PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Slide Rules

We, SIDNEY RADCLIFFE POTTER, a British Subject, of Tameside Mills, Park Road, Dukinfield, in the County of Chester, and JOHN DYSON BLAKELEY, a British Subject, of 72, Cornwall Gardens, Gloucester Road, London, S.W.7, do hereby declare this invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns slide rules.

In relation to many trades and arts there exist numerous formulæ of substantial complexity which require frequent evaluation. One such formula, which is much used in the heat insulating art is

$$q=\frac{ts_1-tm}{\frac{d_1}{2k}\log_e\frac{d_2}{d_1}+\left(\frac{d_1}{d_2}\times\frac{1}{f}\right)}$$

where

q = heat loss through insulating material covering a pipe or the like of circular cross-section in B.Th.U's/square foot of hot surface/hour.

ts_1 = temperature of hot surface in °F.

tm = temperature of ambient air in °F.

d_1 = outside diameter of pipe in inches.

d_2 = outside diameter of insulating material on pipe in inches.

k = thermal conductivity of insulating material in B.Th.U's/square foot/hour/°F./inch thickness.

f = surface co-efficient in B.Th.U's/square foot/hour/°F.

A further formula used in the same art is

$$q=\frac{ts_1-tm}{\frac{z}{k}+\frac{1}{f}}$$

where

q = heat loss through insulating material covering flat surface in B.Th.U's/square foot of hot surface/hour.

z = thickness of insulating material in inches, and the remaining symbols have the same significance as in the first-mentioned formula.

The object of the present invention is to provide a slide rule calculator adapted for the evaluation of these two formulæ.

According to the present invention a slide rule calculator specially adapted for evaluating q according to the formula

$$q=\frac{ts_1-tm}{\frac{d_1}{2k}\log_e\frac{d_2}{d_1}+\left(\frac{d_1}{d_2}\times\frac{1}{f}\right)}$$

is characterised in that for evaluating $\frac{d_1}{2k}\log_e\frac{d_2}{d_1}$ a first group of scales and slides is disposed at the top of the calculator; that for evaluating $\frac{d_1}{d_2}\times\frac{1}{f}$ a second group of scales and slides is disposed in the middle of the calculator; and that for evaluating q, substituting in the formula the values given by manipulation of the first and second groups and the value of ts_1-tm, a third group of scales is disposed at the bottom of the rule

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a view of one form of rule when not in use.

Fig. 2 shows the rule illustrated in Fig. 1 as used to evaluate q under certain conditions, and

Fig. 3 illustrates another form of rule when not in use.

The rules illustrated in the drawings each consist of a stiff base, for example of highly compressed cardboard, on which are marked ten scales (A, C, D, E, H, M, J, N and Q); seven slides, each marked

[*Price 3s. 0d.*]

Price 4s 6d

with a further scale (B, F, G, L, K, O and P respectively), and accommodated in grooves in the base, one groove between the A and C scales carrying the slide marked with scale B, one groove between the E and H scales carrying the slides marked with the F and G scales, one groove between the M and J scales carrying the slides marked with the L and K scales, and one groove between the N and Q scales carrying the slides marked with the O and P scales; and a transparent facing, for instance of methyl methacrylate, riveted to the base. When the rule is assembled the slides are capable of accurate longitudinal movement relative to the base under manual endwise pressure. The scales are all either logarithmic or bear a logarithmic relationship to another scale and their nature will be clearly understood from the following description of the operation of the rule illustrated in Figs. 1 and 2 of the accompanying drawings.

In order to evaluate q from the formula

$$q = \frac{ts_1 - tm}{\frac{d_1}{2k}\log_e\frac{d_2}{d_1} + \left(\frac{d_1}{d_2} \times \frac{1}{f}\right)}$$

the rule is manipulated as follows:—

(a) Adjust the arrow on the B scale to correspond with the value of d_2 on the A scale and opposite the value of d_1 on the B scale read off the value on the C scale.

Since the A scale is a logarithmic scale calibrated from 1 to 50, the B scale is a reversed logarithmic scale of like units calibrated from 1 to 50 (the arrow being at 1) with additional fractional values for convenience, and the C scale is an aligned repeat of the A scale over the range 1 to 10, this first manipulation gives a reading of the value $\frac{d_2}{d_1}$ on the C scale.

To proceed, read the value on the D scale vertically beneath this value of $\frac{d_2}{d_1}$ on the C scale and follow across to the E scale with the aid of the inclined guide lines. Place the arrow on the F scale opposite the indicated position on the E scale. Place the arrow of the G scale against the value of d_1 on the F scale and read the value on the H scale which corresponds to the value of K on the G scale.

The D scale is a linear one corresponding to the logarithmic C scale and the E scale is a logarithmic scale of like units to those of the C scale but displaced from the H scale (on which the result is to be read) by the Napierian constant 2.302. The F scale is as the B scale (but not reversed) with an arrow at 2; the G scale is a reversed logarithmic scale of like units to those of the F scale but calibrated from 1 to 10 (i.e., of greater extent); and the H scale logarithmic to like units as those of the G scale, the left hand part being calibrated from 1 to 20 and the right hand part from 2 to 10 (the significance of which right hand part will later be apparent). It will therefore be clear that the operations described will effect, with reference to the H scale, the conversion of $\frac{d_2}{d_1}$ to $\log\frac{d_2}{d_1}$ (actual value) followed by the correct location of this value relative to the scale of reference to enable by usual process of logarithmic addition and subtraction, the value of $\frac{d_1}{2k}\log_e\frac{d_2}{d_1}$ to be indicated on the H scale.

This value is conveniently designated X.

(b) Place the arrow of the K scale opposite the value of d_1 on the J scale, place the arrow of the L scale opposite the value of d_2 on the K scale and read the value on the M scale which corresponds with the value of f on the L scale.

The M, L, K and J scales are all logarithmic to like units, the L and K scales being reversed. The M scale is numbered from 0.1 to 2, the L scale from 0.1 to 5 (arrow at 1.0), the K scale from 1 to 50 (arrow at 10), and the J scale from 1 to 50 and, like the F scale has convenient fractions marked. The operations described therefore, by normal logarithmic processes, give a value on the M scale of $\frac{d_1}{d_2} \times \frac{1}{f}$.

This value is conveniently designated Y.

(c) Add X and Y together.

Place the arrow of the O scale opposite the value of $(ts_1 - tm)$ on the N scale. Then place the arrow of the P scale opposite the value of (X + Y) on the O scale. Then read the value on the Q scale indicated by the lower end of the arrow of the P scale. Alternatively read the value on the Q scale opposite the value of d_1 on the P scale.

The N and Q scales are like (but the latter is of somewhat greater extent) being logarithmic scales calibrated from 10 to 2000 and 10 to 1000 respectively. The O scale is a reversed logarithmic scale of like units numbered from 1 to 30 (arrow at 1) and the P scale is a repeat of the F scale.

This final operation, therefore, will give, by usual logarithmic processes the value of q.

The arrow of the P scale is at 3.82 (i.e. 12) and therefore the alternative reading on the P scale will give the heat loss per foot length of pipe instead of per square foot of surface.

The temperature on the outer surface of the insulation may be found from the formula

$$ts_2 = q . Y + tm$$

where ts_2 is the temperature of the outer surface of the insulation in °F. and the other symbols are as indicated previously.

To determine this outer surface temperature by means of the rule, place the tail of the arrow of the P scale opposite the value of q (calculated as above) on the Q scale and, oppposite to the head of this arrow, put the significant figure value of Y (calculated as above) on the O scale. The extension of the 10 mark on the O scale will usually indicate on the N scale the correct value of the difference in temperature between the outer surface of the insulation and the ambient air (this difference is numerically equal to the product q. Y) but the significant figure value may be read off at the arrow at 1. The value of ts_2 is the sum of this temperature difference and the temperature of the ambient air.

For flat surfaces the corresponding formula for the evaluation of q is

$$q = \frac{ts_1 - tm}{\frac{z}{k} + \frac{1}{f}}$$

where the symbols have the same significance as before and z = thickness of the insulating material in inches. In order to find the value of q in given circumstances the rule is manipulated as follows.

(a) Place the tail of the arrow of the G scale opposite the value of z on the R scale which is a logarithmic scale co-incident with the H scale but covering values from 1 to 10, and read off the value on the R scale opposite the value of k on the G scale. This value on the R scale is therefore $\frac{z}{k}$ = (say) X_1.

For multiple layer insulation the value of X_1 for each layer can be determined in this way, by inserting the appropriate value of thermal conductivity, and then all the values added together for the final total to be used on the O scale, as described below.

(b) Place the tail of the arrow of the L scale opposite the value 1 on the M scale and read off the value on the M scale opposite the value of f on the L scale. The value on the M scale is therefore $\frac{1}{f}$ = (say) Y_1.

(c) Add X_1 and Y_1 together and place the arrow of the O scale opposite the value of $(ts_1 - tm)$ on the N scale. Then place the arrow of the P scale opposite the value of $(X_1 + Y_1)$ on the O scale. It will then be clear that the value of q, the heat loss, may be read off on the Q scale against the lower end of the arrow of the P scale.

The surface temperature can be ascertained in similar manner as described for pipes above.

In order further to explain the working of the rule a numerical example for a pipe of circular cross section will now be given and Fig. 2 shows the rule settings. It is desired to find the heat loss q through the insulating material.

In the example

$ts_1 = 225°$ F.

$tm = 25°$ F.

$d_1 = 4''$

$d_2 = 8''$

$f = 1.8$ B.Th.U's/square ft./hour/°F.

$k = .5$ B.Th.U's/square ft./hour/°F./ for one inch thickness.

(a) Using scales A to H to evalulate $\frac{d_1}{2k} \log_e \frac{d_2}{d_1} = X$. The slides are positioned as shown in Fig. 2 which gives the value of X on the H scale as 2.77.

(b) Using scales J to M evaluate $\frac{d_1}{d_2} \times \frac{1}{f} = Y$. The slides are positioned as in Fig. 2 which gives the value of Y on the M scale as .278.

(c) $X + Y = 3.048$; $ts_1 - tm = 200$.

Using scales N to Q to make the final evaluation of q the answer given on the Q scale is 65.7 B.Th.U's/square foot/hour. Alternatively the heat loss per foot length is given as 68.9 B.Th.U's/hour.

Fig. 3 illustrates a metric version of the rule shown in Figs. 1 and 2. The method of manipulation is of course the same.

In the metric rule the units are as follows:—

Diameters and thicknesses in centimetres.

Thermal conductivity in Calories $\times 10^3$/metre^2/hour/°C./metre thickness.

Surface co-efficient in calories $\times 10^3$/metres^2/hour/°C.

Temperatures in °C.

Heat loss in Calories $\times 10^3$/metre^2/hour.

What we claim is:—

1. A slide rule calculator specially for evaluating q according to the formula

$$q=\frac{ts_1-tm}{\frac{d_1}{2k}\log_e\frac{d_2}{d_1}+\left(\frac{d_1}{d_2}\times\frac{1}{f}\right)}$$

characterised in that for evaluating $\frac{d_1}{2k}\log_e\frac{d_2}{d_1}$ a first group of scales and slides is disposed at the top of the calculator; that for evaluating $\frac{d_1}{d_2}\times\frac{1}{f}$ a second group of scales and slides is diposed in the middle of the calculator; and that for evaluating q, substituting in the formula the values given by manipulation of the first and second groups and the value of ts_1-tm, a third group of scales is disposed at the bottom of the rule.

2. A slide rule calculator as claimed in claim 1 characterised in that the first group of scales and slides consists of a fixed logarithmic scale, marked with a range of d_2 values, adjacent the top edge of a first groove, a reversed logarithmic scale, marked with a range of d_1 values, on a slide in said groove a fixed logarithmic scale, marked with a range of $\frac{d_2}{d_1}$ values, adjacent the bottom edge of said groove, a fixed linear scale, corresponding to the last mentioned scale, disposed therebelow, a further fixed logarithmic scale adjacent the top edge of a second groove, corresponding values on which are connected with values on the linear scale by guide lines, a logarithmic scale, marked with a range of d_1 values, on a first upper slide in said second groove, a reversed logarithmic scale, marked with a range of k values, on a second lower slide in said second groove, and a fixed logarithmic scale, marked with a range of $\frac{d_1}{2k}\log_e\frac{d_2}{d_1}$ values, adjacent the bottom edge of said second groove, and positioned relative to said further fixed logarithmic scale adjacent the top edge of the second groove so that the markings of the latter are of values of $\log_e\frac{d_2}{d_1}$ relative the markings of the former; and in that said second group of scales and slides consists of a fixed logarithmic scale marked with a range of d_1 values, adjacent the bottom edge of a third groove, a reversed logarithmic scale, marked with a range of d_2 values, on a first, lower slide in the third groove, a reversed logarithmic scale, marked with a range of f values, on a second, upper, slide in the third groove, and a fixed logarithmic scale, marked with a range of $\frac{d_1}{d_2}\times\frac{1}{f}$ values, adjacent the top edge of the third groove; and in that said group of slides and scales consists of a fixed logarithmic scale, marked with a range of ts_1-tm values, adjacent the top edge of a fourth groove, a reversed logarithmic scale, marked with a range of

$$\frac{d_1}{2k}\log_e\frac{d_2}{d_1}+\left(\frac{d_1}{d_2}\times\frac{1}{f}\right)$$

values, on a slide in the fourth groove and a fixed logarithmic scale marked with a range of q values along the bottom edge of the fourth groove.

3. A slide rule calculator as claimed in claim 2 characterised by a further logarithmic scale, marked with a range of d_1 values and a constant, on an additional lower slide in the fourth groove, whereby values of $q\pi d_1$ may be read off.

4. A slide rule calculator as claimed in claims 2 or 3 for evaluating, in addition, q according to to the formula

$$q=\frac{ts_1-tm}{\frac{z}{k}+\frac{1}{f}}$$

characterized by a further fixed logarithmic scale, marked with a range of z values, co-incident with the fixed logarithmic scale adjacent the bottom edge of the second groove.

5. A slide rule calculator as claimed in any one of claims 2 to 4 in which there is a base on which the fixed scale are marked, slides on which the movable scales are marked and which are disposed in grooves in the base, and a transparent facing secured to said base so as to locate the slides in the grooves.

6. A slide rule calculator substantially as hereinbefore described with reference to and as illustrated in Figs. 1 and 2 or Fig. 3 of the accompanying drawings.

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PROVISIONAL SPECIFICATION

Improvements in or relating to Slide Rules

We, SIDNEY RADCLIFFE POTTER, a British Subject, of Tameside Mills, Park Road, Dukinfield, in the County of Chester, and JOHN DYSON BLAKELEY, a British Subject, of 72, Cornwall Gardens, Gloucester Road, London, S.W.7, do hereby declare this invention to be described in the following statement:—

This invention concerns slide rules.

The object of the invention is to provide a silde rule which is specially adapted for the speedy evaluation of standard formula for given conditions.

According to the present invention a slide rule has a plurality of slides adapted, in conjunction with the fixed portions of the rule, to facilitate the speedy evaluation of standard formulæ for given conditions.

The invention will now be described further, by way of example, with reference to the accompanying drawing in which:—

Fig. 1 is a view of the body of a slide rule constructed in accordance with the invention, and

Fig. 2 is a view of the various slides for the body shown in Fig. 1.

The slide rule illustrated is designed for the speedy evaluation of heat losses from insulated circular pipes and flat surfaces according to the formulæ given hereunder.

1. For insulated pipes

$$q = \frac{ts_1 - tm}{\frac{d_1}{2k}\log_e\frac{d_2}{d_1} + \frac{d_1}{d_2}\times\frac{1}{f}}$$

where

q = heat loss through insulating material in B.Th.U's/square foot of hot surface/hour.

ts_1 = temperature of hot surface in °F.

tm = temperature of ambient air.

d_1 = outside diameter of pipe in inches.

d_2 = outside diameter of insulating material on pipe in inches.

k = thermal conductivity of insulating material in B.Th.U's/square foot/hour/°F./inch thickness.

f = surface co-efficient in B.Th.U's/square foot/hour/°F.

In order to obtain the value of q in given circumstances the rule is manipulated as follows:—

(a) Adjust the arrow on the B scale to correspond with the value of d_2 on the A scale and opposite the value of d_1 on the B scale read off the value on the C scale $\left(\frac{d_2}{d_1}\right)$. Read the value on the D scale vertically beneath this latter value to find $\log_{10}\frac{d_2}{d_1}$ and follow across to the E scale as indicated by the inclined guide lines, which gives the correct positioning, for the next operation, of $\log_e\frac{d_2}{d_1}$.

Place the arrow of the F scale opposite this position on the E scale. Place the arrow of the G scale opposite the value of d_1 on the F scale and read the value on the H scale which corresponds to the value of K on the G scale. This value on the H scale is:—

$$\frac{d_1}{2k}\log_e\frac{d_2}{d_1} = \text{(say) X}$$

(b) Place the arrow of the K scale opposite the value of d_1 on the J scale, place the arrow of the L scale opposite the value of d_2 on the K scale, and read the value on the M scale which corresponds with the value of f on the L scale.

This value on the M scale is:—

$$\frac{d_1}{d_2}\times\frac{1}{f} = \text{(say) Y.}$$

(c) Add X and Y together and place the arrow of the O scale opposite the value of $(ts_1 - tm)$ on the N scale. Then place the arrow of the P scale opposite the value of (X+Y) on the O scale.

(d) The value of q, the heat loss, may be read off on the Q scale against the lower end of the arrow of the P scale. To find the heat loss per foot length of pipe instead of per square foot of hot surface the value on the Q scale opposite the value of d_1 on the P scale is read.

The temperature on the outer surface of the insulation may be found from the formula:—

$$ts_2 = q.\text{Y} + tm$$

where ts_2 is the temperature of the outer surface of the insulation in °F. and the other symbols are as indicated previously.

To determine this outer surface temperature by means of the rule place the tail of the arrow of the P scale opposite the value of q (calculated as above) on the Q scale and opposite to the head of this arrow, put the value of "Y" (calculated as above) on the O scale. The extension of the 10 mark on the O scale will then point to the difference in temperature between the outer surface of the insulation and the ambient air (this difference is numerically equal to the product q.Y.). The value of ts_2 is the sum of this temperature difference and the temperature of the ambient air.

2. For insulated flat surfaces

$$q = \frac{ts_1 - tm}{\frac{L}{k} + \frac{1}{f}}$$

where the symbols have the same significance as before and L = thickness of the insulating material in inches. In order to find the value of q in given circumstances the rule is manipulated as follows:—

(a) Place the tail of the arrow of the G scale opposite the value of L on the R scale, and read off the value on the H scale opposite the value k on the G scale. This value on the H scale is $\frac{L}{k}$ = (say) X_1. For multiple layer insulation the value of X_1 for each layer can be determined in this way, by inserting the appropriate value of thermal conductivity, and then all the values added together for the final total to be used on the O scale, as described below.

(b) Place the tail of the arrow of the L scale opposite the L on the M scale and read off the value on the M scale opposite the value of f on the L scale. The value on the M scale is $\frac{1}{f}$ = (say) Y_1.

(c) Add X_1 and Y_1 together and place the arrow of the O scale opposite the value of $(ts_1 - tm)$ on the N scale. Then place the arrow of the P scale opposite the value of $(X + Y)$ on the O scale.

(d) The value of q, the heat loss, may be read off on the Q scale against the lower end of the arrow of the P scale.

The surface temperature can be ascertained in a similar manner as described for pipes above.

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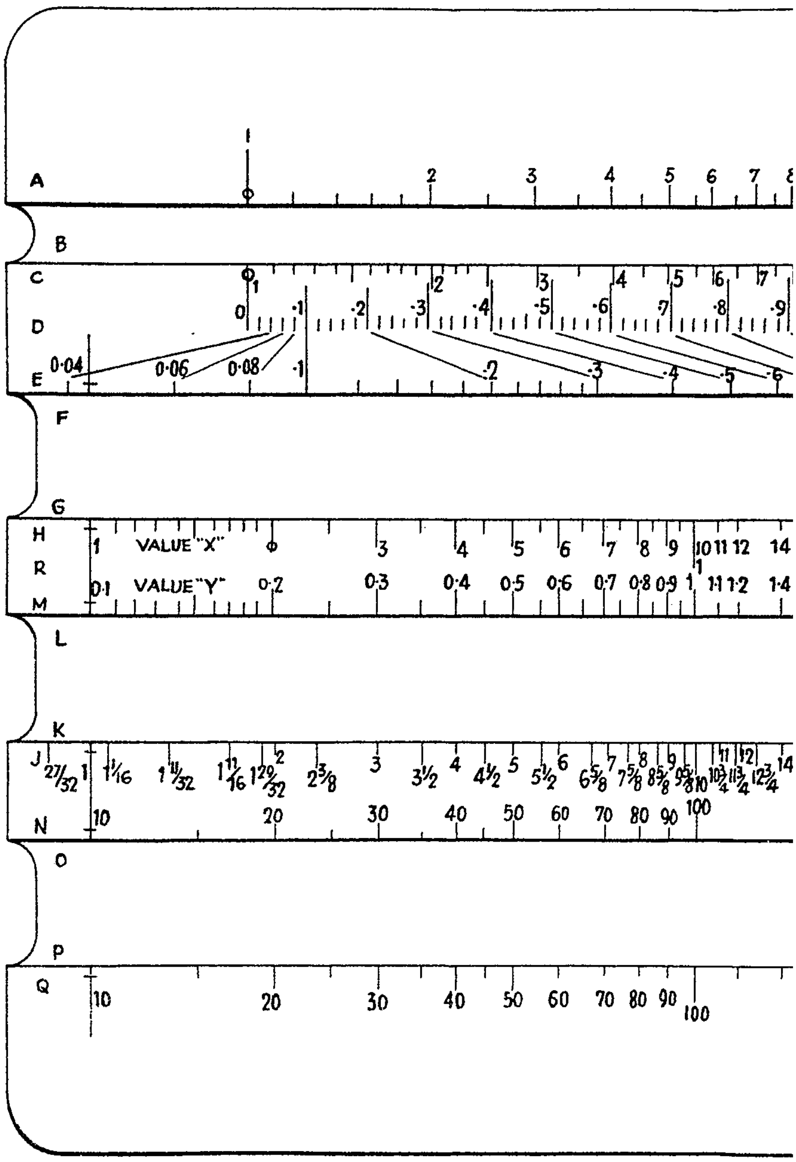
Published at the Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.



-FIG. 1-

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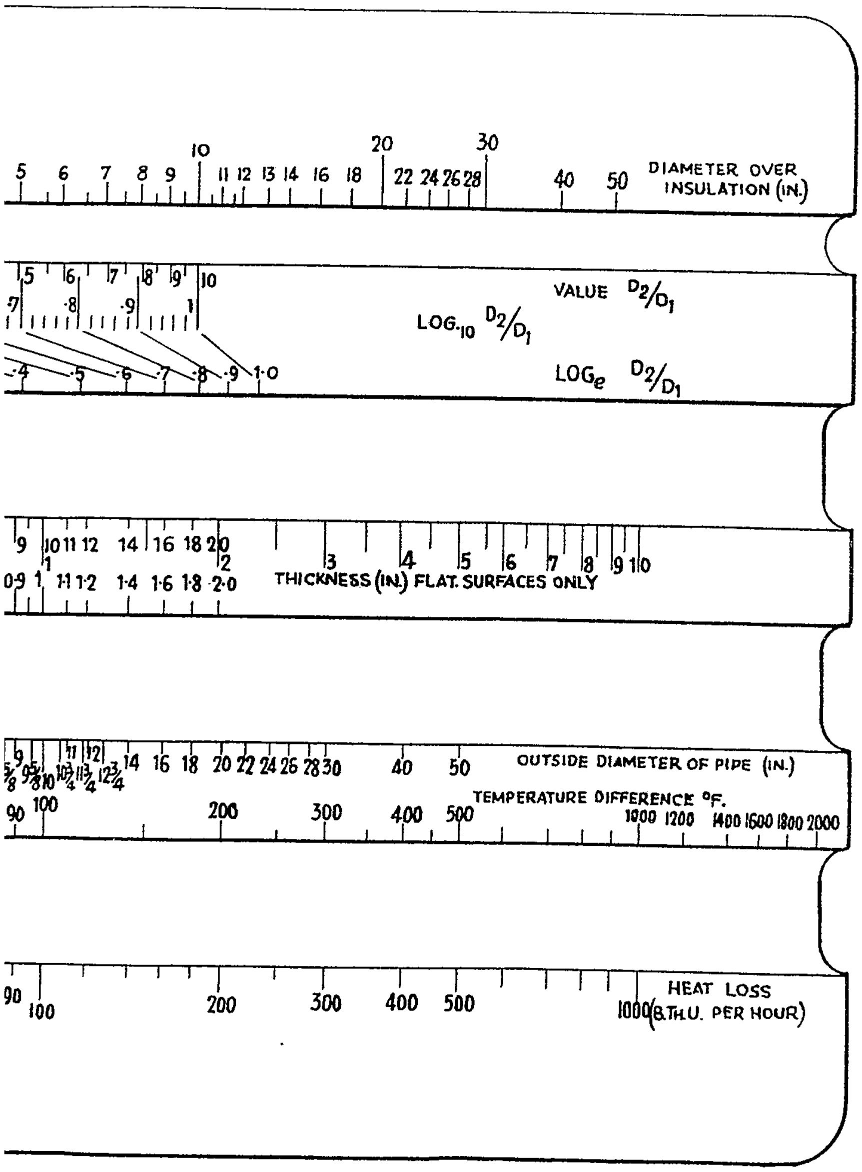
SHEET 1



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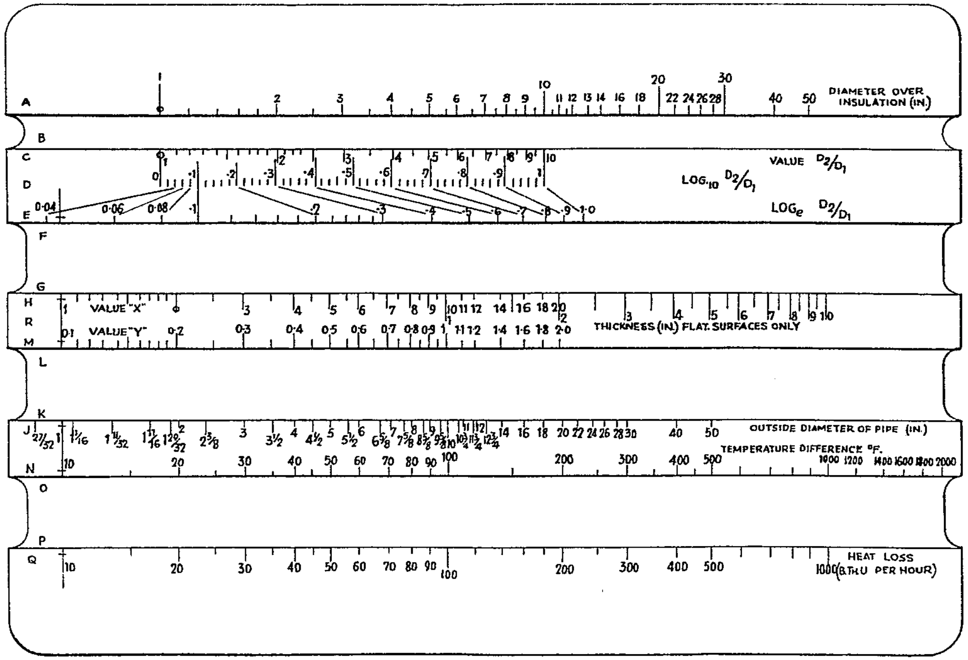
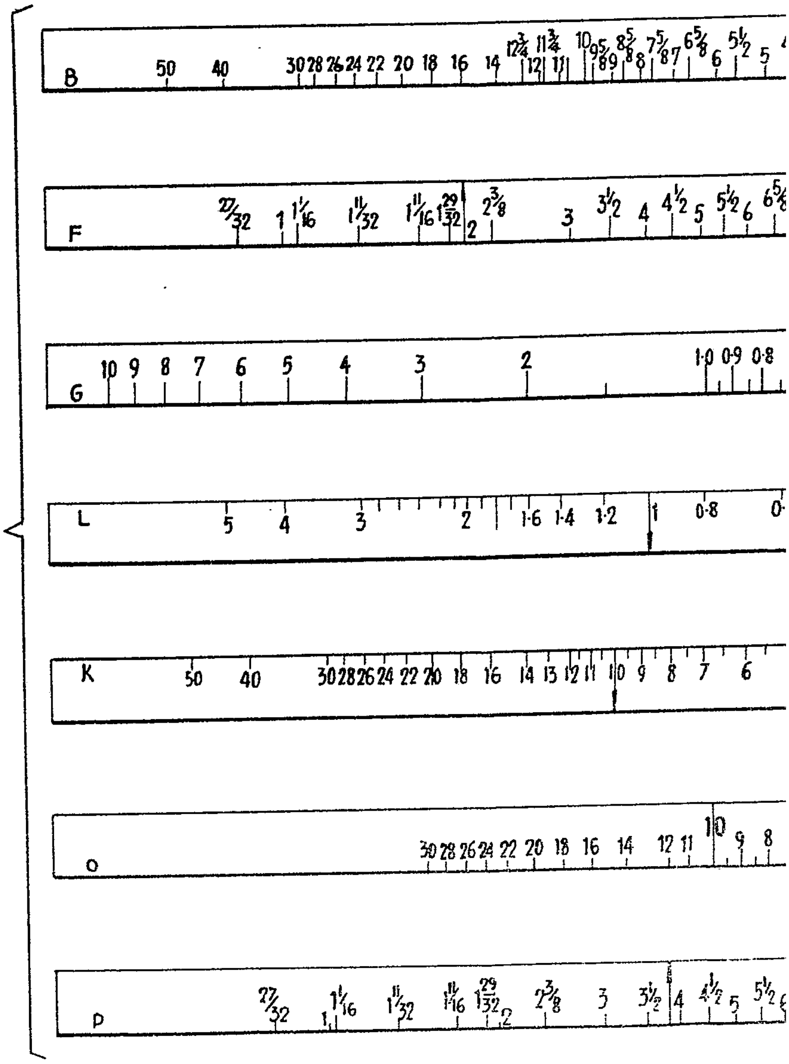


-FIG. 1-

-FIG. 2-



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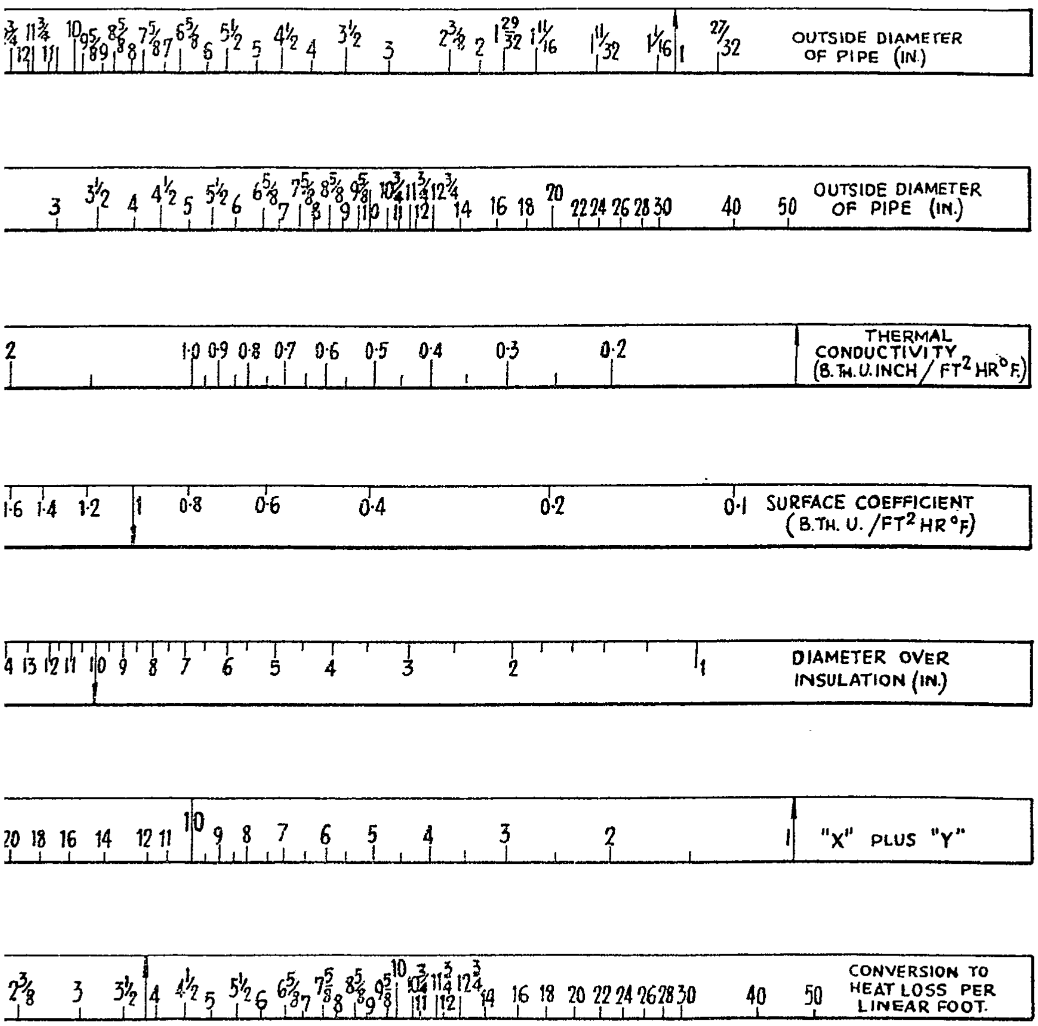
SHEET 2



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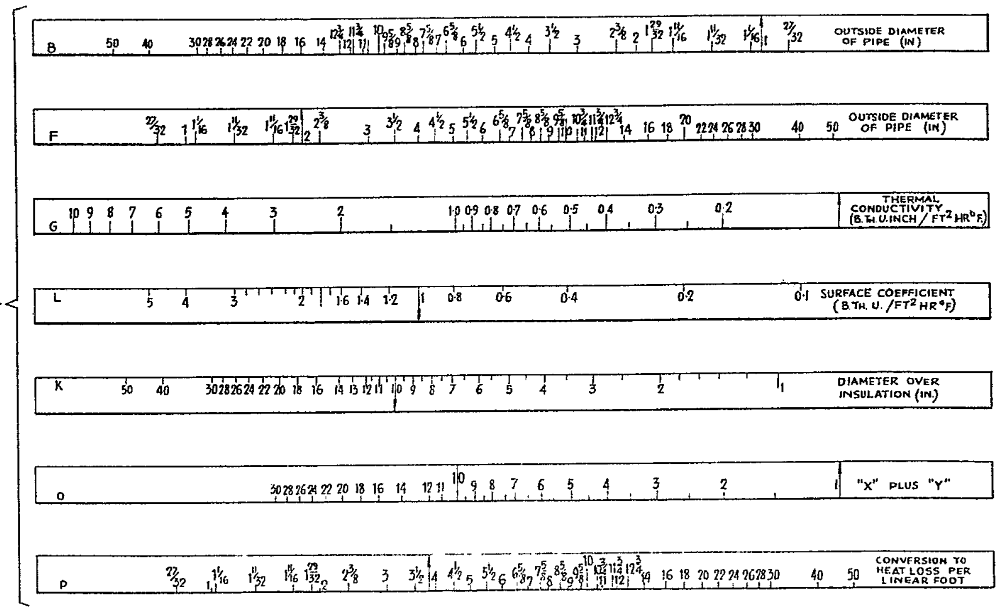

-FIG. 2-

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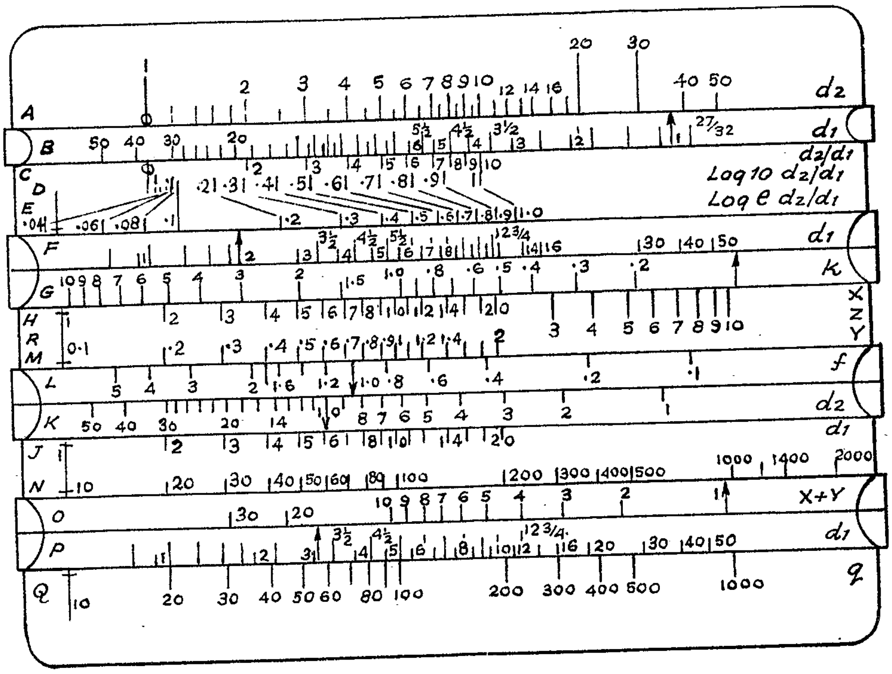

FIG. 1

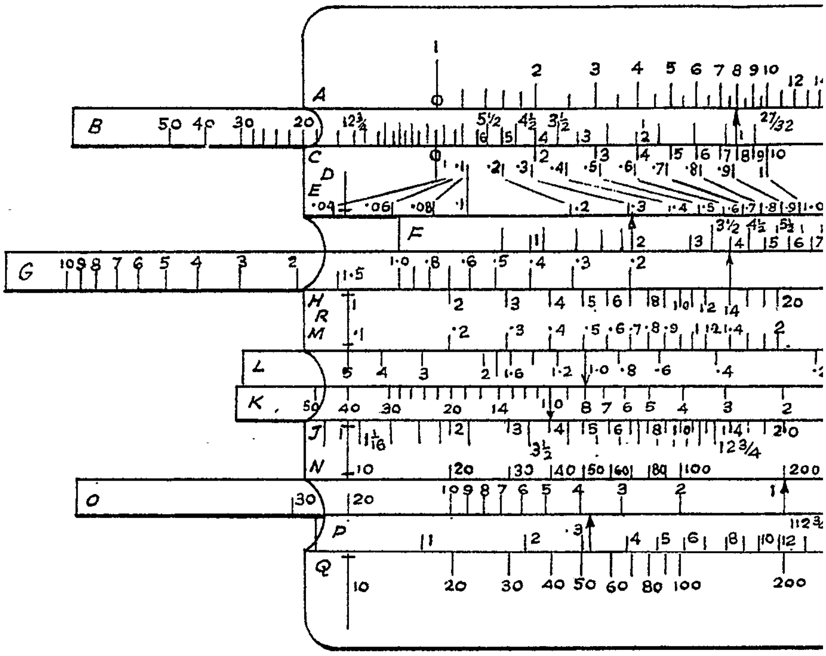

FIG. 2

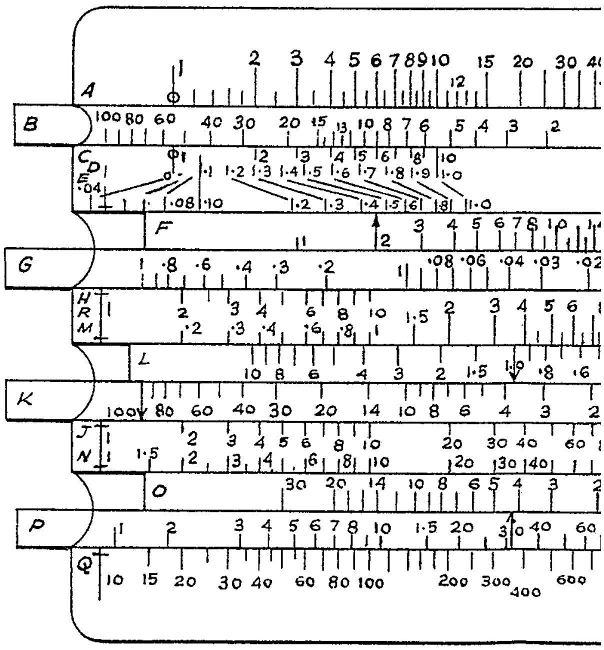

FIG. 3

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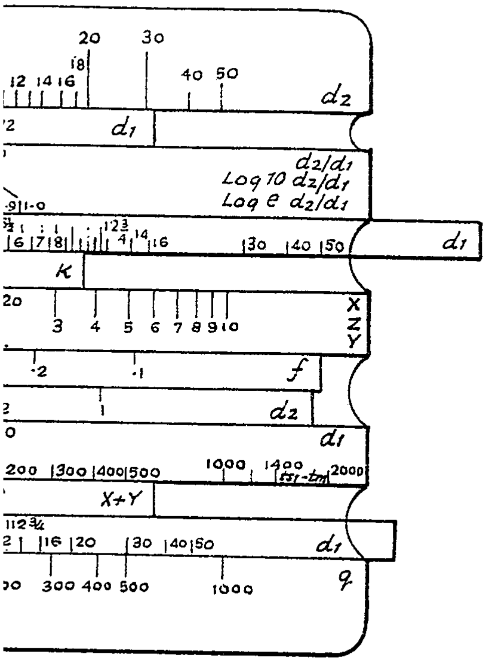
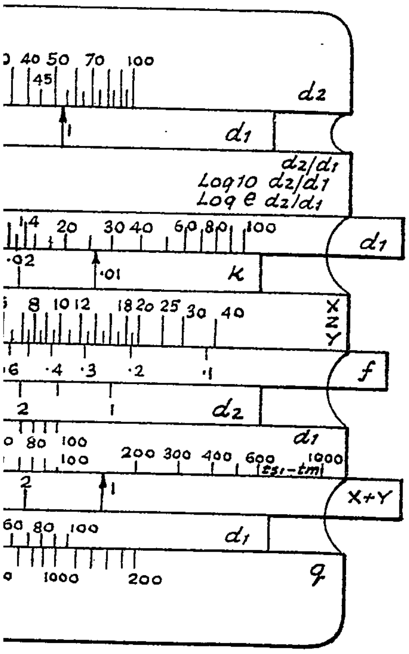
SHEET 2





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SHEET 2

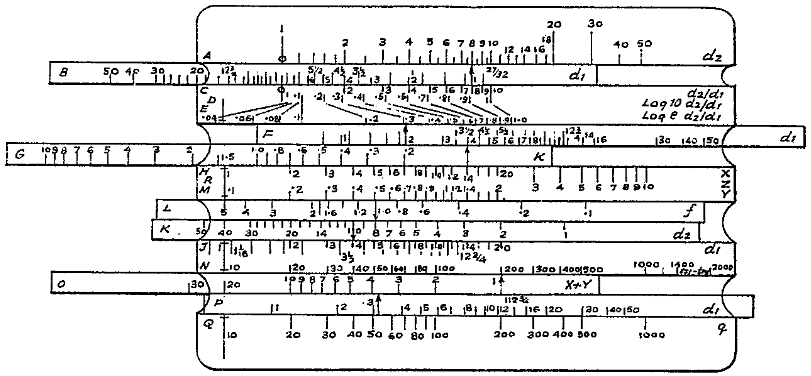

FIG. 2

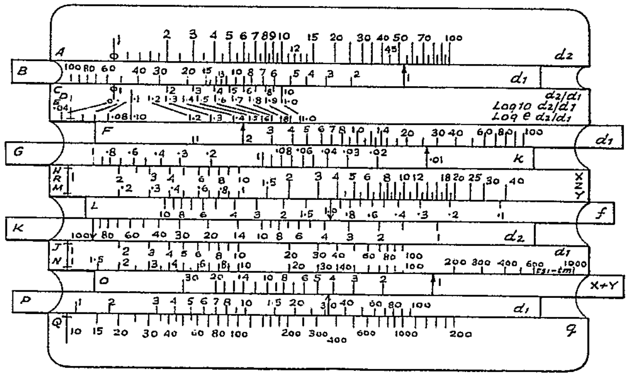

FIG 3