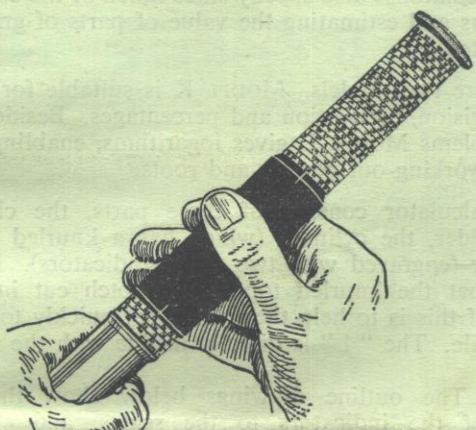
THE OTIS KING CALCULATOR



Instructions For Use

INTRODUCTION

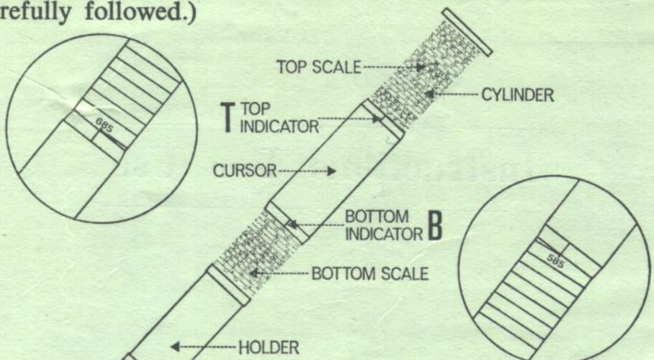
The Otis King Calculator is basically a slide rule. This should not be thought to imply that it is a particularly complicated piece of apparatus suitable only for people with special training; the slide rule is really a very simple article requiring no special mathematical knowledge for its operation, yet with it the drudgery can be removed from much of the calculating work that has to be done in industry and commerce and by students. The Otis King is even simpler than many slide rules because it dispenses with special purpose scales. It is also more accurate than the ordinary slide rule. These two points recommend it to many users.

Because of the cylindrical design of the Otis King it has been possible to produce a very compact instrument. The scales are 66 inches long and carry many more graduations than those of an ordinary slide rule. Consequently the user can read answers comprising several figures directly from the scales instead of estimating the later figures; the setting of the Calculator is also speedy since much of the counting of graduations and estimating the value of parts of graduations is eliminated.

There are two models. Model K is suitable for multiplication, division, proportion and percentages. Besides solving these problems Model L gives logarithms, enabling it to be used for working out powers and roots.

The Calculator consists of three parts, the chromium-plated holder, the cylinder (which has a knurled top), and the cursor (engraved with two white indicators). It will be noticed that the knurled top has a notch cut in it. The purpose of this is to help the user to set quickly to the " 1 " on the scale. The " 1 " is directly in line with the notch.

(Note. The outline drawings below show the correct settings of the indicators to the scales, and should be carefully followed.)



ALWAYS SET THE INDICATORS TO THE LINES – NOT TO THE NUMBERS

INSTRUCTIONS

Multiplication and Division

Model K. This model has a scale from 1 to 10 mounted on the holder. The cylinder also has a scale from 1 to 10 on its upper half and the same scale is repeated on the lower half.

Example: Multiply 2 by 4.

Take the holder in the left hand and open the instrument gently to its full extent.

Set the bottom indicator to 2—which will be found about half an inch above the bottom ONE and slightly to the right of it. (Remember to set to the line and the graduation, not to the figure itself.)

Moving the cylinder by holding the knurled top, set the middle ONE to the top indicator. The middle ONE will be found in line with the notch on the knurled top and about two inches below it. *Do not touch the cursor when making this movement.*

Moving the cursor, slide the top indicator up to 4, which is about one inch below the notch and a little to the right of it.

The answer 8 will be read at the bottom indicator.

Example: Multiply 4 by 4 (on Model K).

Set the bottom indicator to 4—about one inch above the bottom ONE and slightly to the right of it.

Move the cylinder to set the middle ONE to the top indicator. (Remember that the cursor must not be touched during this movement.)

Moving the cursor, slide the top indicator *down* to 4 on the lower half of the cylinder scale.

The answer 16 will be read at the bottom indicator.

Example: Divide 8 by 2.

Set the bottom indicator to 8—near the top of the scale, about a quarter of an inch below the top ONE and a little to the right of it.

Move the cylinder to set 2—about $1\frac{1}{2}$ inches below the notch and a little to the right of it—to the top indicator.

Moving the cursor, slide the top indicator down to ONE at the middle of the cylinder scale.

The answer 4 will be read at the bottom indicator.

Example: Divide 16 by 4.

This is done by the same method as in the previous division example, except that for the final movement the cursor is moved upwards to the ONE at the very *top* of the scale. (For the second movement the 4 on the lower half of the scale on Model K can be used, instead of the 4 on the upper half of the scale; in that case the final movement is to the *middle* ONE.)

MODEL L. This model has a scale from 1 to 10 mounted on the holder. The cylinder has a similar scale on its upper half which is used in conjunction with the holder scale for multiplication and division. On the lower half of the cylinder there is an evenly divided scale. This is used in conjunction with the holder scale to find logarithms.

The instructions given for Model K, for multiplication and division examples, also apply to Model L except where it is otherwise indicated. They should be studied first as this may help the user to locate the position of the numbers on the scales.

Example: Multiply 2 by 4.

Set the bottom indicator to 2.

Move the cylinder to set the 1 at the beginning of the scale on the upper half of the cylinder, to the top indicator.

Moving the cursor, slide the top indicator up to 4.

The answer 8 will be read at the bottom indicator.

Example: Multiply 4 by 4 (on Model L).

Set the bottom indicator to 4.

Move the cylinder to set the top 1—just below the notch —to the top indicator.

Moving the cursor, slide the top indicator down to 4.

The answer 16 will be read at the bottom indicator.

Example: Divide 8 by 2.

Set the bottom indicator to 8.

Move the cylinder to set 2 to the top indicator.

Moving the cursor, slide the top indicator down to 1 at the beginning of the scale on the upper half of the cylinder.

The answer 4 will be read at the bottom indicator.

Logarithms (Model L only)

The lower half of the cylinder on Model L carries an evenly divided scale which is used for finding the logarithm of any number as follows:

Move the cursor to set the bottom indicator to 1 at the bottom of the holder scale.

Move the cylinder to set 000 at the beginning of the evenly divided scale to the top indicator.

Moving the cursor, slide the bottom indicator to any number on the holder scale and read its logarithm on the evenly divided scale at the top indicator.

(Finding antilogarithms is of course the converse of the above. Having made the preliminary settings of the bottom indicator to 1, and 000 to the top indicator, the top indicator is moved to the logarithm and its antilogarithm is found at the bottom indicator.)

Understanding the Scales

To the user who is unfamiliar with slide rules, the graduation of the scales of the Calculator may appear a little confusing, and the following notes of explanation may be useful.

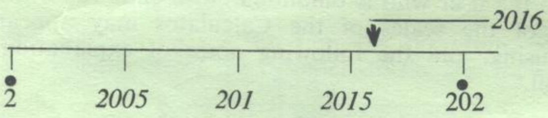
(a) No final " 0 "s and no decimal points are printed on the multiplication and division scales. The user must insert these mentally, for himself, as he requires them. Thus " 57 " can be used to represent " 57 ", " 570 ", " 57000 ", " 5·7 ", " ·057 ", etc.

(b) The value of the small graduations lying between the larger ones against which numbers are actually marked, i.e. " 101 ", " 102 ", etc., can be determined by reference to the marked numbers. Thus between " 101 " and " 102 " the scale is marked with ten graduations and these have the values of " 1011 ", " 1012 ", " 1013 ", " 1014 " and so on up to " 1019 ". If it is desired to set a figure or to read an answer between these small graduations the space must be divided. Thus " 10115 " will be set by placing the indicator halfway between " 1011 " (which may of course be read " 10110 ", as explained above) and " 1012 " (" 10120 "). With practice the user will find that he can judge other values such as " 10112 ", " 10116 ", with a fair degree of accuracy.

(c) It will be noticed that the graduations are not of equal value throughout the scale, and that the lower part of the scale contains many more graduations than the upper part. Thus the scale from " 1 " to " 2 " occupies seven turns of the spiral, from " 2 " to " 3 " occupies only about four turns, from " 3 " to " 4 " three turns, and so on. The result of this is that at the bottom of the scale the user can set and read numbers comprising more figures than those to which he can set higher up the scale. Thus the graduations from " 101 " to " 102 " are " 1011 ", " 1012 ", " 1013 ", etc.; from "202 " to "204 " they represent " 2025 ", "203(0) ", " 2035 "; and from " 62 " to " 625 " they represent " 621 ", " 622 ", " 623 ", " 624 ". It has been shown in note (b) how values between, say, " 2025 " and " 2030 " can be judged.

As has been explained in an earlier note, if it is desired to read figures between, say, " 202(0) " and " 2025 ", these must be judged by the user. For example, for " 2021 " the indicator mark must be set to a point one-fifth of the distance between " 202 " and " 2025 ".

It may be helpful to the beginner if he draws the portion of the scale on a piece of paper first, and inserts the actual values that he requires, thus:



(or 200, ·002, etc.)

With a little practice on these lines any person not previously experienced in using such instruments will find that he can attain proficiency in using the Otis King.

Further Examples

The user is advised to study the foregoing instructions first and to attain familiarity by working through the simple examples several times. When they have been mastered he can proceed to the following calculations. The instructions apply to both Model K and Model L, but in the case of Model L it may sometimes be necessary to use the bottom 1 on the cylinder scale and on other occasions the top 1.

(For the sake of simplicity the bottom white indicator will now be referred to as B and the top white indicator as T.)

Combined Multiplication and Division

Solve $\dfrac{6\times4\times9}{7\times5\times2}$

(This type of calculation can usually best be done by alternate multiplication and division of the individual factors, thus: 6 divide by 7, multiply by 4, divide by 5, multiply by 9, divide by 2. There is no need to take note of the intermediate results and except at the end of the calculation it is not necessary to move the indicator to 1.)

Set B to 6. Set 7 to T. Move T to 4.

(B now indicates answer to $\dfrac{6\times4}{7}$.)

Set 5 to T. Move T to 9.

(B now indicates answer to $\dfrac{6\times4\times9}{7\times5}$.)

Set 2 to T. Move T to 1. Read answer at B: 3·086.

Proportion

I. Solve 12 : 7 :: 16 : *x*?

Set B to 12. Set 7 to T. Move B to 16. Read answer at T. 12 : 7 :: 16 : *9·333*.

II. Solve 18 : 4 :: *x* : 53?

Set B to 18. Set 4 to T. Move T to 53. Read answer at B. 18 : 4 :: *238·5* : 53.

III. Divide 8975 in the proportions 83 : 79 : 33 : 19.

Set B to 8975. Set *sum* of required proportion, viz. 214, to T. Move T in succession to 83, 79, 33, 19, and read the corresponding proportions at B, viz. 3481, 3313, 1384 and 797. (On Model L this calculation necessitates " closing in " the cylinder. *See* page 9.)

Percentages

I. What is 5% (a) of 162?
(b) off 162?
(c) on 162?

Set B to 162 (capital amount or quantity). Set 1 to T. The instrument is now set to solve percentage problems involving % OF, % OFF and % ON 162.

(a) Move T to 5 (rate %). Read answer at B : 5% of 162 = 8·1.

(b) Move T to 95 (100 − rate %). Read answer at B : 5% off 162 = 153·9.

(c) Move T to 105 (100 + rate %). Read answer at B : 5% on 162 = 170·1.

II. What % of 3735 is 4·54?

Set B to 3735. Set 1 to T. Move B to 4·54. Read answer at T: ·12155%.

III. What is the percentage of profit on cost where goods purchased for £5,760 are sold for £9,420?
Set B to 5760 (capital). Set 1 to T. Move B to 9420 (selling price). Read answer at T : 163·5. Percentage of profit = 63·5% (163·5 − 100).

Constant Factors

I. In cases where one pair of factors is repeated throughout a series of problems, the instrument may be set to the constant terms, and the answers found by subsequent movements of the cursor only.

In Percentage Example I, for instance, the instrument being set to the constant terms 162 : 100%, any percentage *of*, *off* or *on* 162 will be shown at B when T is moved to the relative figure, e.g. Move T to 45. Read answer at B : 45% *of* 162 = 72·9. Move T to 126. Read answer at B : 26% *on* 162 = 204·1, and so on.

II. Decimalise $\frac{3}{32}$, $\frac{7}{32}$, $\frac{15}{32}$, $\frac{29}{32}$.
Set B to 32. Set 1 to T (32 and 1 being the constants in this series). Move B in succession to 3, 7, 15, 29 and read the corresponding answers at T, viz. ·09375, ·21875, ·46875, ·9062.

Money Calculations

The Sterling items must be reckoned as decimals of pounds, shillings or pence as best suits the problem.

I. If 54 articles cost £39·225, what is the price of 15? Set B to 39·225. Set 54 to T. (The cost of any number of articles at this price can now be obtained by moving T to the number required.) Move T to 15. Read answer at B : 15 articles cost £10·895.

II. Find interest on £675 at 6½% p.a. for 29 days.

$$(£675 \times \frac{6 \cdot 5}{100} \times \frac{29}{365})$$

Set B to 675. Set 1 to T. Move T to 6·5. Set 365 to T. Move T to 29. Read answer at B : £3·486.

In some calculations it may be found preferable to invert the setting of the instrument and to work to the "1"s on the holder scale instead of to those on the cylinder scale. In this case, the answer is of course read at the pointer opposite to the one indicated in the foregoing examples.

Model L

THE UPPER CYLINDER SCALE.—When this scale is used in conjunction with the Holder Scale to perform the types of calculations described in the preceding pages, it will be noted that upon occasion the cylinder becomes closed in or opened out too far for the pointer on the cursor to be moved to the required figure. In this case proceed as follows, without altering the setting of the instrument:

To close cylinder in. Move T to bottom 1.
Set top 1 to T.

To open cylinder out. Move T to top 1.
Set bottom 1 to T.

The pointer can then be set to the required figure and the calculation completed. This operation may be performed during any calculation and does not affect the process or answer in any way.

THE LOWER CYLINDER SCALE.—Where involved expressions occur above or below the line, the Otis King Calculators offer valuable advantages over the ordinary slide rule, which, even if engraved with log-log scales, cannot solve the following, whereas Model L will give all powers and roots, fractional or otherwise, of all numbers without limit, and solve any expression, however extended. The following expression is given as an example:

$$\frac{1{\cdot}008^{3\cdot 1} \times \sqrt[3]{63} \times 4000}{6 \times \sqrt[5]{260000} \times 42^{1\cdot 82}} = {\cdot}2495.$$

All involved expressions must be replaced by their numerical value before the problem can be dealt with, and this prior process is, of course, common to both the slide rule and the Otis King Calculator. The intermediate stage in dealing with the above problem is to simplify it into the following:

$$\frac{1{\cdot}025 \times 3{\cdot}98 \times 4000}{6 \times 12{\cdot}11 \times 900{\cdot}1}$$

The process for effecting this is as follows:

To LOGARIZE (i.e. find the logarithm representing a number).

Set B to bottom 1 of holder scale. Set "·000" of lower cylinder scale to T. Move B to number (antilogarithm), and read mantissa at T.

To DELOGARIZE (i.e. to find the number represented by a logarithm).

Set B to bottom 1 of holder scale. Set "·000" of lower cylinder scale to T. Move T to mantissa. Read antilogarithm (number) at B.

To ascertain any Power or Root of any number

POWERS

Multiply the logarithm of the number by the index of the power and take the antilogarithm of the product.

4772 Example: What is $1{\cdot}008^{3{\cdot}1}$?
Log. of $1{\cdot}008 = 0{\cdot}0035$.
$0{\cdot}0035 \times 3{\cdot}1 = 0{\cdot}01085$.
Antilog. of $0{\cdot}01085 = 1{\cdot}025$.
Therefore $1{\cdot}008^{3{\cdot}1} = 1{\cdot}025$.

ROOTS

Divide the logarithm of the number by the index of the root and take the antilogartihm of the quotient.

Example: What is $\sqrt[3]{63}$?
Log. of $63 = 1{\cdot}7993$.
$1{\cdot}7993 \div 3 = 0{\cdot}5998$.
Antilog. of $0{\cdot}5998 = 3{\cdot}98$.
Therefore $\sqrt[3]{63} = 3{\cdot}98$.

Compound Interest

Find the amount that £250 will become in 14 years at $5\frac{1}{2}$% compound interest.

(a) Set B to 1.
Set 000 to T.
Move B to 1055 ($100 + 5\frac{1}{2}$%).
Read log. ·0232 at T.

(b) Set B to 232.
Set 1 (beginning of upper cylinder scale) to T.
Move T to 14.
Read 325 at B.

(c) Set B to 1.
Set 000 to T.
Move T to ·325.
Set 1 (beginning of upper cylinder scale) to T.
Move T to 25.
Read 528·5 at B. (Answer: £528 10s.)

2367 1·742

Approximation Method for finding Square Roots and Cube Roots without the use of Logarithms

The following method may be used for finding approximate square roots and cube roots on Model K:

Example: To find the cube root of 9.

Estimate it as, say, 2.

Work out $2 \times 2 \times 2$ on the Calculator, giving 8 at bottom indicator.

Keeping cylinder in same position, move bottom indicator to 9. Read 225 at top indicator.

Note difference between estimate and 225 = 25; divide by 3 = 83, and add to original estimate = 2083.

Example: To find the square root of 87.

Estimate it as, say, 9.

Work out 9×9 on the Calculator, giving 81 at bottom indicator.

Keeping cylinder in same position, move bottom indicator to 87. Read 9665 at top indicator.

Note difference between estimate and 9665 = 665; divide by 2 = 333, and add to original estimate = 9333.

Finding the Decimal Point

In common with all slide rules, the Otis King gives answers which do not show the position of the decimal point. The simplest way of deciding where the decimal point comes is by inspection and for this method it may sometimes be helpful to make a mental calculation with approximate figures. Thus 11·03 multiplied by 20·45 gives 2257 on the Calculator. It is roughly 10 multiplied by 20, which equals 200, so the decimal is placed after the third figure—225·7.

Examples:

$0{\cdot}0027 \times 0{\cdot}00031 = 0{\cdot}00000837;$
approx. $0{\cdot}003 \times 0{\cdot}0003 = 0{\cdot}000009.$

$0{\cdot}48 \times 0{\cdot}056 = 0{\cdot}02688;$
approx. $0{\cdot}5 \times 0{\cdot}05 = 0.025.$

$11 \times 305 \times 29 \times 49 = 4761000;$
approx. $10 \times 300 \times 30 \times 50 = 4500000.$

$577 \div 799 = 0{\cdot}7225;$
approx. $6 \div 8 = 0{\cdot}75.$

$$\frac{18 \times 19 \times 8}{1{\cdot}7 \times 0{\cdot}002 \times 950} = 847{\cdot}8;$$

$$\text{approx. } \frac{20 \times 20 \times 10}{2 \times 0{\cdot}002 \times 1000} = 1000.$$

Where the calculations are too involved for the above method to be used, the decimal point can be determined by the following rules, which apply both to Model K and Model L.

A number having n figures to the left of the decimal point shall be designated as having $+n$ places. A decimal number having n cyphers to the right of the decimal point, between the decimal point and any number other than 0, shall be designated as having $-n$ places.

Thus the numbers—

	5430000,	674,	81·2,	7·82,	0·45,	0·0421,	0·00675
have	+7,	+3,	+2,	+1,	+0,	−1,	−2 places

(See notes 1, 2 and 3 below.)

Multiplication

To find the number of places (p) in the product ($P = X \times Y$).

Let X have m places, and Y have n places.

RULE I. $p = m+n$ or $p = m+n-1$.

(a) When the result is *below* the original setting $p = m+n$.

Example: 3×4 ($m = 1$; $n = 1$).
Set B to 3. Set 1 to T. Move T to 4. (This is below setting.) $p = m+n = 2$. Answer = 12.

(b) When the result is *above* the setting, the product has $m+n-1$ places.

Example: 3×3 ($m = 1$; $n = 1$).
Set B to 3. Set 1 to T. Move T to 3. (This is above setting.) $p = m+n-1 = 1$. Answer = 9.

(See note 4 below.)

Division

To find the number of places (q) in the quotient ($Q = \frac{X}{Y}$).

RULE. II. $q = m-n$ or $q = m-n+1$ as follows:

(c) When the result is *above* the setting, the quotient has $m-n$ places.

Example: $3 \div 4$ ($m = 1$; $n = 1$).
Set B to 3. Set 4 to T. Move T to 1. (This is above setting.) $q = m-n = 0$. Answer = 0·75.

(d) When the result is *below* the setting, the quotient has $m-n+1$ places.

Example: $5 \div 4$ ($m = 1$; $n = 1$).
Set B to 5. Set 4 to T. Move T to 1. Read answer at B. (This is below setting.) Therefore $q = 1-1+1 = +1$. Answer = 1·25.

(See note 5 below.)

Calculations involving Multiplication and Division

RULE III. Two methods may be used in working out complex problems involving both multiplication and division. They are:

(1) Taking numerator and denominator alternately.

(2) Taking all the numerators first and then dividing consecutively by the denominators.

Of these two methods, only the latter can be used if the position of the decimal point is required. If the other is used, the decimal point must be found by inspection.

First multiply consecutively the series of factors in the numerator and then divide consecutively by the factors of the denominator.

Take the algebraic sum of the places in the factors of the denominator from the algebraic sum of the places in the factors of the numerator, and to this result add the algebraic sum of the results obtained from the application of Rules I and II to the several steps of the problem.

Example:

$$\frac{432 \times 32{\cdot}4 \times 0{\cdot}0217 \times 0{\cdot}98}{0{\cdot}00000621 \times 412000 \times 0{\cdot}175 \times 4{\cdot}71} = 141{\cdot}14\ .\ .\ .$$

Number of places in factors of—

Numerator	$= 3+2+(-1)+0$	$= +4$
Denominator	$= -5+6+0+1$	$= +2$
Difference		$= +2$
Results of various steps in calculation	$= -1+1+1$	$= +1$
Number of places in answer		$= +3$

Answer = 141·14.

Notes on determining position of Decimal Point

Note

1. Thus:

1.	5430000·00	(7 figures are to left of decimal point)	has +7 places
	81·2	(2 figures to left of decimal point)	has +2 places
2.	0·45	(no figures to left of decimal point, and no noughts between decimal point and first figure other than 0, to right of decimal point)	has −0 places
	0·0421	(one nought between decimal point and first figure to right of decimal point)	has −1 places

3.

Left of decimal point		Right of decimal point	No. of places
5430000	·		+7
674	·		+3
81	·	2	+2
7	·	82	+1
0	·	45	−0
0	·	0421	−1
0	·	00675	−2

4. MULTIPLICATION. RULE I

When in the third movement of a multiplication calculation the cursor is moved *downwards* the number of places in the product (i.e. figures to the left of the decimal point) is equal to the sum of the number of places in the two terms of the calculation.
If the cursor is moved *upwards* the number of places in the product is one less than the sum of the number of places in the two terms of the calculation.

5. DIVISION. RULE II

When in the third movement of a division calculation the cursor is moved *upwards* the number of places in the quotient is equal to the number of places in the dividend minus the number of places in the divisor.
If the cursor is moved *downwards* the number of places in the quotient is one more than the number of places in the dividend minus the number of places in the divisor.

In summary form, the rules for finding the position of the decimal point are:

When the cursor moves up, in multiplication, the result has $m+n-1$ places.

When the cursor moves up, in division, the result has $m-n$ places.

When the cursor moves down, in multiplication, the result has $m+n$ places.

When the cursor moves down, in division, the result has $m-n+1$ places.

The rules are expressed by the following diagram which it is suggested the user should cut out and fix to the cursor of his Calculator with adhesive transparent tape.

↑	X $m+n-1$
	÷ $m-n$
↓	X $m+n$
	÷ $m-n+1$

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