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**Operating Instructions**

— FOR —

**THE FISHER  
CYLINDRICAL  
CALCULATOR**

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DESCRIPTION

The Fisher Calculator consists of:-

- (a) a central stock - which we shall refer to simply as the STOCK,
- (b) a SLEEVE, which fits over the stock,
- (c) a RUNNER, which fits over the sleeve.

On the stock are mounted four scales, which are distinguished by alternate bands of yellow and white. Reading from the end nearest to the felt bearing, the scales are as follows:-

- Q scale - a short scale marked by a yellow band,
- M scale - the main scale, which is used for multiplication and division, and in conjunction with the Q scale for calculations involving squares and square roots,
- S scale - marked by a yellow band, for calculations involving sines,
- T scale - for calculations involving tangents.

The S and T scales are used in conjunction with the M and Q scales.

The sleeve carries four red arrows, which we shall distinguish by numbers, as shown in the diagram below, though they are not numbered on the sleeve itself:

(Red arrows)       $\Rightarrow$        $\Rightarrow$        $\Rightarrow$        $\Rightarrow$   
                          R-1      R0      R1      R2

The runner has four black arrows, which we shall distinguish as below:

(Black arrows)       $\Rightarrow$        $\Rightarrow$        $\Rightarrow$        $\Rightarrow$   
                          B-1      B0      B1      B2

(All the arrows point towards the felt bearing end of the calculator)

OPERATION

GENERAL. The calculator is held horizontally. Movements of the stock and runner are made with the left hand. Throughout all calculations the sleeve remains held by the right hand at the closed end. When setting figures, set the apex of the arrow to the spiral line of the scale, and the hair-line to the graduation or position between graduations.

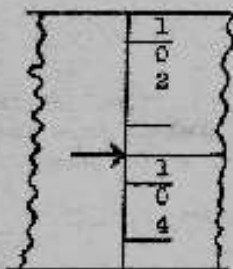


Fig. 1 Correct setting for 1035

The instrument should be held so that the arrows are seen centrally between top and bottom edges of the tube, thus minimising errors of parallax.

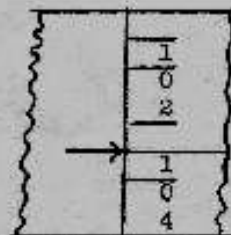


Fig. 2 Wrong. Arrow too near bottom edge of tube.

The scales Q and M serve for an indefinite range of numbers, and decimal points are omitted. Accordingly 156 may serve for 1.56, 1560, .0156, etc. When reading results the user will usually be able to determine the position of the decimal point by a mental calculation. Thus in the calculation 65.4 divided by 41.9, the terms may be roughly rounded off to 60 divided by 40, from which it will be clear that the answer is more than 1 and less than 10. The result given on the calculator is 156 and should be interpreted 1.56.

To help the user to read the Q and M scales easily, terminal 0's are shown at 110, 120, 130, 140, etc., but the number of terminal

0's is of course related to the position of the decimal point and must similarly be determined by the user.

Rules for determining the position of the decimal point in cases where it is not practicable to do so by a rough mental calculation, will be given later.

MULTIPLICATION. Use scale M.

Example:-  $12 \times 3$ .

Hold sleeve in right hand.

Moving stock, set 12 to RC. (12 is shown as 120 on the scale).

Moving runner, set EC to 1.

Moving stock, set 3 to SO. (3 is shown as 300 on the scale).

Read answer 36 at whichever red arrow is on scale M (in this case RC).

Example:-  $12 \times 3 \times 4$ .

Proceed as in previous example, but there is no need to read the figure 36.

Hold sleeve in right hand.

Moving runner, set EC to 1.

Moving stock, set 4 to SO. (4 is shown as 400 on scale).

Read answer 144 at whichever red arrow is on scale M [in this case R1].

DIVISION. Use scale M.

Example:-  $39 \div 13$

Hold sleeve in right hand.

Moving stock, set 39 to RC.

Moving runner, set EC to 13. (Shown as 130 on scale).

Moving stock, set 1 to EC.

Read answer 3 at whichever red arrow is on scale M.

Example :-  $39 \div 13 \div 1.5$

Proceed as in previous example, but there is no need to read the figure 3.

Hold sleeve in right hand.

Moving runner, set 90 to 1.5. (Shown as 150 on scale).

Moving stock, set 1 to 90.

Read answer 2 at whichever red arrow is on scale M.

COMBINED MULTIPLICATION AND DIVISION. Use scale M.

Example :-  $\frac{2 \times 3 \times 4}{4 \times 5 \times 8}$

Hold sleeve in right hand.

Moving stock, set 2 to 90.

Moving runner, set 90 to 4.

Moving stock, set 3 to 90.

Moving runner, set 90 to 5.

Moving stock, set 4 to 90.

Moving runner, set 90 to 6.

Moving stock, set 1 to 90.

Read answer 2 at whichever red arrow is on scale M.

(NOTE:- It is advantageous to do combined multiplication and division in the sequence shown above, rather than do all the multiplications first and then all the divisions.)

PROCEDURE WHEN SLEEVE RUNS OFF M SCALE

In a lengthy calculation, the following may occur:-

Example :-  $\frac{45}{3 \times 5 \times 6}$

After division of 45 by 3 and by 5, R-1 is at 3.

Proceeding as usual, move runner to set 90 to 6.

Upon making the next step, of setting 1 to B0, it will be found that none of the red arrows are on the M. scale. In this case, set 1 to E2 instead, when 3-1 will be on M scale, at answer 5 (to be interpreted as 0.5).

In a different case it may be necessary to use B-1 for the final step of a calculation.

#### EXTRACTION OF SQUARE ROOTS

$$x = \sqrt{y}$$

Use scale Q in conjunction with scale M.

First it is necessary to decide whether to use arrow B1 or arrow B2 and this is determined by the following procedure.

On the number Y, groups of 2 digits are marked off, beginning from the decimal point. The group containing the first actual digit, i.e. in the left hand group, is the "determining group". A number which is wholly decimal is said to contain negative groups. The foregoing is illustrated by the following examples:-

(a)	'81	'60	'00'	3 groups
(b)			'81'6	1 group
(c)			0.'81'6	zero groups
(d)			0.'00'81'6	minus 1 group

In each of the examples (a) to (d), the determining group (81) is a full group of two digits. This is not so in the following examples :-

(e)	'8'16'	2 groups
(f)	'8'16	1 group
(g)	0'08'16	zero groups
(h)	0'00'08'16	minus 1 group

In each of the examples (e) to (h) the determining group, (8) or (08) contains only one actual digit. Note particularly that in example (h) the number of groups is minus 1 just as if the determining group had been a full group of two digits.

Rule :-

For two digits in the determining group, use arrow B2 (which has the double arrow head).

For one digit in the determining group, use arrow B1 (which has the single arrow head).

Note :- If the second digit in the determining group happens to be a zero, this is of no consequence, i.e. B2 is used since the first digit in this group is not zero.

To find  $X = \sqrt{Y}$ . Set Y on scale Q to either B2 or B1 as the rule given above. Read answer at PC on scale M. The procedure of marking off into groups provides the information for finding the position of the decimal point, the decimal value of the figure in the answer being equal to the number of groups in the number Y.

[The "decimal value" (positive) of a number, is the number of digits before the decimal point. A "minus decimal value" indicates a number smaller than 0.1 having a number of zeros between the decimal point and the first actual digit.

Examples :-

- (i) The decimal value of 64300 is 5  
 (j) " " " " 6.43 is 1  
 (k) " " " " 0.643 is zero  
 (l) " " " " 0.00643 is -3.]

Example :- (m)  $X = \sqrt{0.000735}$

As the determining group (07) contains only one digit, arrow B1 is used.

Hold sleeve in right hand.

Moving stock, set 735 on scale Q to B1.

Read result 271 at PC on scale M.

The decimal value of the result is equal to the number of groups in 0.000735, i.e. minus 1. Hence the result is 0.0271.

Example :- (n)  $X = \frac{35.2}{\sqrt{53.7}}$

Hold sleeve in right hand.

Moving stock, set 352 on scale M to 20.

Moving runner, set B2 to 537 on scale Q.

(B2 is used as the determining group contains 2 digits).

Moving stock, set 1 on scale M to 20.

Read result 48 at whichever red arrow is on scale M.

A rough mental calculation indicates that the true result is 4.8.

#### TO OBTAIN SQUARES

Use scale Q in conjunction with scale M.

Example :-  $X = 4^2$

Hold sleeve in right hand.

Moving stock, set 4 on scale M to 20.

Read result 16 at B2 on scale Q.

(Note:- In finding the square of a number only one of the arrows B1 or B2 will rest on scale Q.).

#### TRIGONOMETRIC FUNCTIONS

Use scales S and T in conjunction with scales M and Q.

The numbers on scales S and T represent angles. There are two sets of numbers on each scale and we will first deal with the numbers that are inscribed vertically (as on scale M).

The graduation to which each number refers is the longer one situated below the first or second digit of the number. This graduation line also represents the decimal point. Thus:-



$$\frac{7}{1} = 7.1^\circ \quad (7^\circ 6')$$

$$\frac{5}{8} = 5.8^\circ \quad (5^\circ 48')$$

$$\frac{5}{8} = 58^\circ$$

To find  $X = \sin A$

Hold sleeve in right hand.

Set R-1 to A on scale S.

X is indicated by R0 on scale M. [This result can be used, without the need to read it, for further multiplication or division].

To find  $X = \frac{Y}{\sin A}$

Hold sleeve in right hand.

Moving sleeve set R0 to Y on scale M.

Moving runner, set R-1 to A on scale S.

Moving stock, set 1 on scale M to R0.

X is indicated by red arrow on scale M.

To find  $X = \tan A \sqrt{Y}$

Hold sleeve in right hand.

Moving stock, set A to R-1 on scale T.

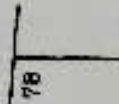
Moving runner, set R0 to 1 on scale M<sup>\*</sup>.

Moving stock, set Y to B2 (or B1 as the case may be) on scale Q.

X is indicated by the red arrow on scale M.

\* Note. It may be necessary to set B2 to 1 instead of B0 to 1.

Scales S and T have a further set of numbers on them to be sideways, thus



It will be seen this number 78 refers to the graduation line  $12^\circ$ . ( $90^\circ - 12^\circ = 78^\circ$ ).

To find  $\cos 78^\circ$  we utilise the fact that  $\cos 78^\circ = \sin (90^\circ - 78^\circ) = \sin 12^\circ$ .

To find  $\cos 76.8^\circ$  there is no need to calculate mentally  $90^\circ - 76.8^\circ = 13.2^\circ$ . Simply read upwards from  $76^\circ$  (written sideways) to  $76.8^\circ$ .

To find  $\tan A$ , where  $A$  is between  $45^\circ$  and  $90^\circ$ , we utilise the fact that  $\tan A = \frac{1}{\tan [90^\circ - A]}$ . Here, we use the numbers written sideways on scale T.

Example :-  $X = \tan 53^\circ$

Hold sleeve in right hand.

Moving stock, set R2 to 1 on scale M.

Moving runner, set B-1 to 53 on scale T (written sideways)

Moving stock, set 1 to B2 on scale M.

Read answer 1.327 at R1.

Cotangents can also be obtained from the fact that

$$\cot A = \frac{1}{\tan A}$$


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To find the sine or tangent of an angle smaller than those marked on scales S or T, we convert the angle from degrees to radians. The sine or tangent of such a small angle is approximately equal numerically to the size of the angle measured in radians. To convert degrees into radians, divide by 57.296. This number is marked on scale H and identified by the letters RD.

METHOD OF DETERMINING POSITION OF DECIMAL POINT IN THE RESULT OF MULTIPLICATION, DIVISION, AND COMBINED MULTIPLICATION AND DIVISION.

Example :-  $x = \frac{138 \times 2.15 \times 0.012 \times 0.17}{88.5 \times 0.0032}$

- Step A. First carry out the actual calculation on the calculator, reading the result 654. This represents the digits only in the result, without the decimal point.
- Step B. Count the number of multiplications performed, i.e. the number of factors in the numerator, excluding the first factor. This gives 3. Now subtract the number of divisions performed, i.e. the number of factors in the denominator. This gives  $3 - 2 = 1$ . Consider the number thus obtained as the number of one of the red arrows, i.e. R1. (For special cases, see sheet '12').
- Step C. We shall call the distance between two adjacent arrows on the sleeve, one "interval". Now count the number of intervals on the sleeve from the arrow identified by step B, to the arrow on scale M (at which the result 654 was read). The direction is important, the number of intervals being considered positive if the counting is from left to right, but negative if the counting is from right to left. In our example we count from R1 (identified by step B) to R-1 (indicating the result on scale M). Thus there are two intervals, and since the counting is from right to left, the number of intervals is minus two.
- Step D. To the number thus obtained, add the "decimal value" (as defined on sheet 6) of each factor in the numerator, and subtract the decimal value of each factor in the denominator, to arrive at the decimal value of the answer to the calculation.