PATENT SPECIFICATION

686,161

Date of Application and filing Complete Specification May 27, 1948.

No. 14352/48.

Complete Specification Published Jan. 21, 1953.

Index at acceptance:—Class 106(i), B5(b: d: g15).

COMPLETE SPECIFICATION

Improvements in and relating to Calculating Devices of the Slide Rule Type

We, DOROTHY CARTER, of 19, Birkwood Avenue, Beckenham, in the County of Kent, and ISME RUTH WADE-PALMER, of 4, Cornwall House, Cornwall Gardens, London, S.W.7, both British Subjects, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to calculating devices of the slide rule type and has as one object, broadly stated, to provide a calculating device of this type for use in reinforced concrete construction and in particular to provide a device which will enable, for wide ranges of beam width, by an adjustment of the slide to the ascertained bending moment, without further calculating operations, the following to be directly read off:—

(1) With a chosen depth of beam:—
  (a) the ratio of steel stress to concrete stress;
  (b) the necessary steel action FE and the position of the neutral axis X;

(2) With a selected steel of cross section FE:—
  (a) the stress ratios in the concrete and steel;
  (b) the necessary depth of beam;
  (c) the position of the neutral axis X.

(3) With a given depth of beam and a given steel cross-section:—
  (a) the stress ratios in the concrete and in the steel.

Hitherto, the depth of the beam, the cross-sectional area of steel and the stresses were generally either determined by lengthy calculating operations or determined with the help of tables.

By the use of tables, a considerable part of the calculating operations was avoided but nevertheless a substantial amount of calculation was necessary.

The calculating operations with or without the aid of tables is time consuming and the more calculating operations necessary, the greater the possibility that calculating errors are introduced.

In such slide rules as have already been proposed for reinforced concrete calculations, either the scope was very limited, or successive different settings of the same sliding element were required.

By the employment of a slide rule in accordance with the invention, practically no calculating operations are necessary and in consequence calculating errors are minimised and the time in effecting the determinations is reduced to a minimum.

The slide rule, in accordance with the invention, serves for one or more of the following cases:—

(1) for the calculation of those concrete floors or beams in which the neutral axis lies in the floor or in the underside of the floor or beam;

(2) for the calculation of those reinforced concrete beams in which the neutral axis lies below the surface of the lower edge of the slab.

In these ribbed beams the compressive stress in the concrete of the web of the beam is not taken into account.

(3) for the calculation of double reinforced rectangular cross sections.

According to this invention, a calculating device for reinforced concrete work comprises a plurality of slips secured to a common foundation member and associated with a plurality of slidable elements, the slips and slidable elements bearing logarithmic scales appropriate to the correlation of depth of beam, width of beam, cross-sectional area of steel, bending moment, steel and concrete stress ratios and position of the neutral axis, and their juxtaposition being such that, if necessary with the aid of one or more cursors, such correlation can be effected without more than one movement of each slide. Preferably, at least some of the slides bear stress ratios and show them as generally transverse lines crossing longitudinal lines representing steel tensile strength, scaled in each case for reading against a respective fixed slip.

In one arrangement the slips give, in separate logarithmic scales, the initial value of the bending moment and the depth of beam, and the resulting values, namely the position of the neutral axis and the cross-sectional area of steel, and the slidable elements comprise a first showing breadth of beam on a lower and an upper graduation on two different scales for representing lower and upper beam breadths and three others showing steel-to-concrete stress ratios. Said first slidable element is preferably constrained for movement with one of said three others and is arranged for adjustment against a slip on which is marked the values of the bending moment. Said three other slidable elements may have the steel-to-concrete stress ratios marked as generally transverse lines crossing longitudinal lines representing steel tensile strength.

If desired the device may comprise one or more slides as follows:—

1. A slide in which steel-to-concrete stress ratios are marked as generally transverse lines crossing longitudinal lines representing ratios of thickness of slab to static depth of beam, for use in the case of ribbed or **T**-beams in which the neutral axis falls below the slab, arranged for reading against depth of beam when positioned in accordance with the breadth of beam and bending moment.

2. A slide in which the steel-to-concrete stress ratios are marked as generally transverse lines crossing longitudinal lines representing the product of the ratio of cross-section of compressive steel to cross-section of tensile steel and the ratio of the distance of the compressive steel from the upper edge of the beam to the distance of tensile steel from the upper edge of the beam, for use in the case of doubly reinforced rectangular cross-section beams, arranged for reading against depth of beam when positioned in accordance with the breadth of beam and bending moment.

3. A slide as just described under (2) and a further slide on which steel-to-concrete stress ratios are similarly marked but scaled for reading against a stationary slip bearing tensile steel cross-section when adjusted in accordance with the breadth and depth of beam.

The slides described above under (1) and (2) may bear markings for beam breadth and be arranged for adjustment against a stationary slip bearing a range of values of bending moment.

Conveniently, the foundation member is recessed and the slides are of equilateral triangular section, showing different ranges of the respective values on each face, whereby the width of the device is reduced.

The accompanying drawings illustrate two embodiments of the invention, the markings being as follows:—

M initial value of bending moment;
h depth of beam;
x position of neutral axis;
fe cross-sectional area of steel;
b breadth of beam;
r_1 slide showing steel-concrete stress ratios for relating M to *h*;
t_1 slide showing steel-concrete stress ratios for relating M to *fc*;
s slide showing steel-concrete stress ratios for relating M to *x*;
d slab thickness of **T** or ribbed beam;
fed steel section under compression;
fez steel section under tension;
r_2 slide showing steel-concrete stress ratios and *d*/*h* ratios for relating M to *fe*;
h_1 depth of upper reinforcement in doubly reinforced beam;
r_3 slide showing *b* and steel-concrete stress ratios and $\frac{fed}{fez} \times \frac{h^1}{h}$ values for relating M to *h*;
t_3 slide showing *b* and steel-concrete stress ratios and $\frac{fed}{fez} \times \frac{h^1}{h}$ values for relating *fez* to M;
L cursor;
LR cursor groove.

Figures 1 and 2 of the accompanying drawings show the slide rule in flat plate form for designing slabs, and those ribbed beams in which the neutral axis falls within the slab. The slide rule is shown both in section and in plan.

Figures 3 to 7 show the slide rule having slides of the form of equilateral triangular prisms.

The prisms bear on each side inscriptions of the influence values of different qualities of steel. In the case of the equilateral triangular prisms for instance on one side are marked the values of the low-stressed qualities of steel (stress from 700 to 1300 kilogrammes per square centimetre), on the second side those with medium stress (1300 to 1900) and on the third side those for high grades of steel (1900 to 2500 kilogrammes per square centimetre). The different sides of the prisms are tinted in various colours, so that the same kind of steel has the same tint. When the kind of steel is changed, the prisms are drawn out and turned so that the desired kind of steel is shown on the top.

The prisms and flat sides are mounted in a casing. These prisms that carry with them at the same time a flat side are connected with these flat sides by connecting pieces V, which are rotatably mounted in the prism axis, and are so fitted in the flat tongue that they can be inserted in and removed from it.

Figure 3 shows a section. The casing and the fixed bars are drawn in heavy lines, the slidable prisms and bars are hatched.

Figure 4 shows a side with two prisms, which serves for designing slabs, and those ribbed beams in which the neutral axis falls in the slab, x therefore being equal to or less than d.

Figure 5 shows an edge with one prism upon which for all cases the position of the neutral axis X is shown.

Figure 6 shows the broad side with two prisms, which serves for designing doubly reinforced rectangular cross-sections.

Figure 7 shows the edge, which serves for designing those ribbed beams in which the neutral axis falls below the slab, x being therefore greater than d.

The following describes the mode of use of the device.

For slabs and ribbed beams in which the neutral axis falls in the slab, as in figures 2, 4 and 5.

Adjustment

(1) The lower beam breadth, marked on the slide b is adjusted to the bending moment of the fixed scale M. Since the slide r_1 is fixedly connected with the slide b, the slide r_1 is itself correctly positioned.

(2) The starting point of the slide t_1, is adjusted to the upper beam breadth, marked on the slide b.

(3) The starting point of the slide s is adjusted to the selected beam depth h which is marked upon the fixed scale h.

Reading

(1) The stress ratio of steel to concrete is to be read off above the selected depth of beam on the scale h upon the slide r_1.

(2) Above the same stress ratio of steel to concrete upon the slide t_1 is read off upon the fixed scale fe, the necessary cross-sectional area of steel in square centimetres or in square inches.

(3) Below the same stress ratio of steel to concrete of the slide s the value of x in centimetres or in inches is read off on the fixed scale x.

In ribbed beams in which the neutral zone lies below the slab, first the ratio of the thickness of the slab d to the static depth of beam h is ascertained. At the point of intersection of the hair-line of the cursor, which has been adjusted to the depth of the beam, and the corresponding d/h line (Figure F), the ratio of steel stress to concrete stress will be seen.

In designing doubly reinforced rectangular cross-sections, first the ratio of the cross-section of the compressive steel fed (see Figure 6) to that of the tensile steel fez is ascertained, and also the ratio of the distance h_1 of the compressive steel from the upper edge of the beam to the distance h of the tensile steel from the upper edge of the beam. After adjusting the beam breadth b scale to the bending moment, over the selected depth of beam h upon the line showing the product of fed/fez and h_1/h the stress ratio is visible on the slide r_3.

The tensile steel cross-section fez is to be found over the same stress ratio of concrete to steel on the tongue t_3, after b has been adjusted to h.

In general, the slide rules are so constructed that no tensile stresses have to be taken up by the concrete, but they can be so constructed that tensile stresses can be assigned to the concrete.

Having now paricularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A calculating device for reinforced concrete work comprising a plurality of slips secured to a common foundation member and associated with a plurality of slidable elements, the slips and slidable elements bearing logarithmic scales appropriate to the correlation of depth of beam, width of beam, cross-sectional area of steel, bending moment, steel and concrete stress ratios and position of the neutral axis, and their juxtaposition being such that, if necessary with the aid of one or more cursors, such correlation can be effected without more than one movement of each slide.

2. A calculating device as set forth in claim 1, wherein at least some of the slides bear stress ratios and show them as generally transverse lines crossing longitudinal lines representing steel tensile strength, scaled in each case for reading against a respective fixed slip.

3. A calculating device for reinforced concrete work comprising a plurality of slips secured to a common foundation member on which are given in separate logarithmic scales, the initial value of the bending moment and depth of beam, and the resulting values, namely the position of the neutral axis and the cross-sectional area of steel, together with slidable elements, a first showing breadth of beam on a lower and an upper graduation on two different scales for representing lower and upper beam breadths and three

others showing steel-to-concrete stress ratios.

4. A calculating device as set forth in claim 3, in which said first slidable element is constrained for movement with one of said three others and is arranged for adjustment a slip on which is marked the values of the bending moment.

5. A calculating device as set forth in claim 3 or 4, in which said three other slidable elements have the steel-to-concrete stress ratios marked as generally transverse lines crossing longitudinal lines representing steel tensile strength.

6. A calculating device as set forth in claim 3, 4 or 5 having a slide in which steel-to-concrete stress ratios are marked as generally transverse lines crossing longitudinal lines representing ratios of thickness of slab to static depth of beam, for use in the case of ribbed or **T**-beams in which the neutral axis falls below the slab, arranged for reading against depth of beam when positioned in accordance with the breadth of beam and bending moment.

7. A calculating device as set forth in claim 3, 4, 5 or 6, having a slide in which the steel-to-concrete stress ratios are marked in generally transverse lines crossing longitudinal lines representing the product of the ratio of cross-section of compressive steel to cross-section of tensile steel and the ratio of the distance of the compressive steel from the upper edge of the beam to the distance of tensile steel from the upper edge of the beam, for use in the case of doubly reinforced rectangular cross-section beams, arranged for reading against depth of beam when positioned in accordance with the breadth of beam and bending moment.

8. A calculating device as set forth in claim 3, 4, 5 or 6 having a slide as set forth in claim 7 and a further slide on which steel-to-concrete stress ratios are similarly marked but scaled for reading against a stationary slip bearing tensile steel cross-section when adjusted in accordance with the breadth and depth of beam.

9. A calculating device as set forth in claim 6 or 7, wherein the slide referred to bears markings for beam breadth and is arranged for adjustment against a stationary slip bearing a range of values of bending moment.

10. A calculating device as set forth in any of the preceding claims, in which the foundation member is recessed and the slides are of equilateral triangular section, showing different ranges of the respective values on each face, whereby the width of the device is reduced.

11. A calculating device substantially as hereinbefore described with reference to, and as shown in, Figures 1 and 2.

12. A calculating device substantially as hereinbefore described with reference to, and as shown in, Figures 3—7.

MARKS & CLERK.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1953
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2. from which copies may be obtained.

686,161 COMPLETE SPECIFICATION
3 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

Fig. 2

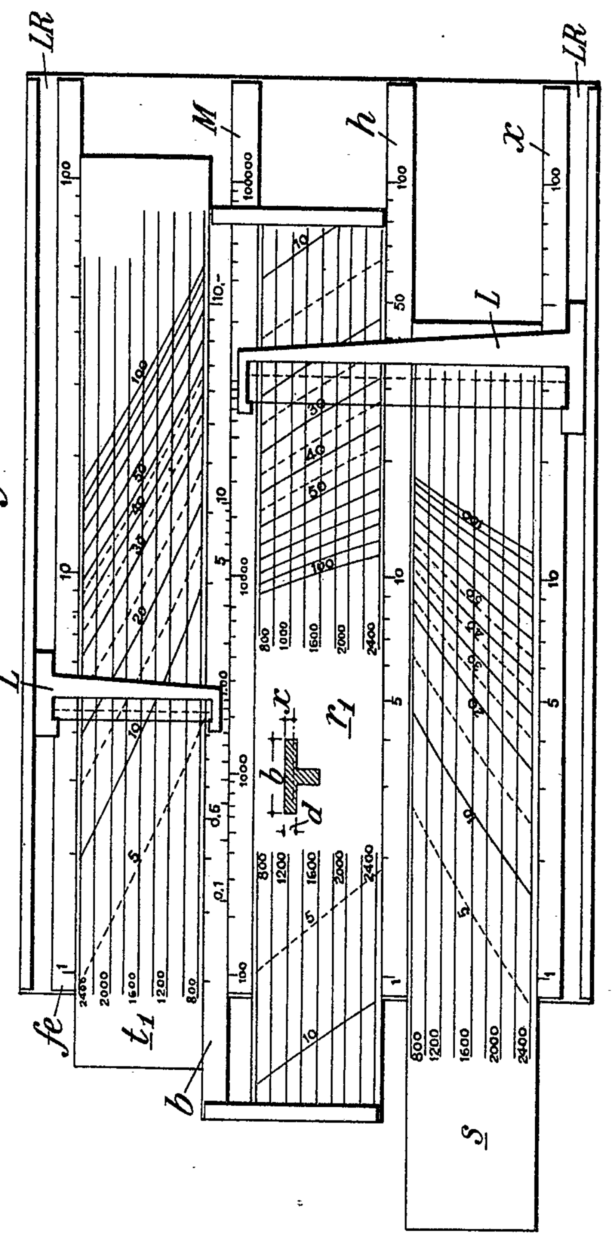


Fig. 1

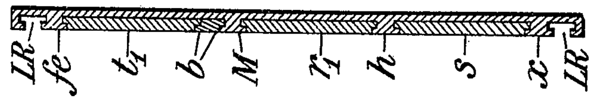


Fig.3

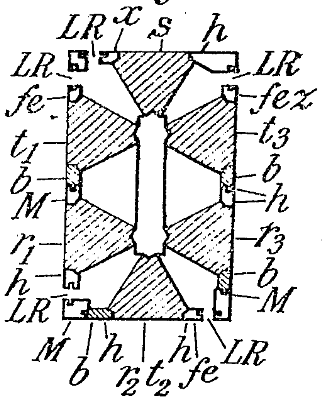


Fig. 4

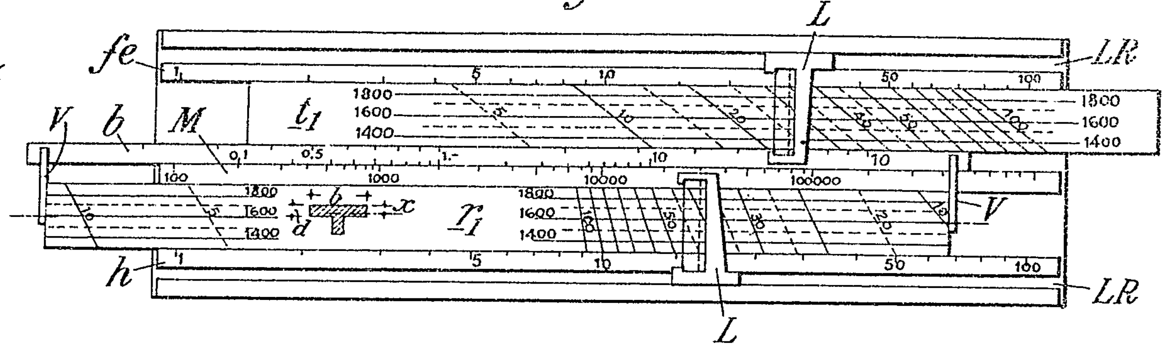
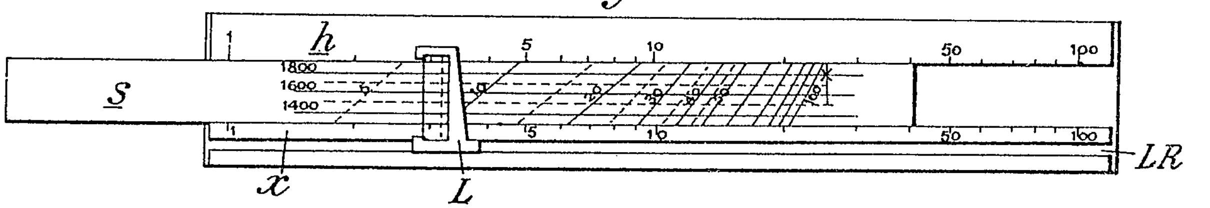


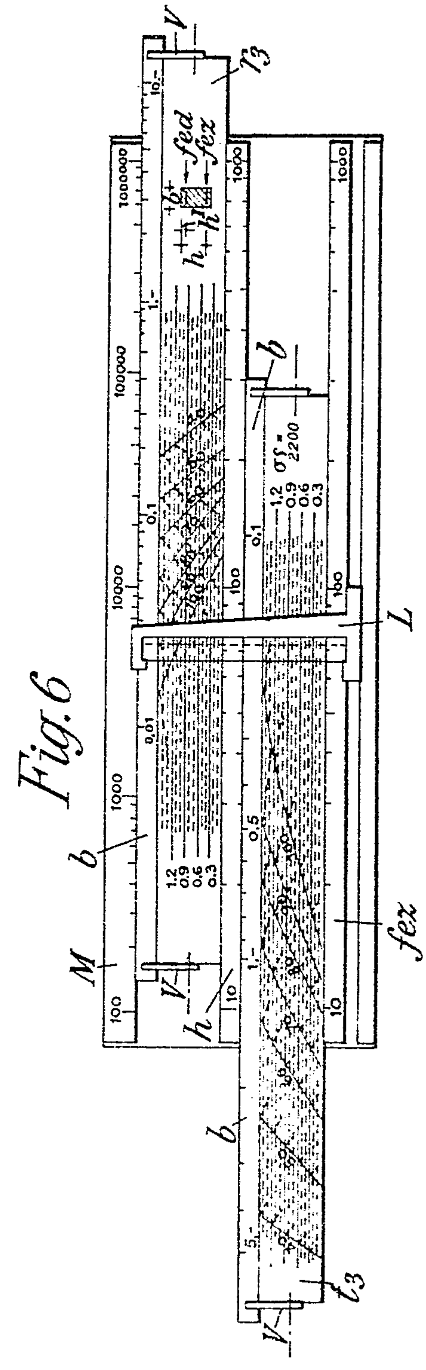
Fig.5

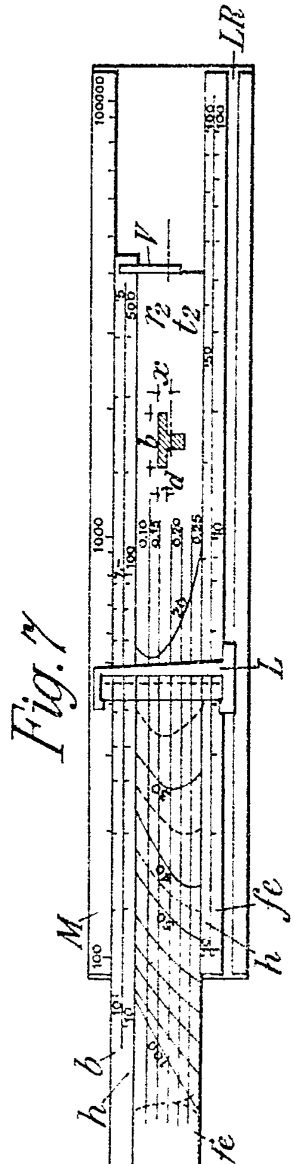


686,161 COMPLETE SPECIFICATION
3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 2 & 3





686,161 COMPLETE SPECIFICATION
3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 2 & 3

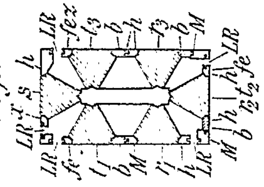


Fig. 3

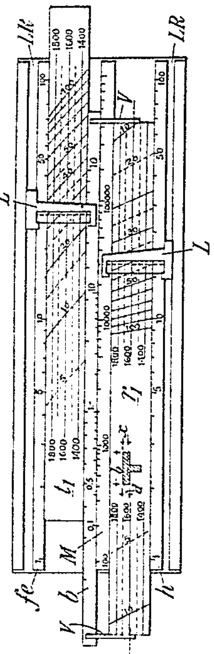


Fig. 4

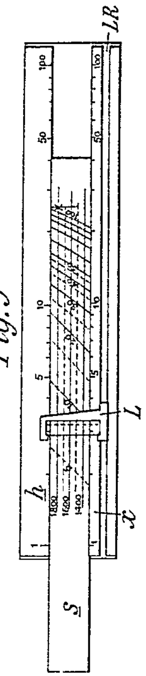


Fig. 5

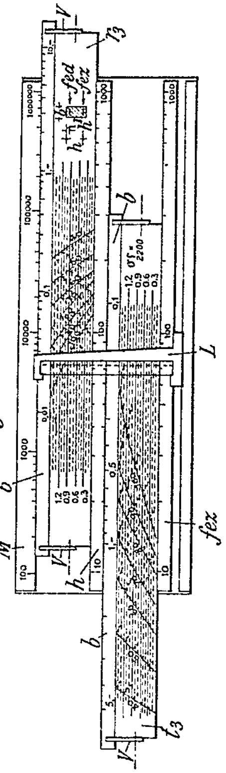


Fig. 6

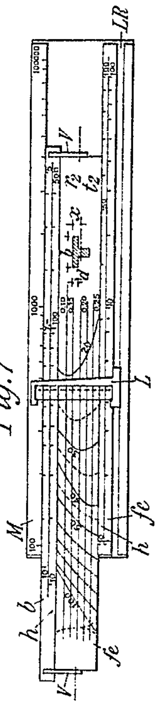


Fig. 7