PATENT SPECIFICATION 859,063

DRAWINGS ATTACHED.

Inventor :—ROBERT SELWYN MORGAN.

Date of filing Complete Specification : Sept. 23, 1959.

Application Date : June 25, 1958. No. 20317/58.

Complete Specification Published : Jan. 18, 1961.

Index at Acceptance :—**Class 106(1)**, B5(A : B : GX).

International Classification :—G06g.

COMPLETE SPECIFICATION.

Improvements in or relating to Slide-Rules or Calculators.

I, MINISTER OF AVIATION, London, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention relates to slide-rules or calculators and has for its object to provide a slide-rule or calculator for the rapid solution of a number of calculations associated with protection from gamma-radiation.

The process of determining by mathematical calculation, the thickness of a container necessary to obtain a specified dose-rate of radiation on the surface of said container, is a very laborious one, and is normally done by a series of approximations, while the calculation of barrier thickness necessary to obtain a specified dose-rate at a distance from a source of gamma-radiation requires the use of attenuation curves as well as a separate calculation for distance.

In accordance with the invention, a slide-rule or calculator for the rapid solution of calculations associated with protection from gamma-radiation comprises two members movable relatively to one another, the first of which members has a logarithmic distance scale representing the distance from the source of gamma-ray output at which a dose-rate is specified or to be calculated, and the second member a logarithmic dose-rate scale, the logarithmic cycle of which is half that of the distance scale, there also being provided on the first member, adjacent the dose-rate scale on the second member, a logarithmic source-strength scale having the same cycle as, but in opposition to, the said dose-rate scale, and also on the second member, one or more thickness scales which are disposed adjacent the distance scale on the first member and represent the thickness of the protective material.

The construction of the slide-rule or calculator, according to the invention is based on the following equation :—

$$R = \frac{(3.28)^2 \text{ r.C.A.}}{d^2}$$

where R is the dose-rate in milli-rontgens per hour, at a point, distant d in feet, from a source of strength C in milli-curies and gamma-ray output r in milli-rontgens per hour per milli-curie at 1 metre, and A is the attenuation in the absorbing material interposed between the source and the measuring point, being an exponential function of x, the thickness of the material in inches.

By translating the above equation into common logarithms a second equation is obtained as follows :—

$$2 \log_{10} d = \log_{10} \frac{C}{R} + \log_{10} r + \log_{10} A + 1.0320.$$

from which it will be evident that these quantities can be arranged in the form of a slide-rule or calculator.

In determining experimentally the attenuation curves for plates of both lead and concrete sufficiently large to ensure "broad beam" conditions such as normally arise in shielding practice, it was found that the said curves become linear after initial filtration, thus indicating exponential absorption, with a constant half-value thickness, in which case :—

$$\log_{10} A = -ax + b$$

where a and b are constants.

Initially, however, the curve possesses a "shoulder" along which the half-value thickness is continuously changing. This must be taken into account in designing containers, shields or barriers, otherwise the thickness as calculated will be in error, as for example, in the case of Cobalt-60 where the calculated thickness of lead would lead to lower protection than that desired, and with the other sources such as Iridium, Caesium and Radium (or Radon) the lead shielding would be thicker and heavier than it need be.

This initial variation in the half-value thickness is therefore incorporated in the thickness of protective material scales of the slide-rule or calculator according to the invention, in the following manner :—

Graphs of d against $\frac{C}{R}$ are plotted using double logarithmic scales for various values of A, in terms of x, obtained from the attenuation curves, as a result of which a series of parallel straight lines is obtained.

For a chosen logarithmic cycle on the $\frac{C}{R}$ axis, the intercepts which the straight lines make on this axis constitute the thickness scale.

Two alternative forms of the invention will now be described with reference to the accompanying drawings, in which :—

Figure 1 shows in plan view the "straight" form of slide-rule constructed according to the invention ; and

Figure 2 shows, also in plan view, a second or circular form of slide-rule constructed according to the invention.

Referring to Figure 1, a slide-rule or calculator according to the invention comprises the usual straight main member 1 of any suitable rigid material which is centrally slotted from end to end and within which slot 2 is slidably mounted a second straight member of similar material constituting a slide 3. Engraved or otherwise marked upon the main member 1 is a logarithmic distance scale 4 representing the distance from a source of gamma-ray output at which a dose-rate is specified or to be calculated, the said scale extending along the lower edge of the slot 2, immediately adjacent the corresponding lower edge of the slide 3, and being graduated in feet with the first foot graduated in inches. Upon its face and along its upper edge immediately adjacent the corresponding upper edge of the slot 2, the slide 3 has engraved thereon a logarithmic dose-rate scale 5, the logarithmic cycle of which is half that of the distance scale 4 and which scale is graduated in opposition to the distance scale in millirontgens per hour.

Upon the face of the main member 1 along the upper edge of the slot 2 and adjacent the corresponding upper edge of the slide 3, and the dose-rate scale 5, is engraved a logarithmic source-strength scale 6 graduated in both curies and milli-curies and having the same cycle as, but in opposition to, the dose-rate scale. Finally, the slide 3 has engraved thereon in opposition to the distance scale 4, a set of thickness scales 7 extending along the slide 3 and arranged one above the other, at substantially equal intervals from the lower edge thereof. The number of scales in a set corresponds to the number of different sources of strength to be included in the calculations capable of being solved by the slide-rule or calculator. In the present example, four thickness scales are provided in a set, representing the thicknesses in inches of the protective material, as for example, lead, for the sources Iridium-192, Caesium-137, Radium (or Radon) and Cobalt-60.

An arrow or other indicating mark 8 is engraved at the 1 milli-rontgen per hour mark on the dose-rate scale 5, and the relative position of the thickness scales 7 for the four different sources of a set is fixed by sliding the main member 1 and the slide 3 relatively to one another until the said arrow is set against the 1 milli-curie mark on the source-strength 6, and marking the zeros against the appropriate values of d on the distance scale 4 obtained from either of the first two equations hereinbefore referred to, for the values of $A = 1$ and $\frac{C}{R} = 1$, in which case

$$d = 3.28 \sqrt{r} \text{ ft.}$$

The slider 3 is reversible and may have engraved thereon a duplicate dose-rate scale and a corresponding set of thickness scales for determining the same mathematical calculations in respect of a second protective material, as for example, concrete.

A cursor having a cursor line 9 is preferably provided for greater accuracy in taking readings from the slide-rule or calculator.

Referring now to Figure 2, a second or circular form of slide-rule or calculator according to the invention comprises a disc 10 of any suitable rigid material which has mounted therein a ring 11 of similar material which is retained within the disc 10 by engaging within an annular groove 12 formed in the latter so as to permit the ring and disc to be rotated relatively to one another. The external diameter of the ring 11 is made smaller than that of the disc 10 so that the periphery of the latter extends beyond that of the ring to provide an annular band of the disc between the two peripheries. Engraved or otherwise marked upon the disc 10 is a logarithmic distance scale 13 representing the distance from a source of

gamma-ray output at which a dose-rate is specified or to be calculated, the said scale extending in the form of an arc immediately adjacent the inner peripheral edge of the ring member 11 and being graduated in feet with the first foot graduated in inches. Upon its surface, immediately adjacent a part of its outer peripheral edge, the ring member 11 has engraved thereon a logarithmic dose-rate scale 14, the logarithmic cycle of which is half that of the distance scale 13 and which scale is graduated in milli-rontgens per hour. A duplicate of this dose-rate scale 14 is also engraved along the diametrically opposite outer peripheral edge of said ring member 11. The number of dose-rate scales 14 corresponds to the number of different protective materials capable of inclusion in the calculations to be solved by the slide-rule or calculator, which materials in the present example, are two, viz, concrete and lead.

Engraved upon half the perimeter of the disc 10 along the annular band thereof between the periphery of said disc and the outer periphery of the ring 11 is a logarithmic source-strength scale 15 graduated in both curies and milli-curies and having the same cycle as, but in opposition to, the two dose-rate scales 14, the said scale 15 by relative rotation of the disc and the ring member being capable of being set adjacent to either of the said dose-rate scales along the outer peripheral edge of the ring member. Finally the ring member 11 has engraved thereon two sets of arcuate thickness scales 16, one set for each dose-rate scale, each set comprising a number of concentric scales arranged at substantially equal radial intervals, from the inner peripheral edge of the ring 11. The number of scales in each set is the same and corresponds to the number of different sources of strength to be included in the calculations capable of being solved by the slide-rule or calculator. In the present example, four thickness scales are provided in each set, one set representing the thicknesses in inches of concrete for the sources Iridium-192, Caesium-137, Radium (or Radon) and Cobalt-60, and the other set the thicknesses, also in inches, for lead in respect of the same sources of strength, either of which sets of scales, by relative rotation between the disc and the ring member can be brought adjacent the distance scale on the disc.

An arrow or other indicating mark 17 is engraved at the 1 milli-rontgen per hour mark on each of the dose-rate scales 14, and the relative positions of the thickness scales 16 for the four different sources of each of the two sets (concrete and lead) are fixed by rotating the disc and ring member relatively to one another until the said arrow is set against the 1 milli-curie mark on the source-strength scale 15, and marking the zeros against the appropriate values of d on the distance scale 13 obtained from either of the first two equations hereinbefore referred to, for the values of $A = 1$ and $\frac{C}{R} = 1$, in which case

$$d = 3.28 \sqrt{r} \text{ ft.}$$

A cursor is preferably provided for greater accuracy in taking readings from the slide-rule or calculator, which is in the form of a rotatable arm pivoted at its inner end to the centre of the disc, and extending radially across both the ring member 11 and the disc 10 to the outer perimeter of the latter, and which has a cursor line 18.

The following selected examples illustrate the manner in which a slide-rule or calculator as described with reference to Figure 1 or 2, is intended to operate.

(a) To find the thickness of concrete required to produce a dose-rate of radiation of 7.5 milli-rontgens per hour at a distance of 12 ft. from an unprotected source of 1 curi eof Cobalt-60.
  (1) Set the arrow 8 or 17 on the appropriate dose-rate scale 5 or 14 against 1 curie on the source-strength scale 6 or 15.
  (2) Place the cursor line 9 or 18 on 7.5 milli-rontgens per hour on the said dose-rate scale 5 or 14.
  (3) Move the slide 3 or ring 11 until the arrow 8 or 17 of the dose-rate scale 5 or 14 is under the cursor line 9 or 18.
  (4) Read the concrete thickness for Cobalt-60 (12 inches) against 12 ft. on the distance scale 4 or 13.

(b) To find the dose-rate of radiation through $\frac{1}{4}$ inch of lead at a distance of 5 ft. from an unprotected source of 3 curies of Iridium-192.
  (1) Set $\frac{1}{4}$ in. of lead for Iridium-192 against 5 ft. on the distance scale 4 or 13.
  (2) Set the cursor line 9 or 18 on the arrow 8 or 17 on the appropriate dose-rate scale 5 or 14.
  (3) Move the slide 3 or ring 11 until the said arrow 8 or 17 is against the 3 curies' mark on the source-strength scale 6 or 15.
  (4) Read the dose-rate (about 190 milli-rontgens per hour) beneath the cursor line 9 or 18 on the dose-rate scale 5 or 14.

(c) To find the wall-thickness of a lead container required to accommodate 50 curies of Cobalt-60 and give a surface dose-rate of 600 milli-rontgens per hour.
  (1) Set the arrow 8 or 17 of the appropriate dose-rate scale 5 or

14 against the 50 curies mark on the source-strength scale 6 or 15.

(2) Place the cursor line 9 or 18 on the 600 milli-rontgens per hour mark on the dose-rate scale 5 or 14.

(3) Move the slide 3 or ring 11 until the dose-rate arrow 8 or 17 is below the cursor line 9 or 18.

(4) The wall-thickness is found in coincidence with its own value on the distance scale 4 or 13 (in this case 6.5 ins.).

In this calculation, no account has been taken of the space at the centre of the container required to accommodate the source. In designing a spherical container, provided this space, say $\frac{1}{4}$ in. radius, is added to the lead thickness, thereby increasing the overall diameter of the container, and is not obtained at the expense of the lead thickness, the error in the calculation will be small and lie on the side of safety, i.e. the surface dose-rate will be slightly lower than that intended.

(d) To find the strength of a source of Caesium-137 which can be accommodated in a lead-container of wall-thickness 2.5 ins. to give a surface dose-rate on the outside of the container of 1000 milli-rontgens per hour. (Assume that the source is accommodated in a spherical cavity of $\frac{1}{4}$" radius).

(1) Set the 2.5 in. mark on the lead-thickness scale 7 or 16 for Caesium-137 against the 2.75 in. mark on the distance scale 4 or 13.

(2) Place the cursor line 9 or 18 over the arrow 8 or 17 on the appropriate dose-rate scale 5 or 14.

(3) Move the slide 3 or ring 11 until the 1000 milli-rontgens per hour mark is under the cursor line 9 or 18.

(4) Read the source strength (6 curies), against the arrow 8 or 17.

(e) To find the minimum safe distance from an unprotected source of 2 curies of Cobalt-60.

(1) Set the arrow 8 or 17 on the dose-rate scale 5 or 14 against the 2 curies mark on the source strength scale 6 or 15.

(2) Place the cursor line 9 or 18 on the maximum permissible dose-rate for whole-body irradiation (at present 7.5 milli-rontgens per hour).

(3) Move the slide 3 or ring 11 until the arrow 8 or 17 is under the cursor line 9 or 18.

(4) Read the distance (62 ft.) against zero thickness on the thickness scale 7 or 16 for Cobalt-60.

Instructions as to the general procedure for using the slide-rule or calculator may be engraved on the back or front thereof, according to whether the said slide-rule or calculator is of the straight or rotary disc type, and are such as will enable the user to determine any one quantity when the other three quantities are known.

It will be understood that by lengthening the slide of the " straight " type of slide-rule or calculator, or by enlarging the circular type, or alternatively, by reducing the size of the scales in both cases, it would be possible to provide readings in respect of more than two protective materials.

WHAT I CLAIM IS :—

1. A slide-rule or calculator for the rapid solution of calculations associated with protection from gamma-radiation, comprising two members movable relatively to one another, the first of which members has a logarithmic distance scale representing the distance from the source of gamma-ray output at which a dose-rate is specified or to be calculated, and the second member a logarithmic dose-rate scale, the logarithmic cycle of which is half that of the distance scale, there also being provided on the first member, adjacent the dose-rate scale on the second member, a logarithmic source strength scale having the same cycle as, but in opposition to, the said dose-rate scale, and also on the second member, one or more thickness scales which are disposed adjacent the distance scale on the first member and represent the thickness of the protective material.

2. A slide-rule or calculator as claimed in Claim 1, wherein the number of thickness scales for setting out the different thicknesses of any one form of protective material, corresponds to the number of different sources of radiation for which the slide-rule is required to calculate.

3. A slide-rule or calculator as claimed in Claim 1 or 2, comprising a straight main member which is longitudinally slotted from end to end and within which slot is slidably mounted a second straight member, there being engraved or otherwise marked upon the main member along one longitudinal edge of the slot therein, the logarithmic distance scale, and along the opposite longitudinal edge of said slot, the logarithmic source strength scale, whilst upon the second straight member is engraved or otherwise marked, the logarithmic dose-rate scale which extends along that edge of said second member adjacent the source strength scale, and the one or more thickness scales which extend along the opposite edge of said second member adjacent the distance scale.

4. A slide-rule or calculator as claimed in Claim 3, wherein two sets of dose-rate and thickness scales are arranged one on each side of the second straight member in order to

allow for calculations to be made in respect of two kinds of protective materials, so that by reversing said member within its slot, one or other of the said sets of scales can be brought adjacent the single set of sources of strength and distance scales provided on the main member.

5. A slide-rule or calculator as claimed in Claim 1 or 2, comprising a disc having an annular groove formed in one face thereof within which is rotatively mounted a ring, there being engraved or otherwise marked upon the disc along one peripheral edge of the groove therein, the logarithmic distance scale, and along the other peripheral edge of said slot, the logarithmic source strength scale, whilst upon the ring is engraved or otherwise marked, the logarithmic dose-rate scale which extends along that peripheral edge of the ring adjacent the source strength scale, and the one or more thickness scales which extend along the opposite edge of said ring adjacent the distance scale.

6. A slide-rule or calculator as claimed in Claim 5, wherein two sets of dose-rate and thickness scales are arranged diametrically opposite one another in the form of arcs upon the ring in order to allow for calculations to be made in respect of two kinds of protective materials, one or other of which sets of scales, by relative rotation between the disc and the ring, can be brought adjacent a single set of source of strength and distance scales also disposed in the form of arcs and positioned around one half of said disc.

7. A slide-rule or calculator as claimed in any of the preceding claims, wherein for the purposes of greater accuracy in taking readings therefrom, a cursor is provided.

8. A slide-rule or calculator substantially as hereinbefore described with reference to the accompanying drawings.

R. G. CHANNEN,
Chartered Patent Agent,
Agent for the Applicant.

PROVISIONAL SPECIFICATION.

Improvements in or relating to Slide-Rules or Calculators.

I, MINISTER OF AVIATION, London, do hereby declare this invention to be described in the following statement :—

This invention relates to slide-rules or calculators and has for its object to provide a slide-rule or calculator for the rapid solution of a number of calculations associated with protection from gamma-radiation.

The process of determining by mathematical calculations, the thickness of a container necessary to obtain a specified dose-rate of radiation on the surface of said container, is a very laborious one, and is normally done by a series of approximations, while the calculation of barrier thickness necessary to obtain a specified dose-rate at a distance from a source of gamma-radiation requires the use of attenuation curves as well as a separate calculation for distance.

In accordance with the invention, a slide-rule or calculator for the rapid solution of calculations associated with protection from gamma-radiation comprises two members movable relatively to one another, the first of which members has a logarithmic distance scale representing the distance from the source of gamma-ray output at which a dose-rate is specified or to be calculated, and the second member a logarithmic dose-rate scale, the logarithmic cycle of which is half that of the distance scale, there also being provided on the first member, adjacent the dose-rate scale on the second member, a logarithmic source strength scale having the same cycle as, but in opposition to, the said dose-rate scale, and also on the second member, one or more thickness scales which are disposed adjacent the distance scale on the first member and represent the thickness of the protective material.

The construction of the slide-rule or calculator according to the invention is based on the following equation :—

$$R = \frac{(3.28)^2\ r.C.A.}{d^2}$$

where R is the dose-rate in milli-rontgens per hour, at a point, distant d in feet, from a source of strength C in milli-curies and gamma-ray output r in milli-rontgens per hour per milli-curie at 1 metre, and A is the attenuation in the absorbing material interposed between the source and the measuring point, being an exponential function of x, the thickness of the material in inches.

By translating the above equation into common logarithms a second equation is obtained as follows :—

$$2 \log_{10} d = \log_{10} \frac{C}{R} + \log_{10} r + \log_{10} A + 1.0320$$

from which it will be evident that these quantities can be arranged in the form of a slide-rule or calculator.

In determining experimentally, the attenuation curves for plates of both lead and concrete sufficiently large to ensure

"broad beam" conditions such as normally arise in shielding practice, it was found that the said curves become linear after initial infiltration, thus indicating exponential absorption, with a constant half-value thickness, in which case :—

$$\log_{10} A = -ax + b$$

where a and b are constants.

Initially, however, the curve possesses a "shoulder" along which the half-value thickness is continuously changing. This must be taken into account in designing containers, shields or barriers, otherwise the thickness as calculated will be in error, as for example, in the case of Cobalt-60 where the calculated thickness of lead would lead to lower protection than that desired, and with the other sources such as Iridium, Caesium and Radium (or Radon) the lead shielding would be thicker and heavier than it need be.

This initial variation in the half-value thickness is therefore incorporated in the thickness of protective material scales of the slide-rule or calculator according to the invention, in the following manner :—

Graphs of d against $\frac{C}{R}$ are plotted using double logarithmic scales for various values of A, in terms of x, obtained from the attenuation curves, as a result of which a series of parallel straight lines is obtained. For a chosen logarithmic cycle on the $\frac{C}{R}$ axis, the intercepts which the straight lines make on this axis constitute the thickness scale.

In one construction, a slide-rule or calculator according to the invention comprises the usual straight main member of any suitable rigid material which is centrally slotted from end to end and within which slot is slidably mounted a second straight member of similar material constituting the slide. Engraved or otherwise marked upon the main member is a logarithmic distance scale representing the distance from a source of gamma-ray output at which a dose-rate is specified or to be calculated, the said scale extending along the lower edge of the slot, immediately adjacent the corresponding lower edge of the slide, and being graduated in feet with the first foot graduated in inches. Upon its face and along its upper edge immediately adjacent the corresponding upper edge of the slot, the slide has engraved thereon a logarithmic dose-rate scale, the logarithmic cycle of which is half that of the distance scale and which scale is graduated in opposition to the distance scale in milli-rontgens per hour.

Upon the face of the main member along the upper edge of the slot and adjacent the corresponding upper edge of the slide, and the dose-rate scale, is engraved a logarithmic source-strength scale graduated in both curies and milli-curies and having the same cycle as, but in opposition to, the dose-rate scale. Finally, the slide has engraved thereon in opposition to the distance scale, a set of thickness scales extending along the slide and arranged one above the other at substantially equal intervals from the lower edge thereof. The number of scales in a set corresponds to the number of different sources of strength to be included in the calculations capable of being solved by the slide-rule or calculator. In the present example, four thickness scales are provided in a set, representing the thickness in inches of the protective material, as for example, lead, for the sources Iridium-192, Caesium-137, Radium (or Radon) and Cobalt-60.

An arrow or other indicating mark is engraved opposite the 1 milli-rontgen per hour mark on the dose-rate scale, and the relative position of the thickness scales for the four different sources of a set is fixed by sliding the main member and the slide relatively to one another until the said arrow is set against the 1 milli-curie mark on the source-strength scale, and marking the zeros against the appropriate values of d on the distance scale obtained from either of the first two equations hereinbefore referred to, for the values of A = 1 and $\frac{C}{R} = 1$, in which case

$$d = 3.28\sqrt{r} \text{ ft.}$$

The slider is reversible and may have engraved thereon a duplicate dose-rate scale and a corresponding set of thickness scales for determining the same mathematical calculations in respect of a second protective material, as for example, concrete.

A cursor is preferably provided for greater accuracy in taking readings from the slide-rule or calculator.

The following selected examples illustrate the manner in which a slide-rule or calculator according to the invention, is intended to operate.

(a) To find the thickness of concrete required to produce a dose-rate of radiation of 7.5 milli-rontgens per hour at a distance of 12 ft. from an unprotected source of 1 curie of Cobalt-60.
   (1) Set the arrow on the appropriate dose-rate scale against 1 curie on the source-strength scale.
   (2) Place the cursor line on 7.5 milli-rontgens per hour on the said dose-rate scale.
   (3) Move the slide until the arrow of

the dose-rate scale is under the cursor line.

(4) Read the concrete thickness for Cobalt-60 (12 inches), against 12 ft. on the distance scale.

(b) To find the dose-rate of radiation through $\frac{1}{4}$ inch of lead at a distance of 5 ft. from an unprotected source of 3 curies of Iridium-192.

(1) Set $\frac{1}{4}$ in. of lead for Iridium-192 against 5 ft. on the distance scale.

(2) Set the cursor line on the arrow on the appropriate dose-rate scale.

(3) Move the slide until the said arrow is against the 3 curies' mark on the source-strength scale.

(4) Read the dose-rate (about 190 milli-rontgens per hour) beneath the cursor line on the dose-rate scale.

(c) To find the wall-thickness of a lead container required to accommodate 50 curies of Cobalt-60 and give a surface dose-rate of 600 milli-rontgens per hour.

(1) Set the arrow of the appropriate dose-rate scale against the 50 curies mark on the source-strength scale.

(2) Place the cursor line on the 600 milli-rontgens per hour mark on the dose-rate scale.

(3) Move the slide until the dose-rate arrow is below the cursor line.

(4) The wall-thickness is found in coincidence with its own value on the distance scale (in this case 6.5 ins.).

In this calculation, no account has been taken of the space at the centre of the container required to accommodate the source. In designing a spherical container, provided this space, say $\frac{1}{4}$ in. radius, is added to the lead thickness, thereby increasing the overall diameter of the container, and is not obtained at the expense of the lead thickness, the error in the calculation will be small and lie on the side of safety, i.e. the surface dose-rate will be slightly lower than that intended.

(d) To find the strength of a source of Caesium-137 which can be accommodated in a lead-container of wall-thickness 2.5 ins. to give a surface dose-rate on the outside of the container of 1000 milli-rontgens per hour. (Assume that the source is accommodated in a spherical cavity of $\frac{1}{4}''$ radius).

(1) Set the 2.5 ins. mark on the lead-thickness scale for Caesium-137 against the 2.75 ins. mark on the distance scale.

(2) Place the cursor line over the arrow on the appropriate dose-rate scale.

(3) Move the slide until the 1000 milli-rontgens per hour mark is under the cursor line.

(4) Read the source-strength (6 curies), against the arrow.

(e) To find the minimum safe distance from an unprotected source of 2 curies of Cobalt-60.

(1) Set the arrow on the dose-rate scale against the 2 curies mark on the source-strength scale.

(2) Place the cursor line on the maximum permissible dose-rate for whole-body irradiation (7.5 milli-rontgens per hour).

(3) Move the slide until the arrow is under the cursor line.

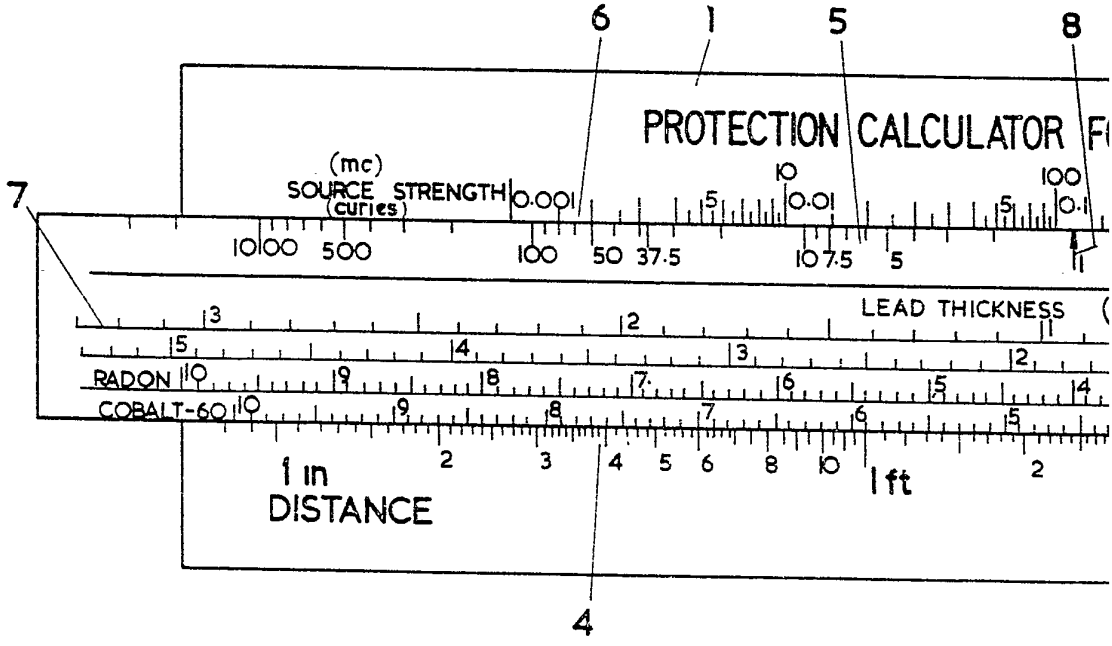
(4) Read the distance (62 ft.) against zero thickness on the thickness scale for Cobalt-60.

It will be understood that the invention is not limited to the straight type of slide-rule or calculator but can also be applied to the rotary disc type in which the slide is in the form of a ring mounted in the disc or main member.

Instructions as to the general procedure for using the slide-rule or calculator may be engraved on the back or front thereof, according to whether the said slide-rule or calculator is of the straight or rotary disc type, and are such as will enable the user to determine any one quantity when the other three quantities are known.

R. G. CHANNEN,
Chartered Patent Agent,
Agent for the Applicant.

Abingdon: Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1960.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2,
from which copies may be obtained.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5
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(curies)
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10
0.01
100
0.1
10100
500
100
50
37.5
10
7.5
5
7
LEAD THICKNESS
RADON
COBALT-60
1 in
DISTANCE
1 ft
4

FIG. 1.

859,063 COMPLETE SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

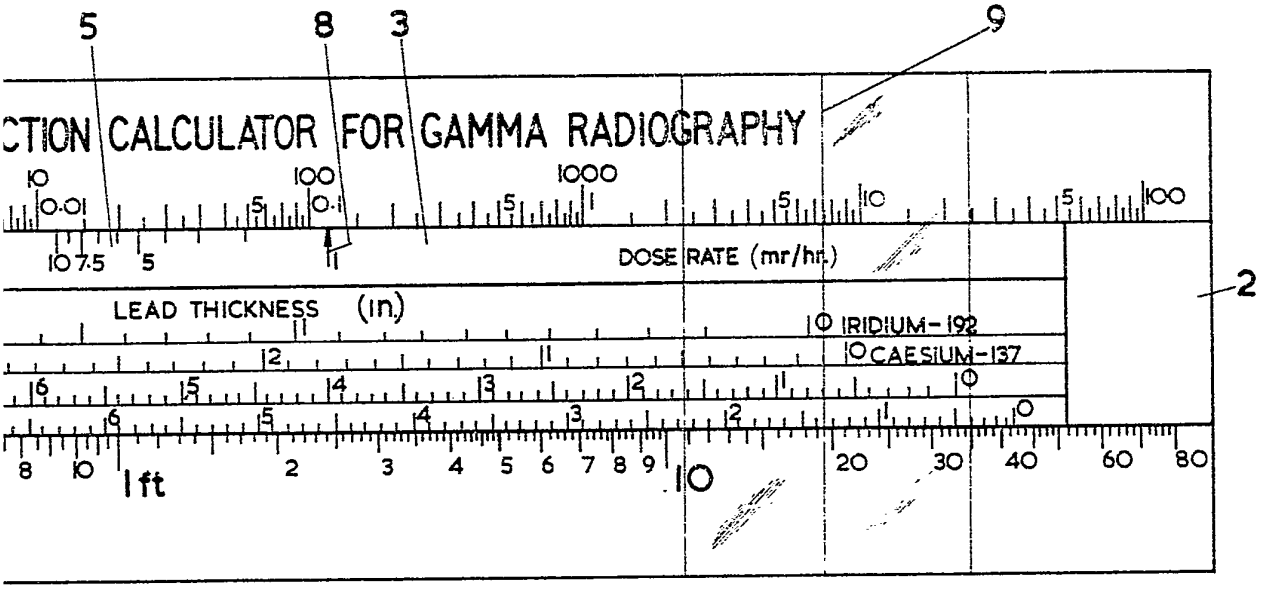


FIG. 1.

859,063 COMPLETE SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

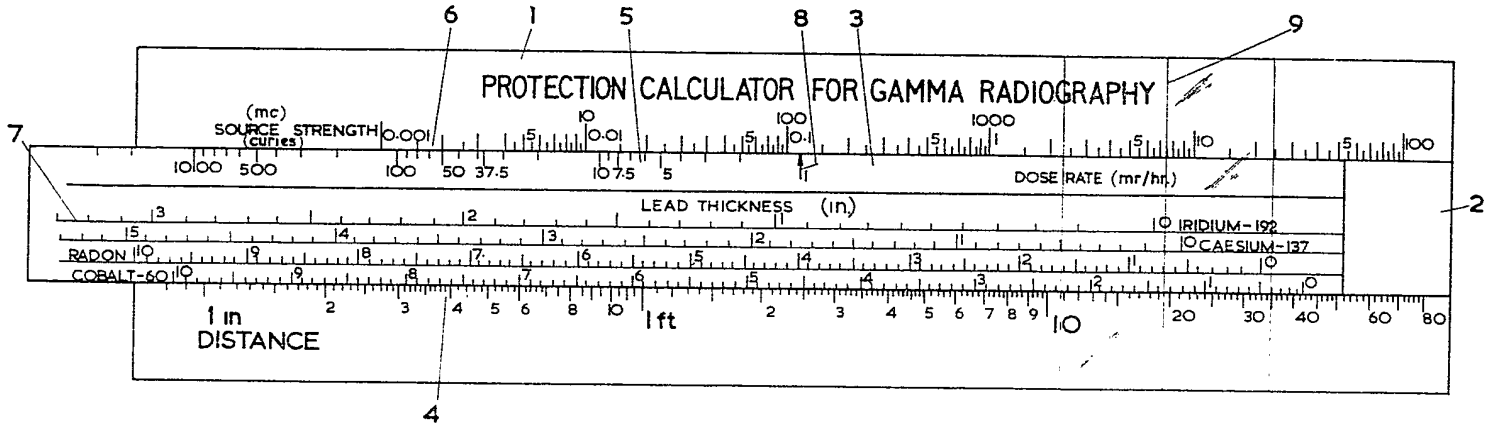
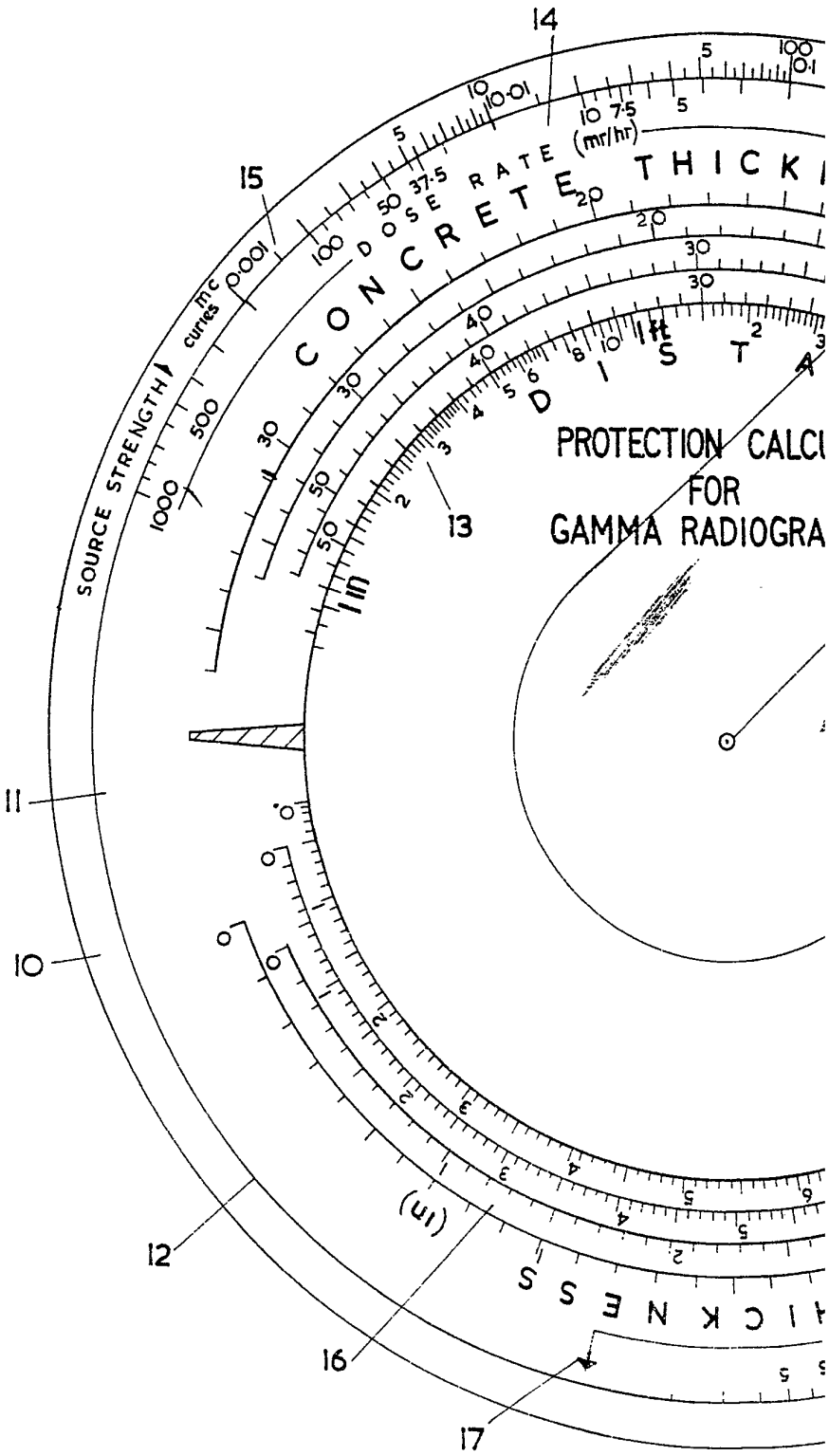


FIG. 1.


14
15
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CONCRETE THICK
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PROTECTION CALCI
FOR
GAMMA RADIOGRA
(in)
THICKNESS

859,063 COMPLETE SPECIFICATION
2 SHEETS

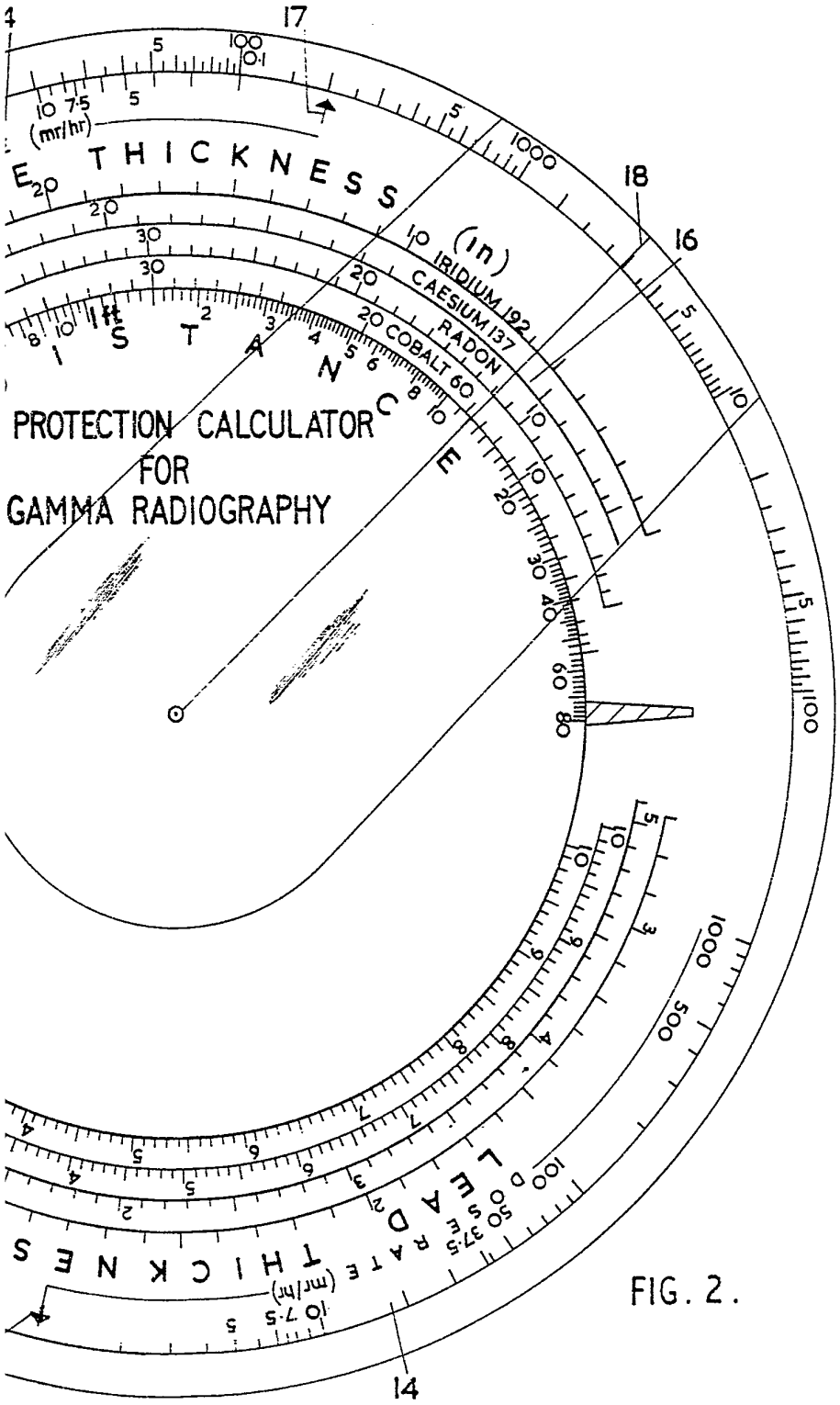

FIG. 2.

859,063 COMPLETE SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 2

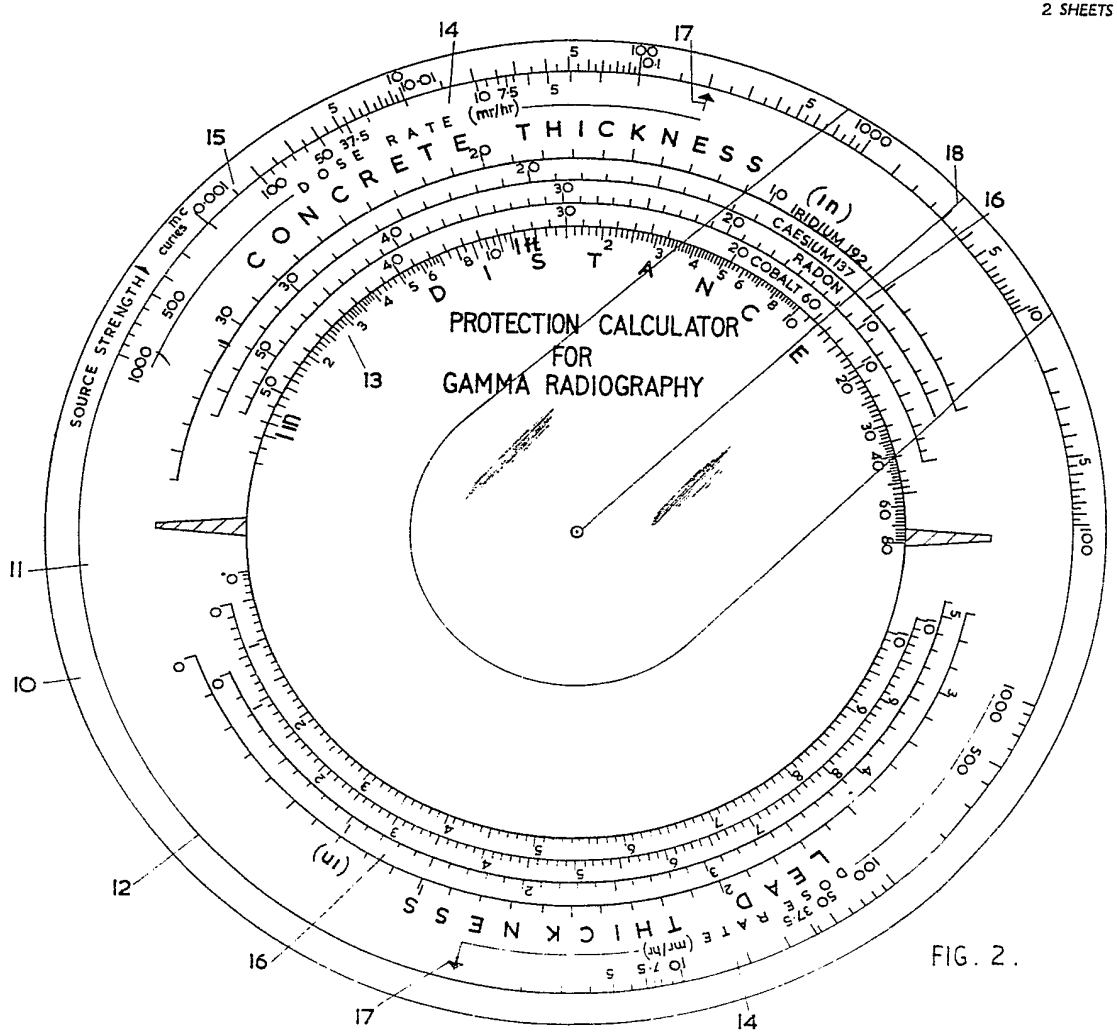

FIG. 2.