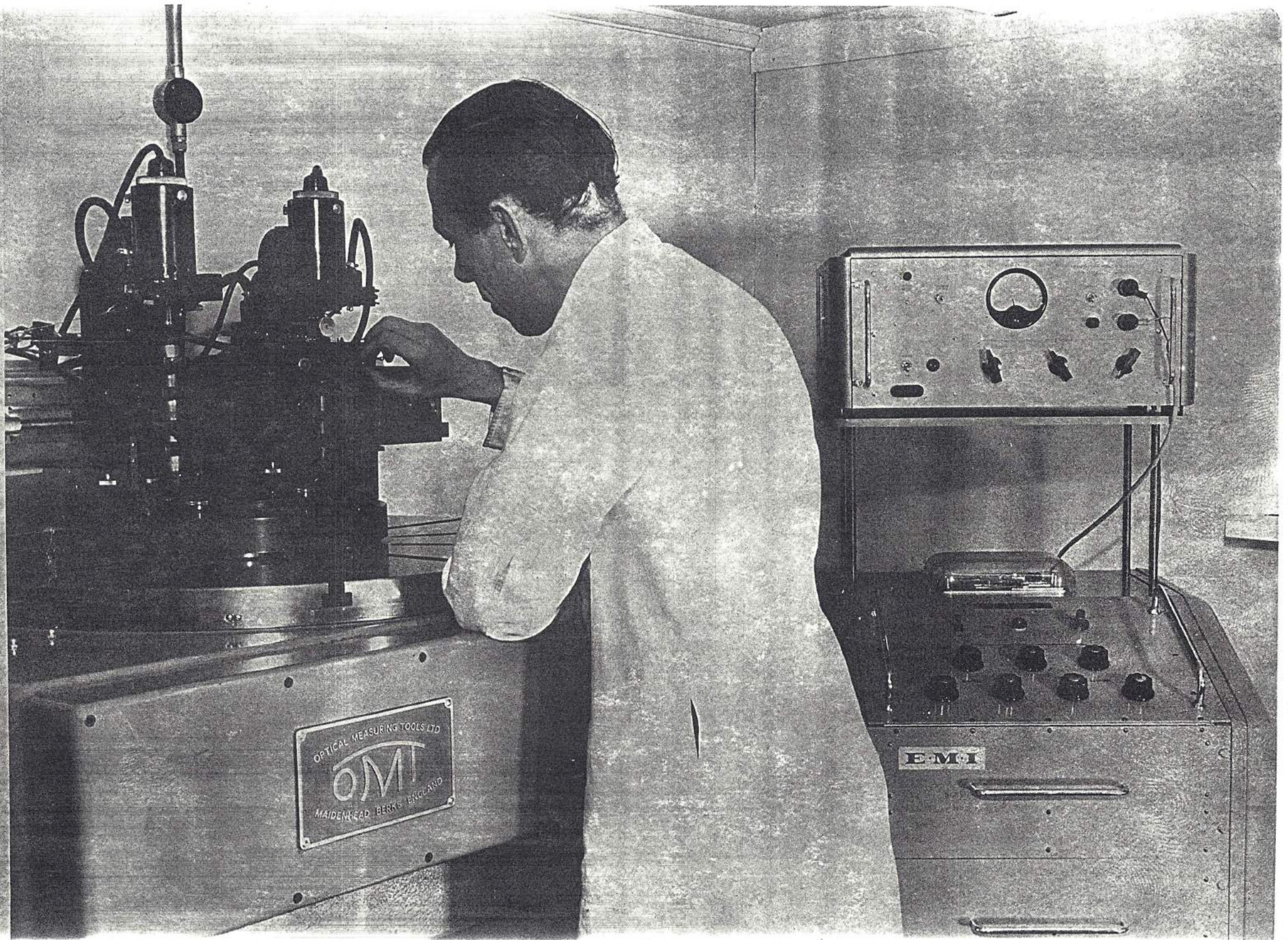
JUST A SECOND!

And forget for the moment the proverbial bat of an eyelid, for the object of this exercise is not a study of time, but a consideration of space. Not, mind you, an evaluation of inter-planetary distances, but a brief look at some of the techniques employed by Optical Measuring Tools Ltd. in producing rotary tables essential equipment for precise machining and testing component parts to the high order of accuracy demanded in thousands of contemporary engineering projects.

The following illustration depicts the photo-electric apparatus by which master negatives are produced .
Circular glass scales that have precise 360° markings which form the basis of precision angular measurement are printed from the negatives. The lines and related figures are exposed by projection on to a specially prepared sensitised plate. The 0.0001" thick lines are accurately spaced by means of an O. M. T. tape-controlled, auto-positioning 30-inch rotary table which has been calibrated at every degree to an accuracy of 1 second of arc.
Automatic positioning accuracy of the table permits repeat settings to be made within $\frac{1}{2}$ second of arc.

(Print No. OMT/100)

Products of OPTICAL MEASURING TOOLS LTD. MAIDENHEAD, ENGLAND, are marketed in England by
NEWALL GROUP SALES LIMITED
Peterborough 'phone 67116 or Maidenhead 'phone 26171



OPTICAL MEASURING TOOLS LTD
OMT
MAIDENHEAD, BERKS ENGLAND

EMI

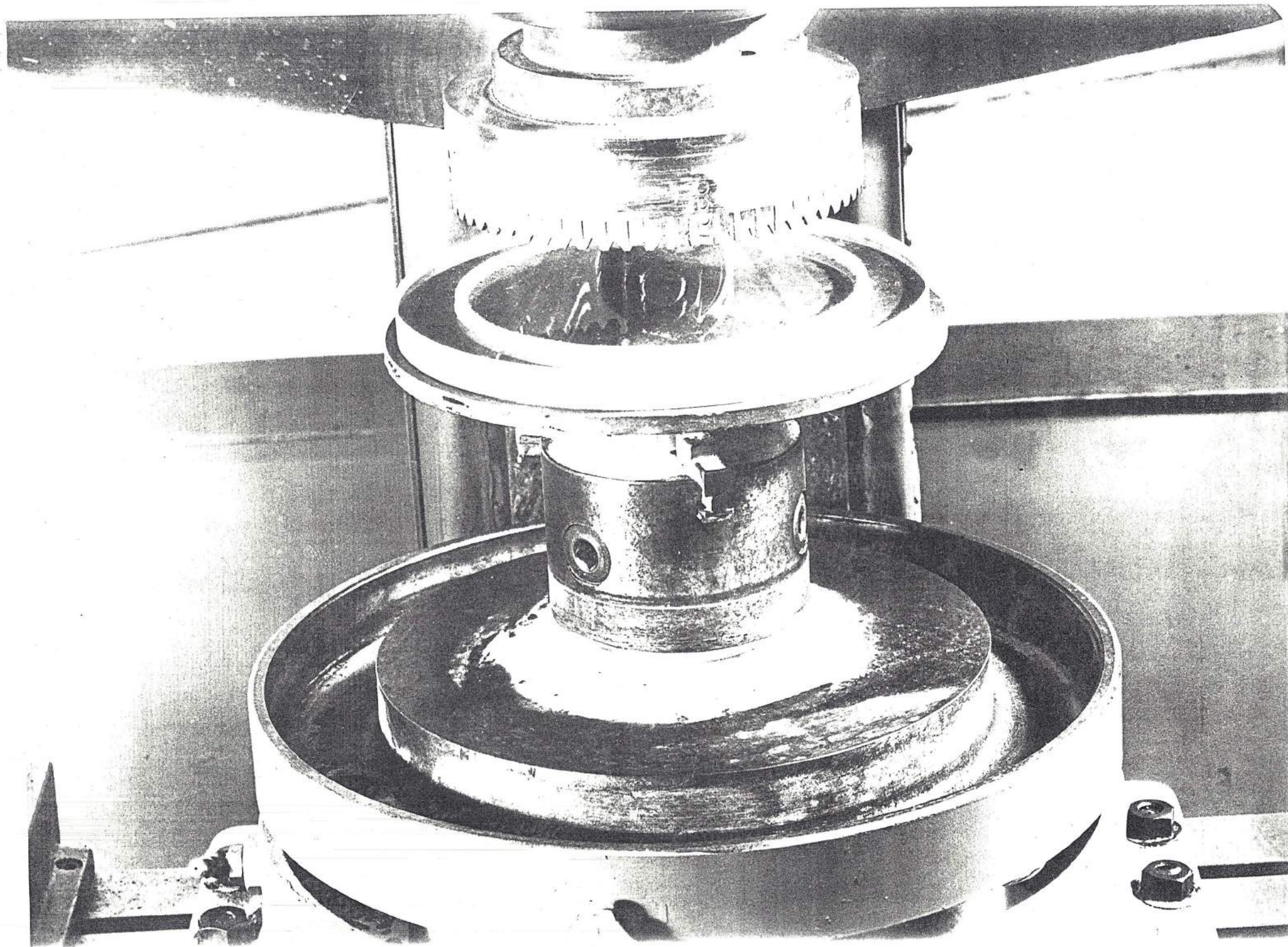
TO BE PRECISE

1902.

The concept of accuracy and quality as applied to O. M. T. optical rotary tables originated over 60 years ago with The Newall Engineering Company (parent concern of Optical Measuring Tools) devising the Newall Standard Table of Limits and Fits, which defined tolerances requisite to achieve perfection in mating and interchangeability of their engineered products. This system established at the time an internationally accepted standard which still applies. Measurement and gauging of work to the stated limits was generally beyond the scope of any inspection equipment available at the turn of the century. To remedy this deficiency, the Company commenced manufacturing high precision gauges and mechanically controlled measuring equipment. It was, in fact, producing linear measuring machines capable of determining accuracy within 0.00001" (ten millionths) over a century ago.

The succeeding photograph shows the operation of trepanning the centre from a glass scale with a diamond impregnated cutter.

(Print No. OMT/94)



PURELY OPTICAL

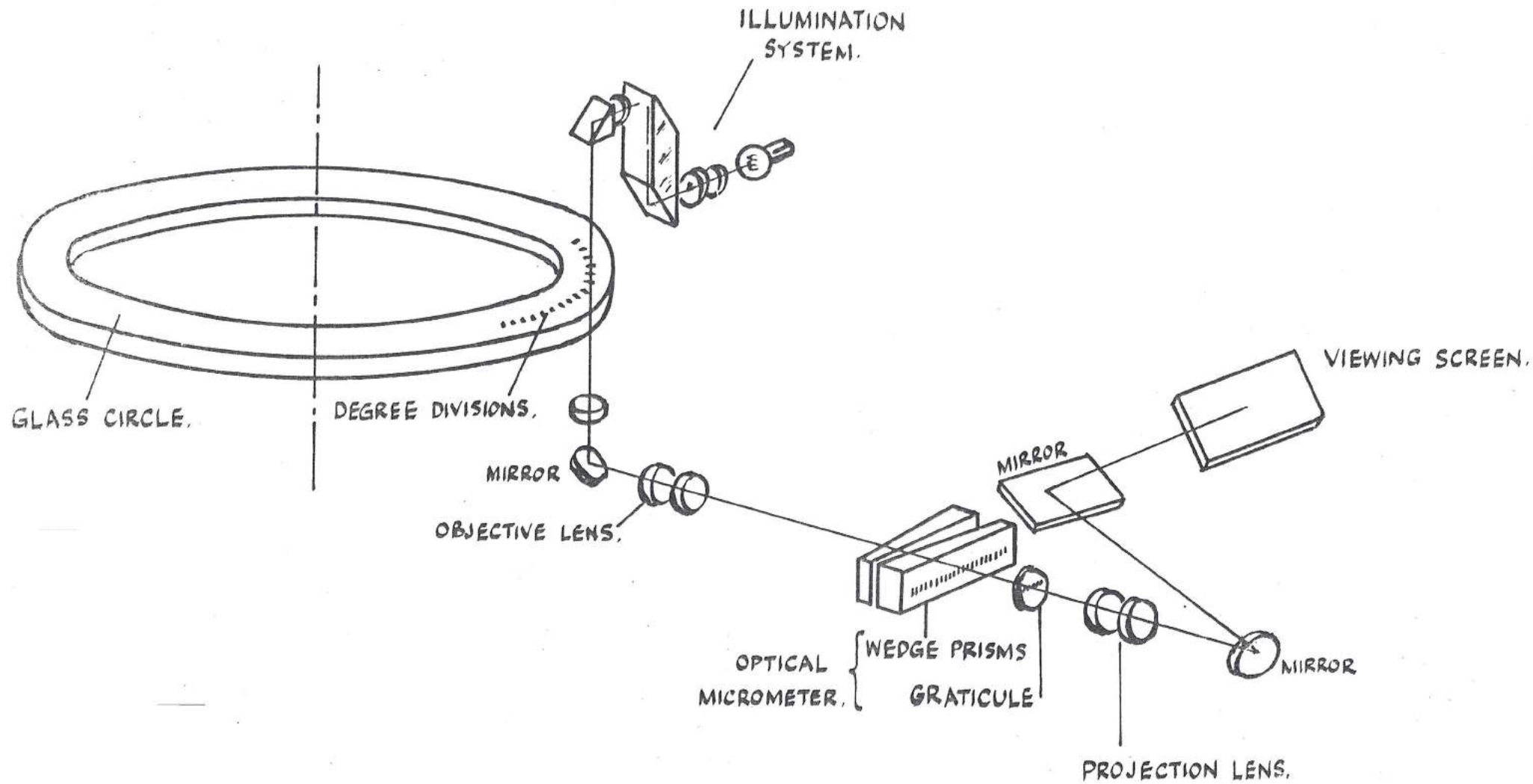
Specialised production is the keynote of Optical Measuring Tools' success in the development and marketing of optical rotary and rotary inclinable tables. It is also the predominant factor which has resulted in the unequalled accuracy of the equipment and the Company becoming the world's largest producer of ultra-precision rotary tables.

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

1. The inherent accuracy of the table is maintained after years of use because the optical system is entirely divorced from the mechanism actuating table movement.
2. Great ease of setting and reading, particularly of models incorporating illuminated projection screens.

The following sketch details the optical system of the O. M. T. 16" projection type rotary table .

(Print No. 16PT/35)



11. OPTICAL TABLE DISASSEMBLY UNIT OF OPTICAL SYSTEM

MORE OPTICS

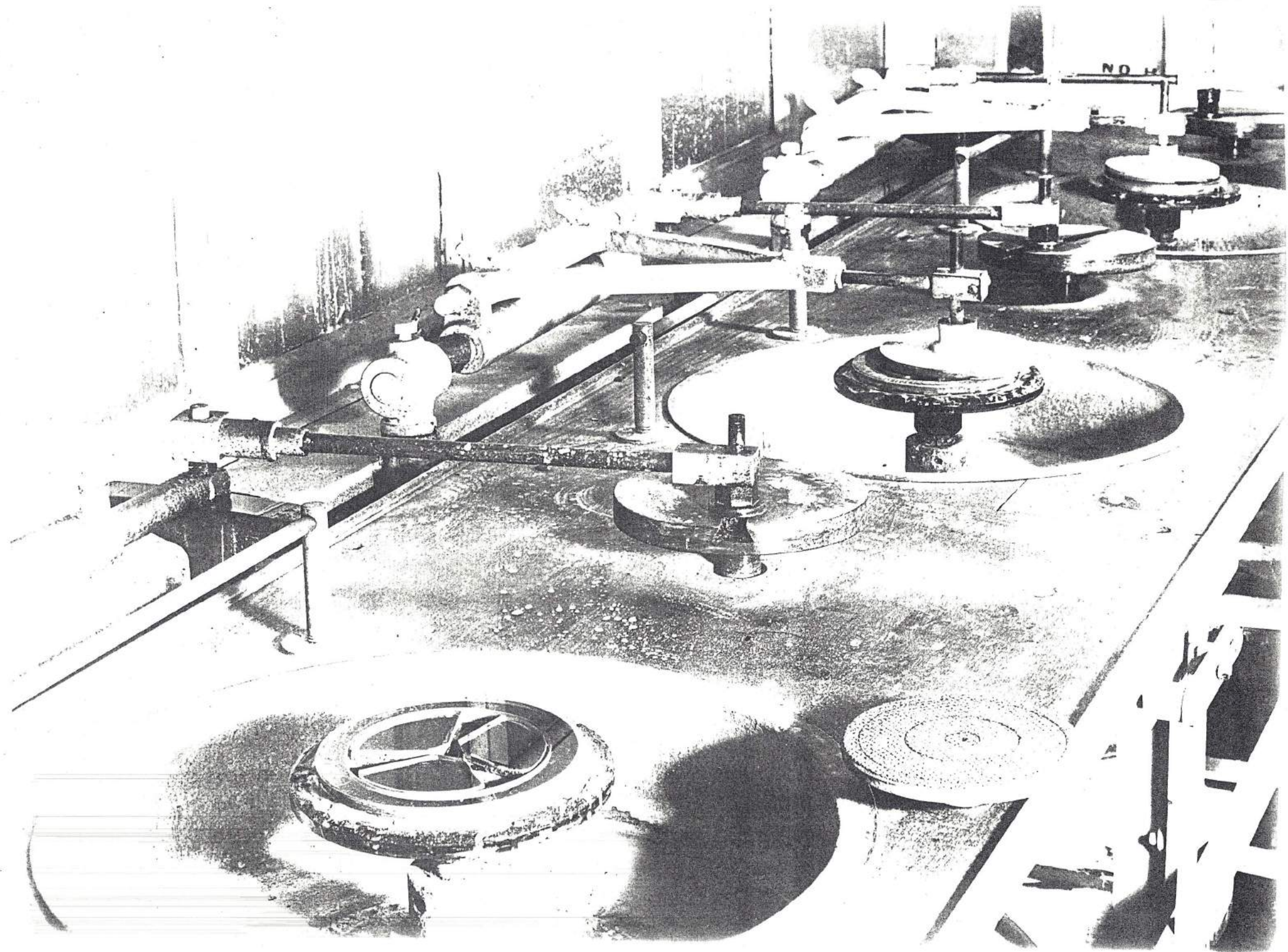
The high order of accuracy obtainable with the range of O. M. T. rotary and rotary-inclinable tables is based on the employment of angular glass scales and quadrants. The scales are, in effect, optically worked glass annulars (circles) whose surfaces are flat within 0.00002" and mutually parallel within 0.0003".

The degree lines and figures, seen either through an eyepiece or projected on to a viewing screen, are produced on the annular by a photographic process perfected after several years' research. The degree lines are 0.006" long and have a width of only 0.0001". Stringent acceptance tests are applied to the circle and quadrant before assembly, and the angular spacing error of any degree line does not exceed ± 3 seconds of arc.

With the exception of tables with a 30" or larger diameter platen, all models incorporate glass scales with the degree division on a 6" pitch circle diameter; the ± 3 seconds of arc tolerance therefore represents a linear displacement of only ± 0.000045 ".

Production of graduated scales to seconds of arc precision is reliant upon a high order of accuracy for flatness and parallelism. The following photograph shows glass circles being polished in the O. M. T. optical division.

(Print No. OMT/95)



OPTICS PRECISELY

Ultra-precision tables in the O. M. T. range have scales reading direct to 1 second of arc. This is accomplished by using an optical vernier to divide the degree units into minute intervals and then sub-dividing the minutes into second intervals through the medium of an optical micrometer.

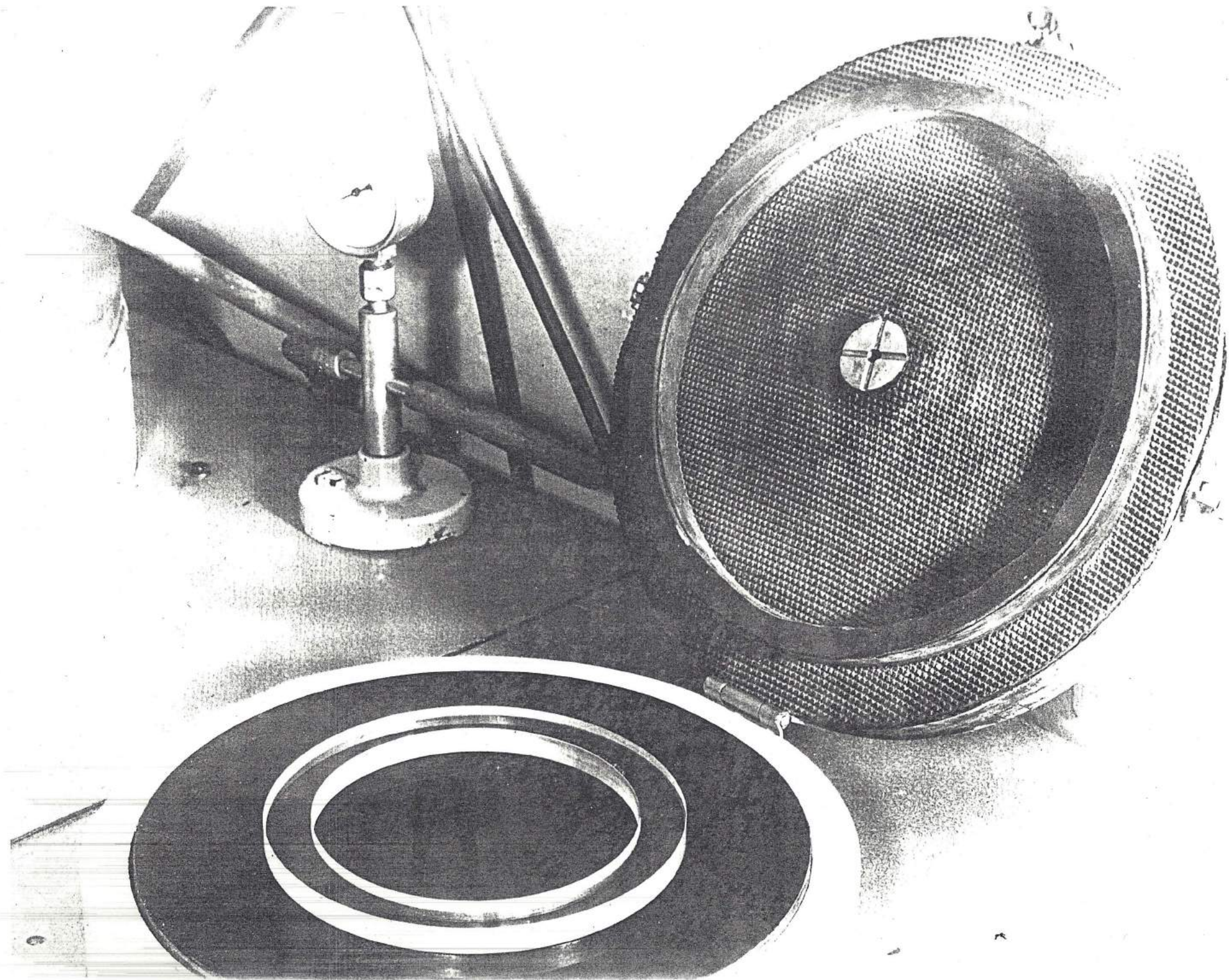
Main advantages of an optical vernier over the conventional mechanical type are as follows :-

- (a) Absolute freedom from parallax is possible, as the image of one scale can be focused exactly in the plane of another. If, therefore, the eye is moved relative to the scales, no variation in reading occurs.
- (b) By reason of the magnification factors involved, fine sub-division is possible; a greater reading accuracy can thus be obtained.
- (c) Any wear which occurs in moving parts cannot affect reading accuracy, as the readings taken are by direct comparison of one optical scale with another.

The optical micrometer sub-divides the minutes into seconds by refraction of the image of the degree scale through a glass prism assembly. In practice, the main scale line is brought into coincidence with fiducial blocks on the minute scale by moving the prism unit across this field and thereby deviating the image of the scale line by refraction. The seconds scale on the prism can then be read off against a pointer.

This system permits minutes and seconds to be pre-set and provides facilities to zero the optical setting to the nearest pair of fiducial minute blocks.

After being optically worked, the scale blank is coated with a high resolution emulsion to ensure maximum accuracy and definition of the 360 degree lines. The sensitized blank is exposed to the master negative under measured vacuum in a rigid printing frame as portrayed in the succeeding illustration. (Print No. OMT/96)



OPTICAL AND NO ILLUSION

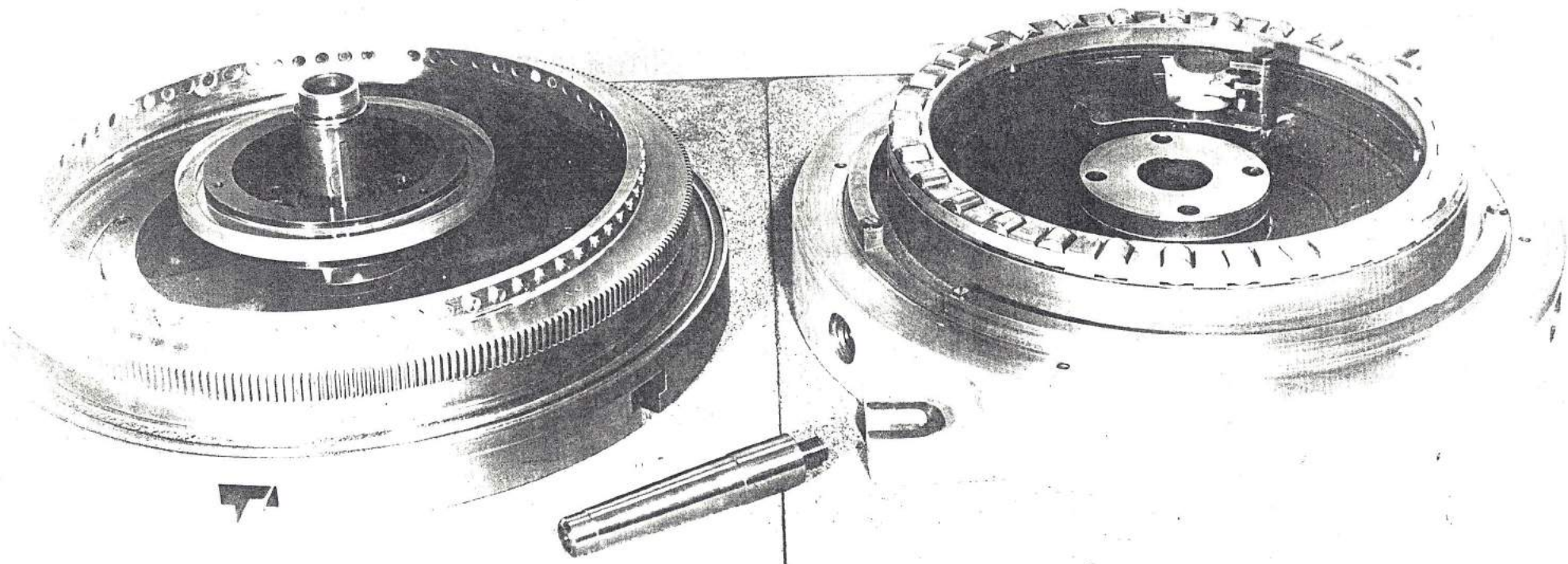
O. M. T. claims with every justification to offer the most comprehensive range of high precision optical rotary and tilting tables available from any single manufacturer in the world. Sizes range from an 8-inch tilting model to a 36-inch plain table, and all have optical setting systems.

The most precise have scales reading direct to 1 second of arc, with a guaranteed setting accuracy in any position within 360° of ± 3 seconds, and repeatability of setting to within 1 second.

O. M. T. not only claim accuracy of tables and issue a certificate of such with each item, but, to customer requirement, submit tables for checking by The National Physical Laboratory (British Bureau of Standards) or any overseas Standards Bureau to provide a detailed and certified statement of accuracy.

The following illustration shows (left) the top and (right) the bottom housings of a 16-inch projection table. The top unit incorporates the circular glass scale, the gear wheel governing platen movement and the clamping system comprising free-sliding pins to avoid distortion when clamping is applied. The outer roller bearing support and part of the optical unit which projects the scale image on to the viewing screen are shown in the bottom housing. The centre test plug, required to run truly to 0.0001" on final assembly, is centred between the two units.

(Print No. 16PT/25)



THAT SECOND AGAIN

Like the engineer's "tenth", or rather "hundredth", in this era of ultra close tolerance work a second of arc is easy to say but rather more difficult to envisage as a measurement. For instance, an error of one second of arc on a 5-inch radius in terms of linear measurement = $0.00000484 \times 5'' = 0.00002420''$. A quick and generally accepted formula for converting angular displacement to length measurement is as follows :-

$$\text{ANGULAR TOLERANCE} \times \text{RADIUS} \times 3 = \text{ANSWER IN TEN THOUSANDTHS INCH}$$

(3 is a constant)

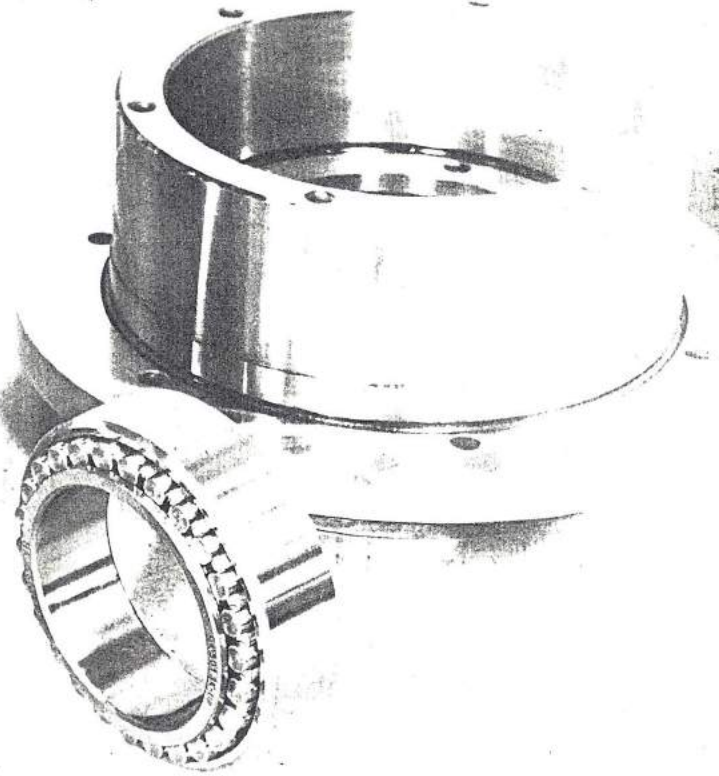
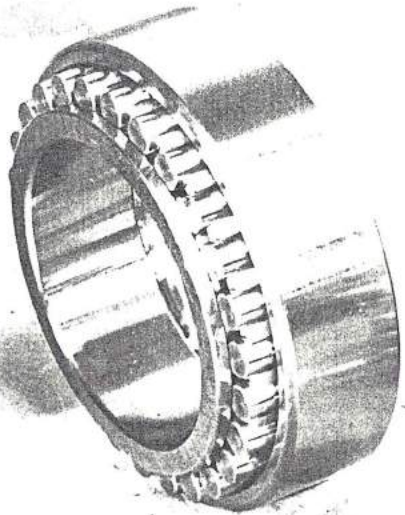
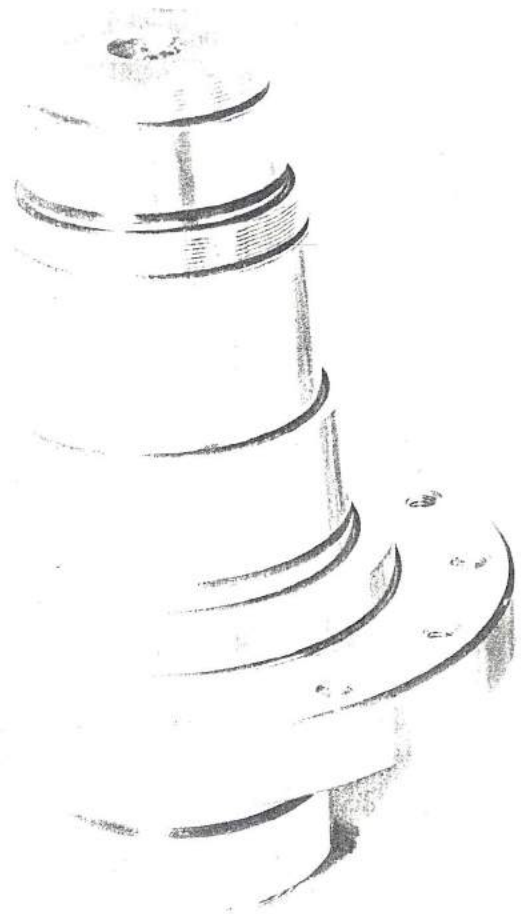
Thus, with a 1 second error on a 5-inch radius we have :

$$\frac{1}{60} \times 5'' \times 3 = 0.000025'' \left(\frac{1}{4} \text{ tenth}\right)$$

For purpose of comparison, a " $\frac{1}{4}$ tenth" is to 1-inch as 1-inch is to the liners Queen Mary, France and America in line astern with some 200 feet of space between each vessel. Alternatively, a " $\frac{1}{4}$ tenth" is approximately $\frac{1}{100}$ th of the diameter of a human hair.

These statistics could well be an eye-opener to the many people who are prone to accept claims for equipment accuracy without realising the importance of such claims.

Optimum rotational accuracy and rigidity of the 30-inch table are achieved by means of a precisely machined centre pivot and ultra precision S. K. F. cylindrical bearings. These component parts are portrayed in the following photograph.



AUTOMATICALLY A SECOND

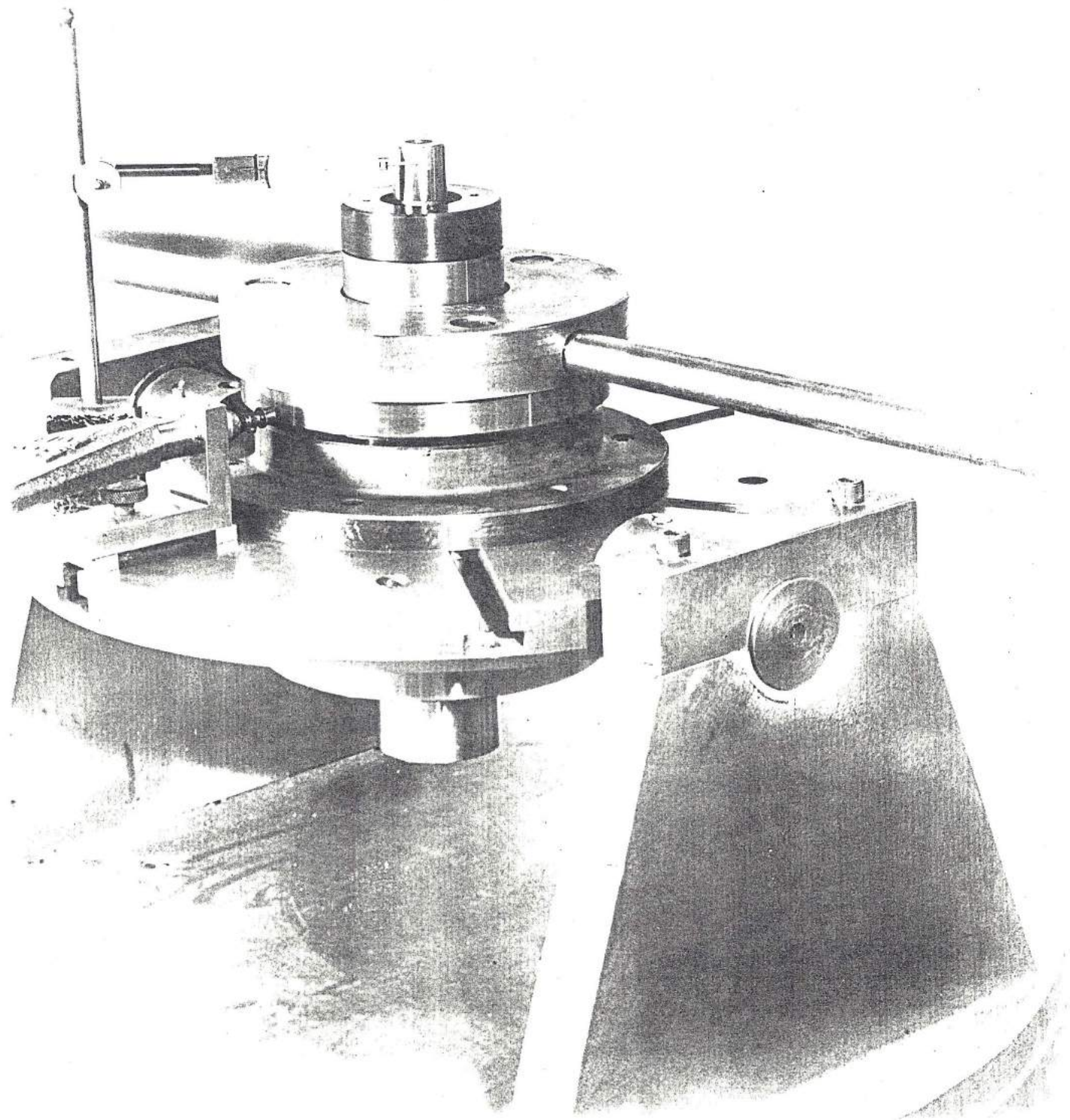
The O. M. T. manufacturing programme has always kept in advance of industrial requirements, particularly in respect of rotary tables. The envisaged demand for a tape-controlled, auto positioning model resulted in production of the 30-inch unit with E. M. I. 'Inductosyn' control system. With direct positioning to the nearest second, a guaranteed setting accuracy within ± 3 seconds of arc, and repeatability to ± 1 second, this was the world's first fully automated rotary table capable of such precise angular spacing.

For users in the U. S. A. , 30" and 36" tables are available with alternative control systems, such as Farrand, and providing a similar high order of automatic setting accuracy.

After assembly, the centre bearing of the 30-inch table is pre-loaded and a running accuracy of the test plug to within 0.00015" is established.

The set-up for applying pre-load and checking rotational accuracy is disclosed in the following illustration.

(Print No. 30T/19)

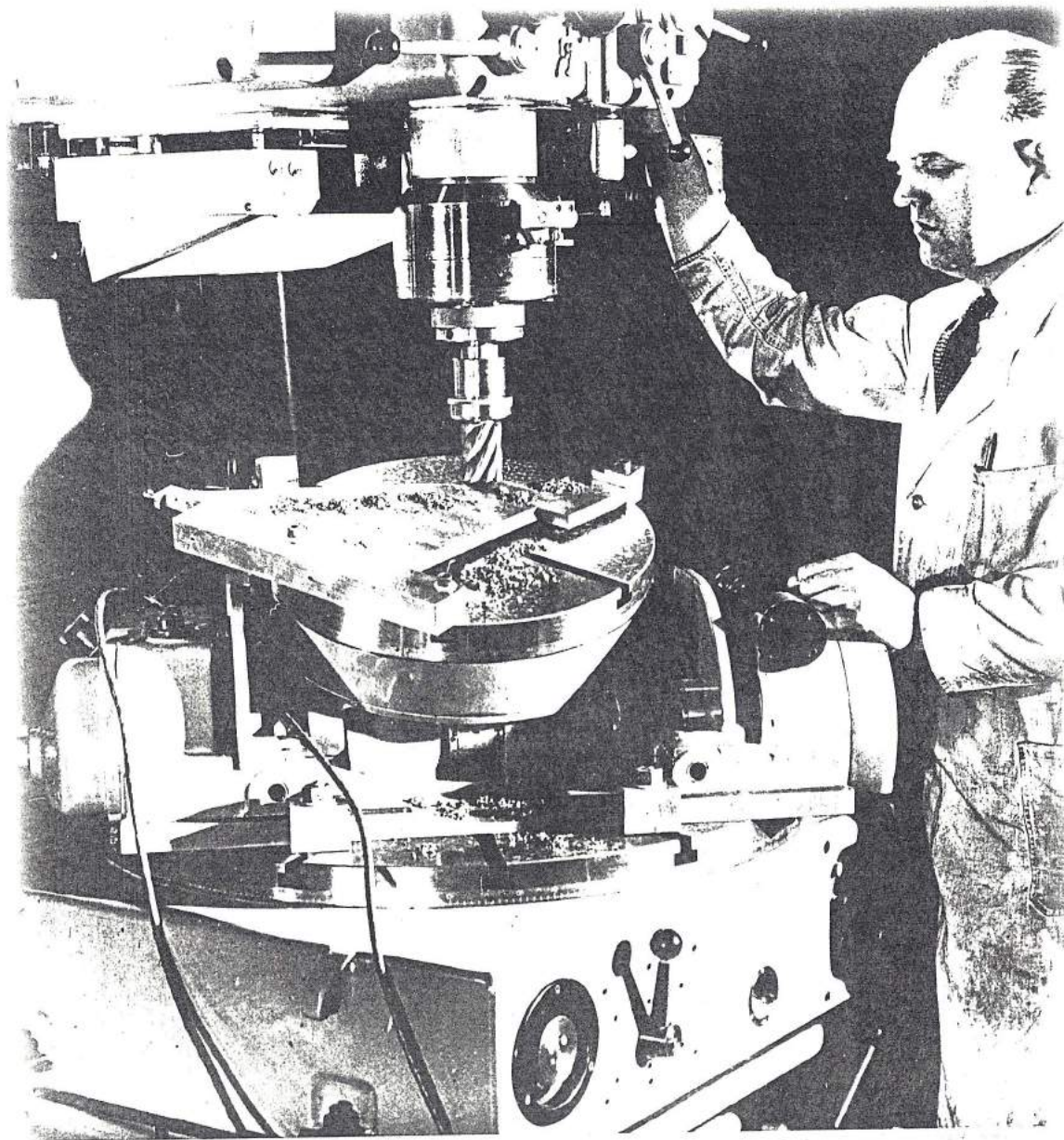


PROOF OF THE PUDDING

In the past twenty years approaching 2,500 O. M. T. optical rotary and rotary inclinable tables have been sold; distribution has been world-wide. One of our major customers is the UNITED KINGDOM ATOMIC ENERGY AUTHORITY (59 tables of all types), and the vast majority of large organisations we supply specify O. M. T. when ordering new equipment.

Depicting joint employment of O. M. T. 30-inch rotary and 16-inch rotary/inclinable tables for tangential milling of an aerofoil section, the following photograph is reproduced by courtesy of The English Electric Company Ltd.

(Print No. 30T/6)



SOME OF OUR U. K. CUSTOMERS

GOVERNMENT

The Admiralty
H. M. Dockyards
Ministry of Supply
Ministry of Aviation
Inspectorate of Armaments
National Physical Laboratory
Post Office Engineering Department
Royal Ordnance Factories
Royal Aircraft Establishments
Department of Scientific & Industrial Research

INDUSTRY

Armstrong Whitworth Aircraft Ltd.
Armstrong Siddeley Ltd.
Atomic Energy Authority (United Kingdom)
Atomic Weapons Research Establishment
Associated Electrical Industries Ltd.
Austin Motor Co. Ltd.
Blackburn & General Aircraft Co. Ltd.
British Timken Ltd.
Bristol Aeroplane Co. Ltd.
British Overseas Airways Corporation
Boulton Paul Aircraft Co. Ltd.

INDUSTRY (continued)

Courtaulds Ltd.
Cambridge University
Colchester Lathe Co. Ltd.
Dunlop Co. Ltd.
De Havilland Aircraft Ltd.
Decca Navigator Co. Ltd.
English Electric Co. Ltd.
E. M. I. Ltd.
Ex-Cell-O Corporation Ltd.
Euclid Ltd.
General Electric Co. Ltd.
Gloster Aircraft Co. Ltd.
Ferranti Ltd.
Folland Aircraft Ltd.
Frigidaire Ltd.
Alfred Herbert Ltd.
Harland & Wolff Ltd.
Hunting Aircraft Co. Ltd.
Imperial Chemical Industries Ltd.
Ingersoll-Rand Ltd.
I. B. M. (United Kingdom) Ltd.
International Computers Ltd.
Jaguar Cars Ltd.
Joseph Lucas Ltd.

SOME OF OUR U. K. CUSTOMERS (continued)

INDUSTRY (continued)

Leyland Motors Ltd.
Morris Motors Ltd.
Massey-Harris-Ferguson Ltd.
Marconi Ltd.
Metropolitan Vickers Ltd.
National Cash Register Co. Ltd.
Pye Telecommunications Ltd.
Rolls-Royce Ltd.
Standard Telephones Ltd.

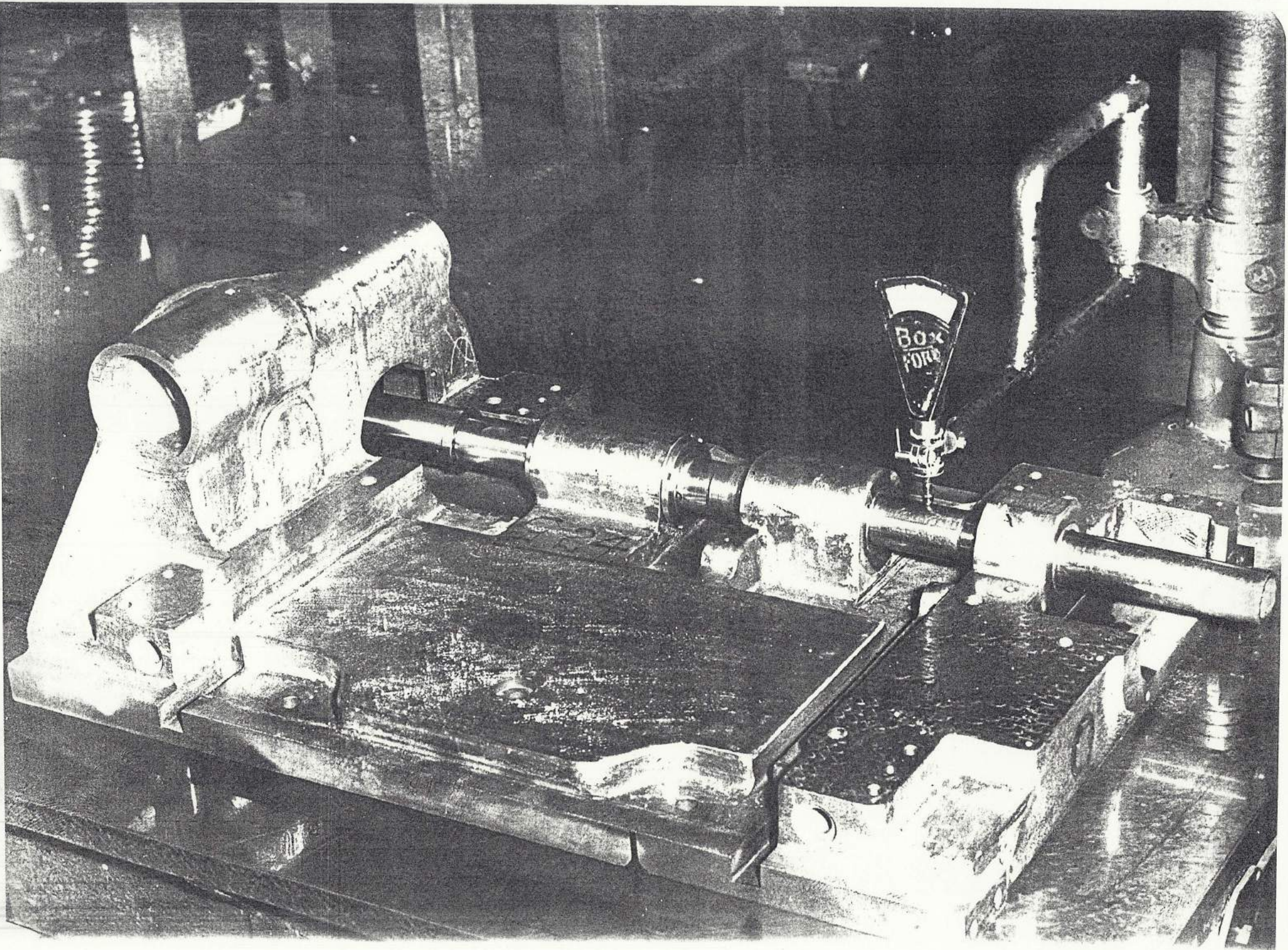
Saunders Roe Ltd.
Short Bros. & Harland Ltd.
Standard Motor Co. Ltd.
Textile Machinery Ltd.
Technicolor Ltd.
Tube Investments Ltd.
Vickers Armstrong Ltd.
Westinghouse Brake & Signal Co. Ltd.
Westland Aircraft Ltd.

R. I. T. - PAGE TEN(A)

Meticulous and comprehensive inspection procedures are applied to every O. M. T. table to ensure that each unit complies with the Specification of Accuracy agreed to by the NATIONAL PHYSICAL LABORATORY. A selection of inspection phases relating to a rotary inclinable table is illustrated in the following pages.

The following illustration depicts a set-up for checking parallelism of the inclinable axis to the underside of the main base prior to painting and assembling. The maximum error which can be tolerated is 0.0003" in 14 inches. The height of the shaft is also recorded at this stage.

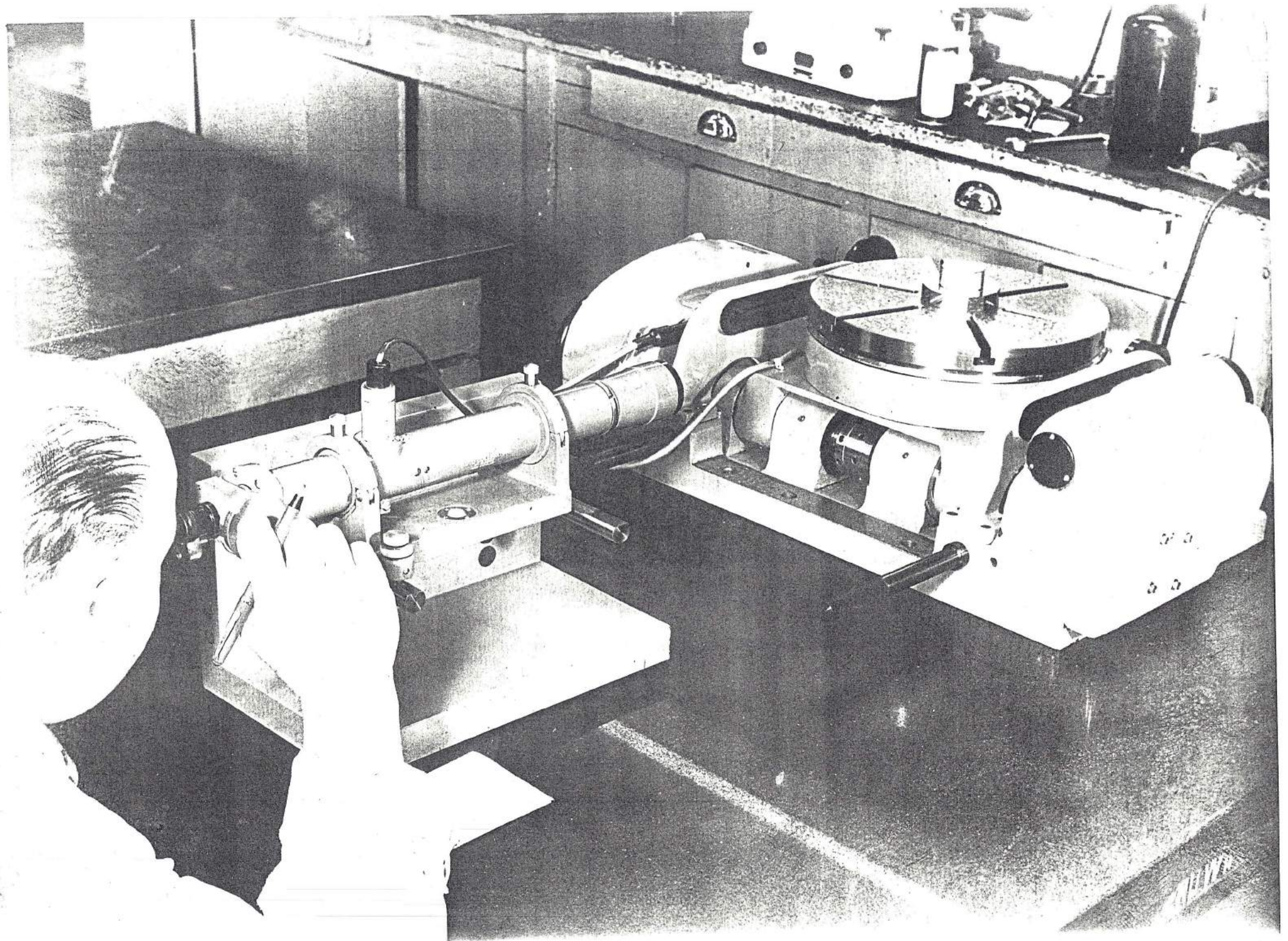
(Print No. 16IT/32)



A 12-inch Rotary Inclinable Table being checked for positional accuracy of the rotary section at 30 degree intervals is shown in the succeeding photograph. The check is carried out with the aid of a National Physical Laboratory calibrated 12-sided polygon used in conjunction with a 0.2 second direct reading auto-collimator. The accuracy of determination is ± 1 second of arc.

(Print No. 12T/16)

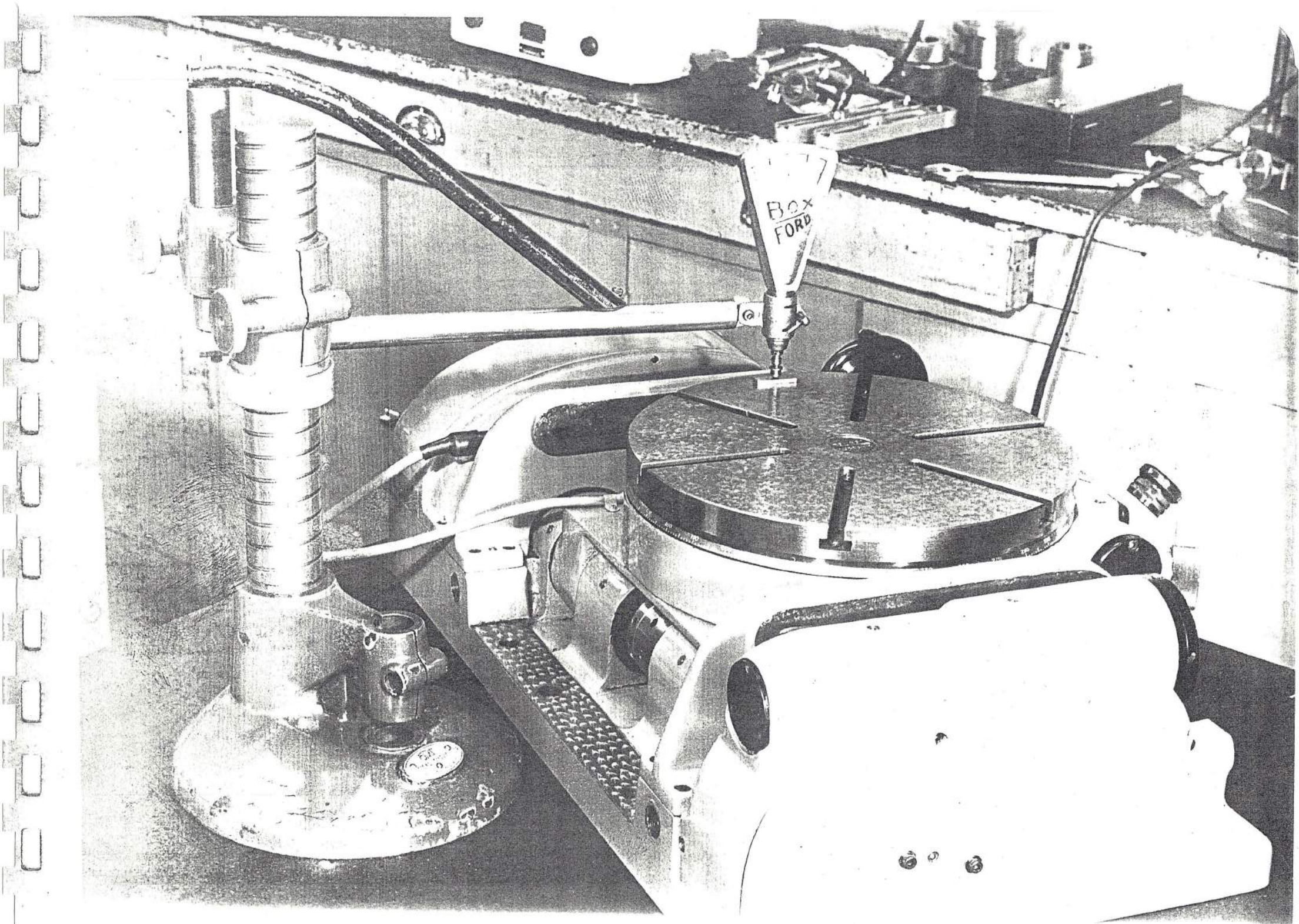
R. I. T. - PAGE TWELVE



The rotary platen of a 12-inch Rotary Inclinable Table is depicted in the following illustration in process of being checked for accuracy of rotation to its base. The permissible tolerance is 0.0002" over the full diameter.

(Print No. 12T/18)

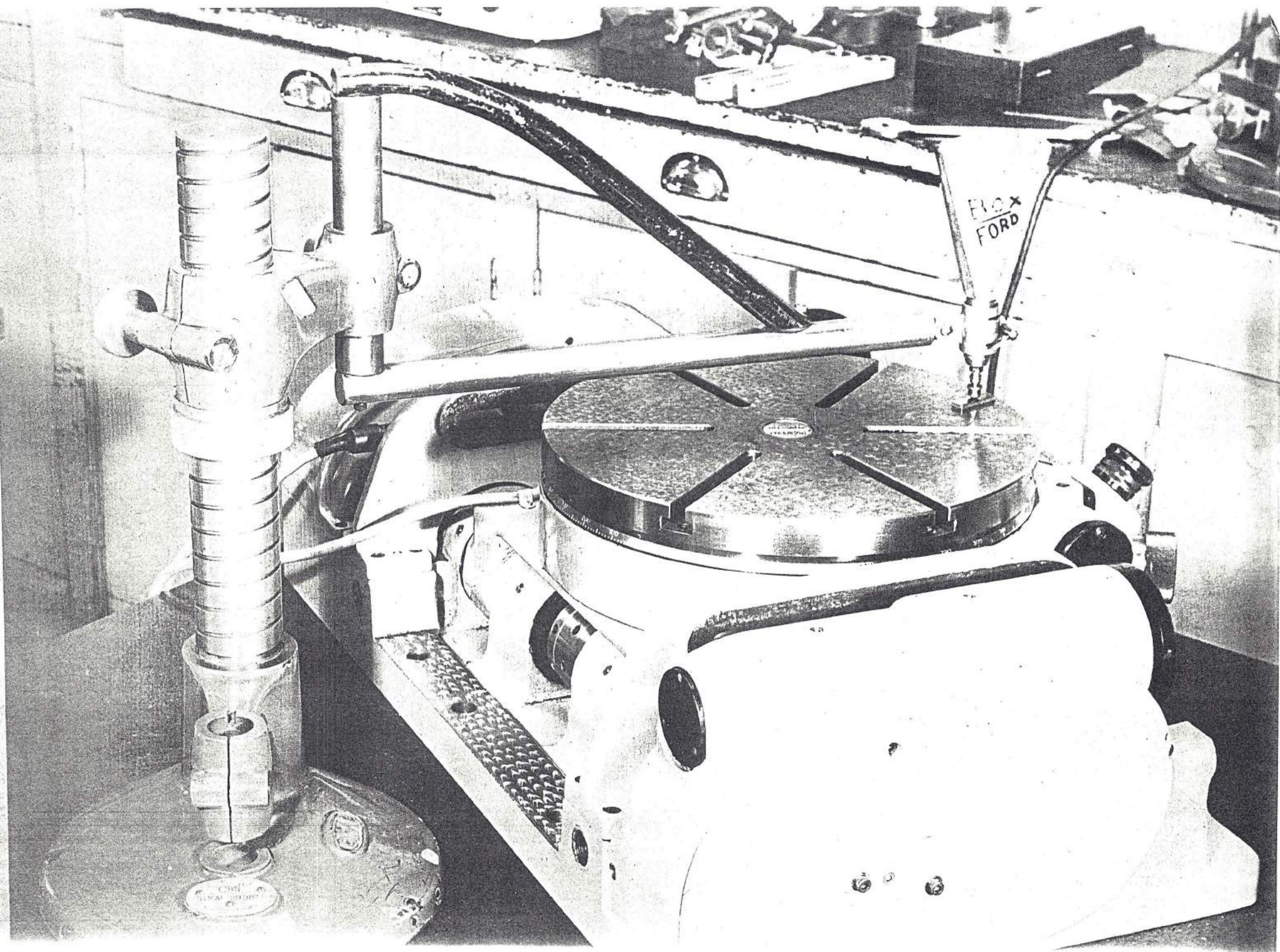
R. I. T. - PAGE THIRTEEN



To assess the accuracy of the inclinable scale zero setting, the platen is set parallel to its base by use of a 0.0001" indicator. The true position is read off in the inclinable scale microscope. The set-up for the check is depicted in the following photograph.

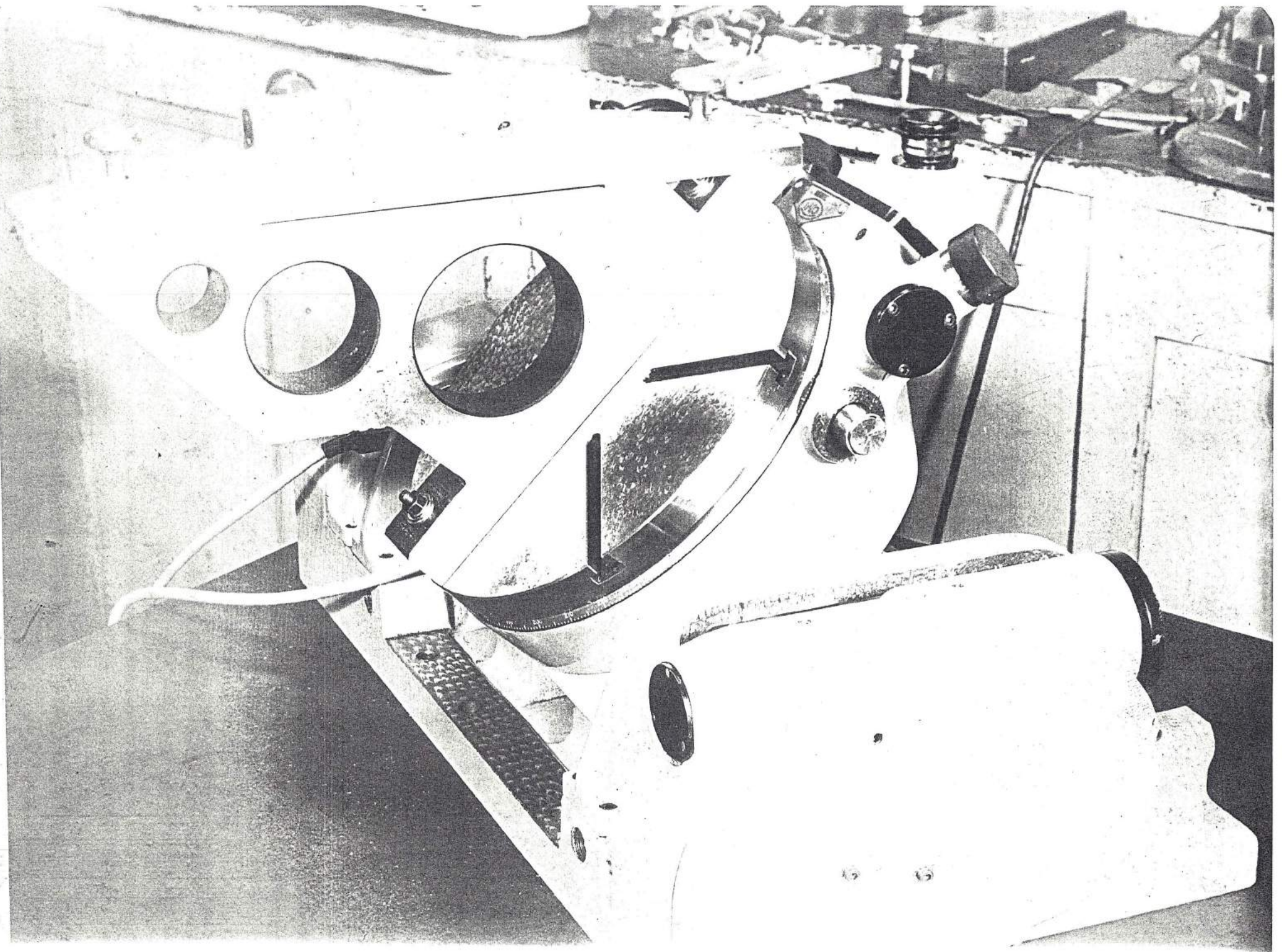
(Print No. 12T/19)

R. I. T. - PAGE FOURTEEN



To assess the accuracy of the inclinable scale at 45° , a precision level is used in conjunction with a calibrated 45° setting piece. Any error is disclosed in the inclinable scale microscope, which should read exactly 45° . The method adopted for this check is portrayed in the succeeding illustration.

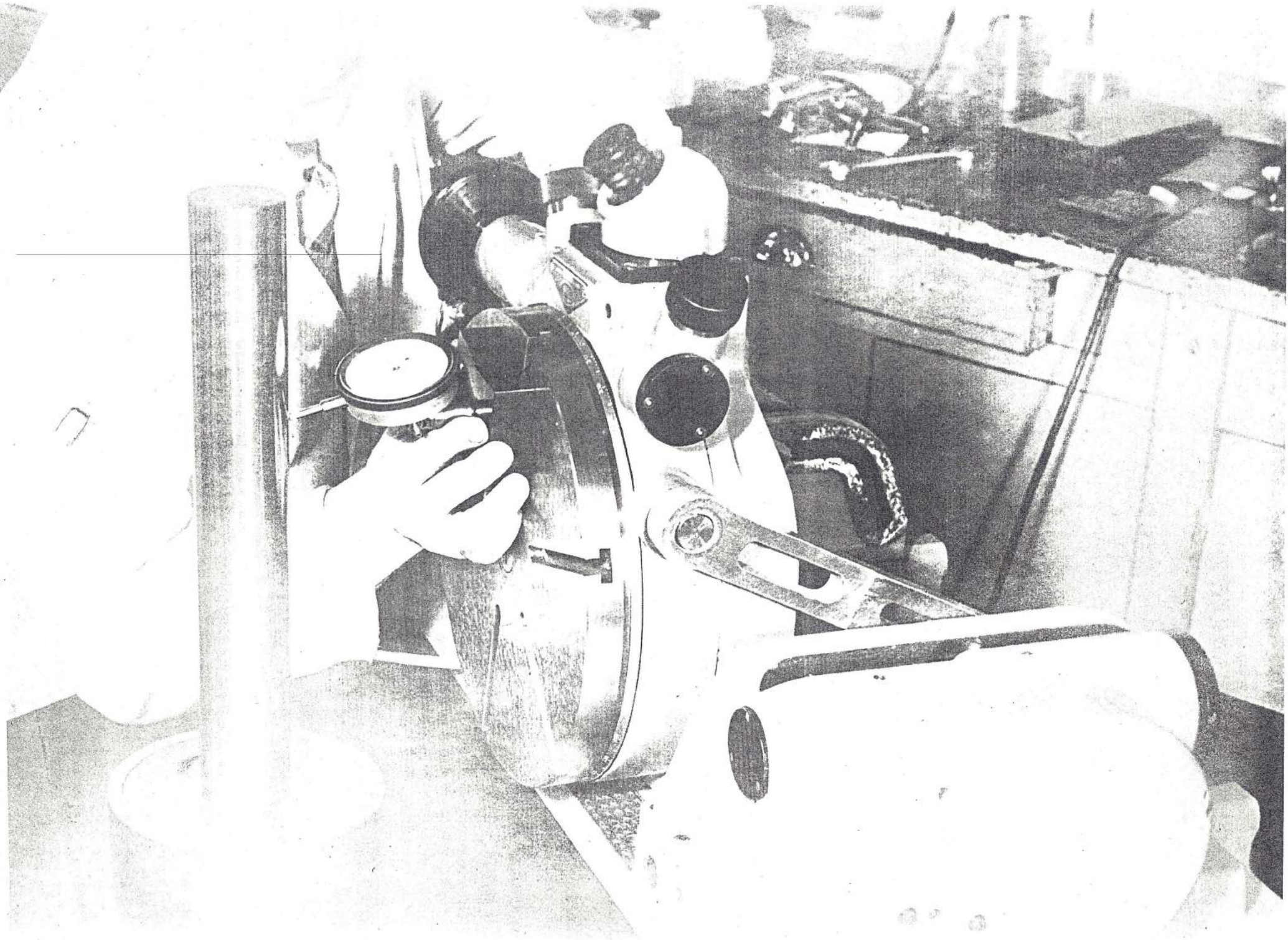
(Print N. 12T/20)



To assess the accuracy of the inclinable scale at 90° , the table is inclined and set mechanically square by means of a pole square and indicator. A reading of the inclinable optical scale then shows any deviation from accuracy. The arrangement for this check is shown in the following photograph.

(Print No. 12T/21)

R. I. T. - PAGE SIXTEEN



The height of the rotational axis is measured with the table inclined at 90° by checking over the setting plug and a corresponding bank of slip gauges. The separation of the rotational and inclining axis can then be calculated by subtracting the height of the shaft. The accuracy of determination is 0.0001". Procedure for this check is shown in the following illustration.

(Print No.12T/22)

R. I. T. - PAGE SEVENTEEN

