United States Patent [19]

Kolan

[11] **3,814,308**

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[54] **CALCULATING DEVICE**

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[52] **U.S. Cl.** **235/70**

[51] **Int. Cl.** **G06g 1/02**

[58] **Field of Search** 235/70, 78, 84, 85–89

[56] **References Cited**

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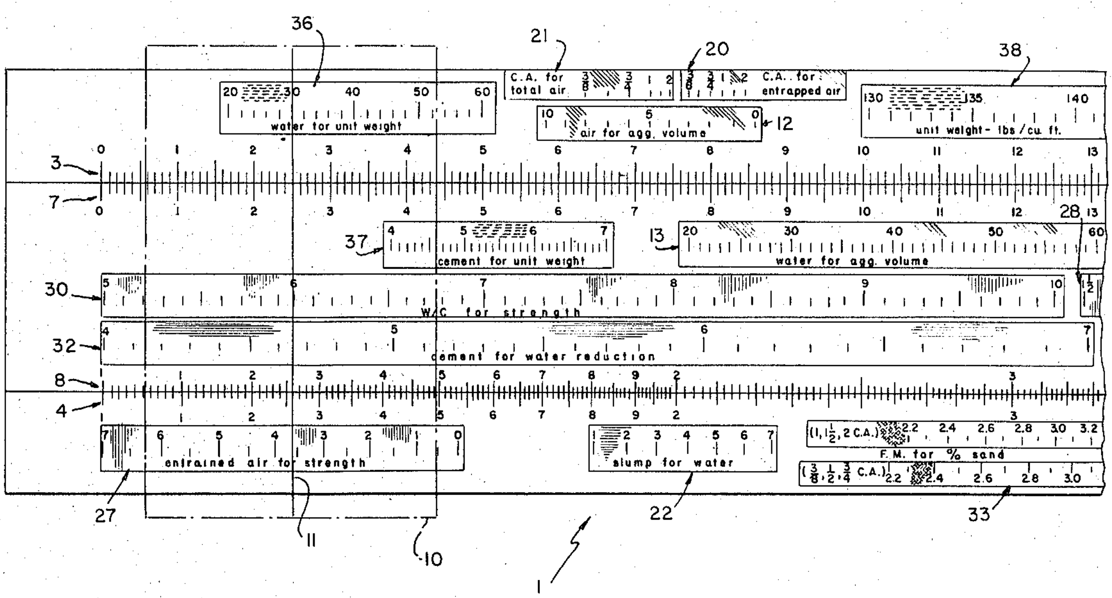
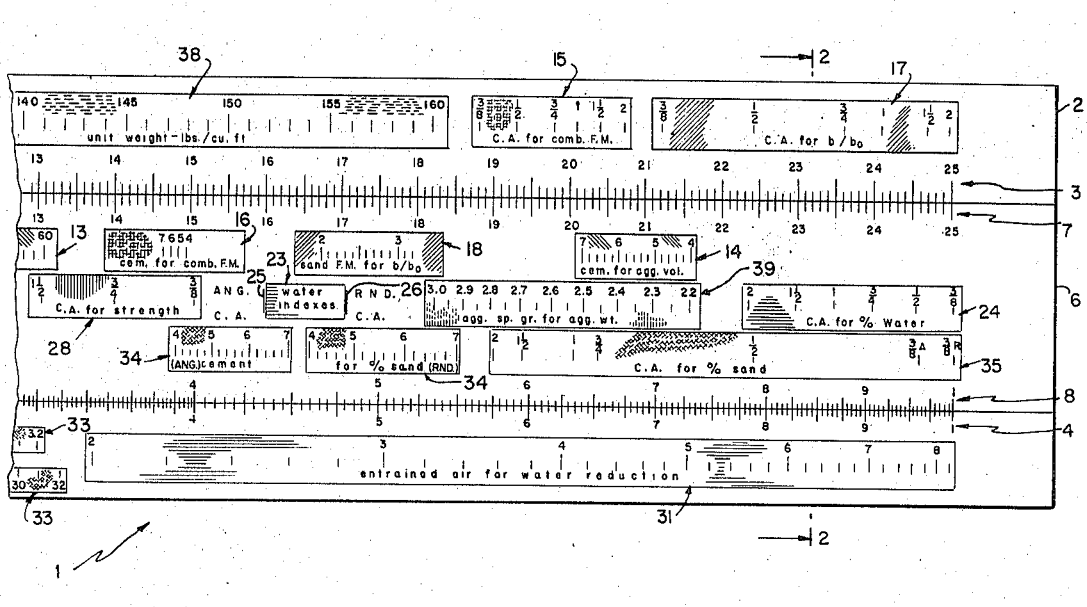
[57] **ABSTRACT**

A calculator for estimating concrete mix proportions of air, cement, water, fine and coarse aggregates comprising a calculating device having a pair of linear scales, a pair of logarithmic scales and a slidable cursor. Each pair of the scales has associated therewith a group of scalar representations of concrete mix factors which are interrelated. All members of each group are set forth in a visually distinct manner so as to facilitate computations by use of the calculator.

20 Claims, 4 Drawing Figures





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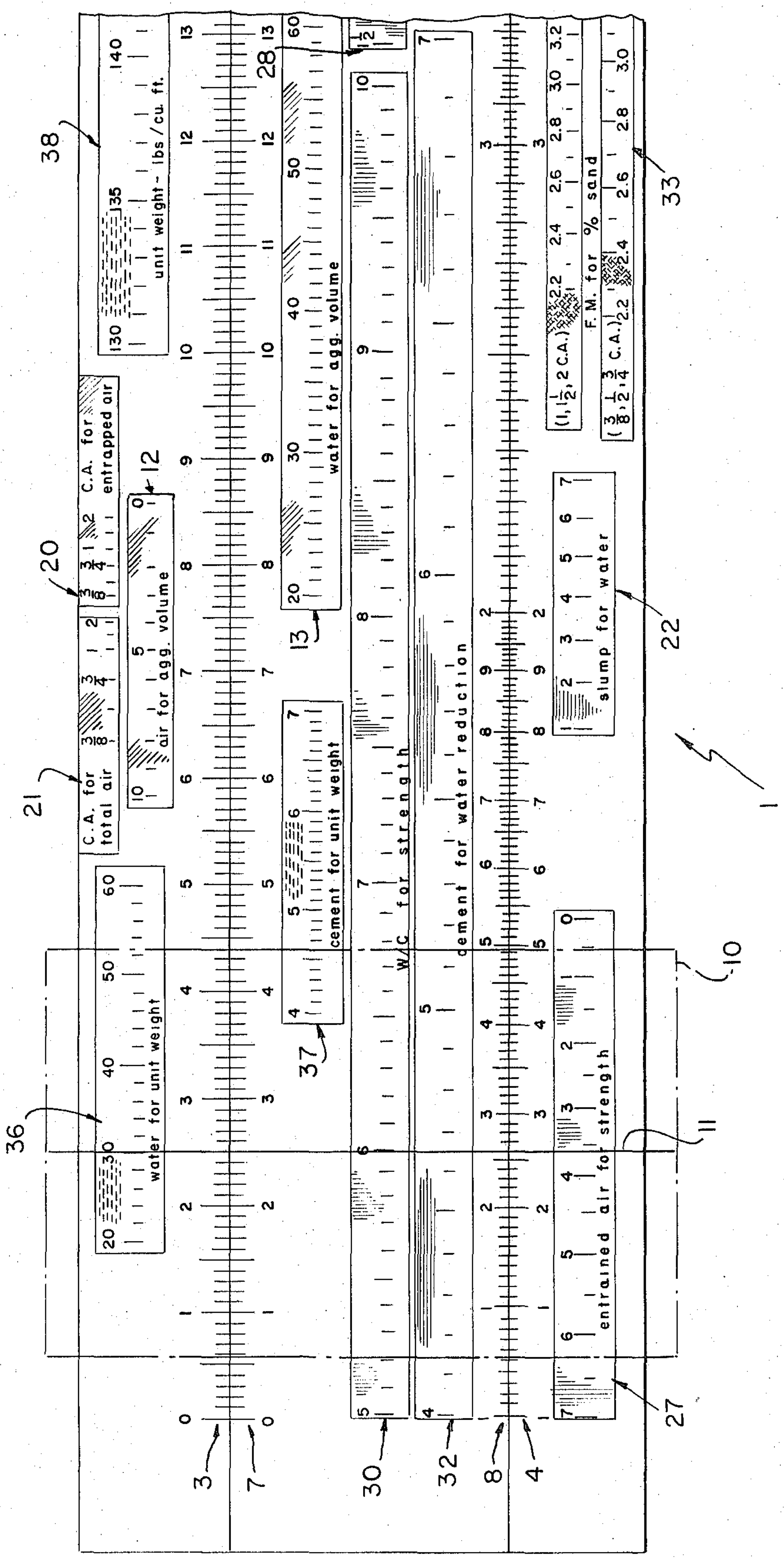


FIG. 1A

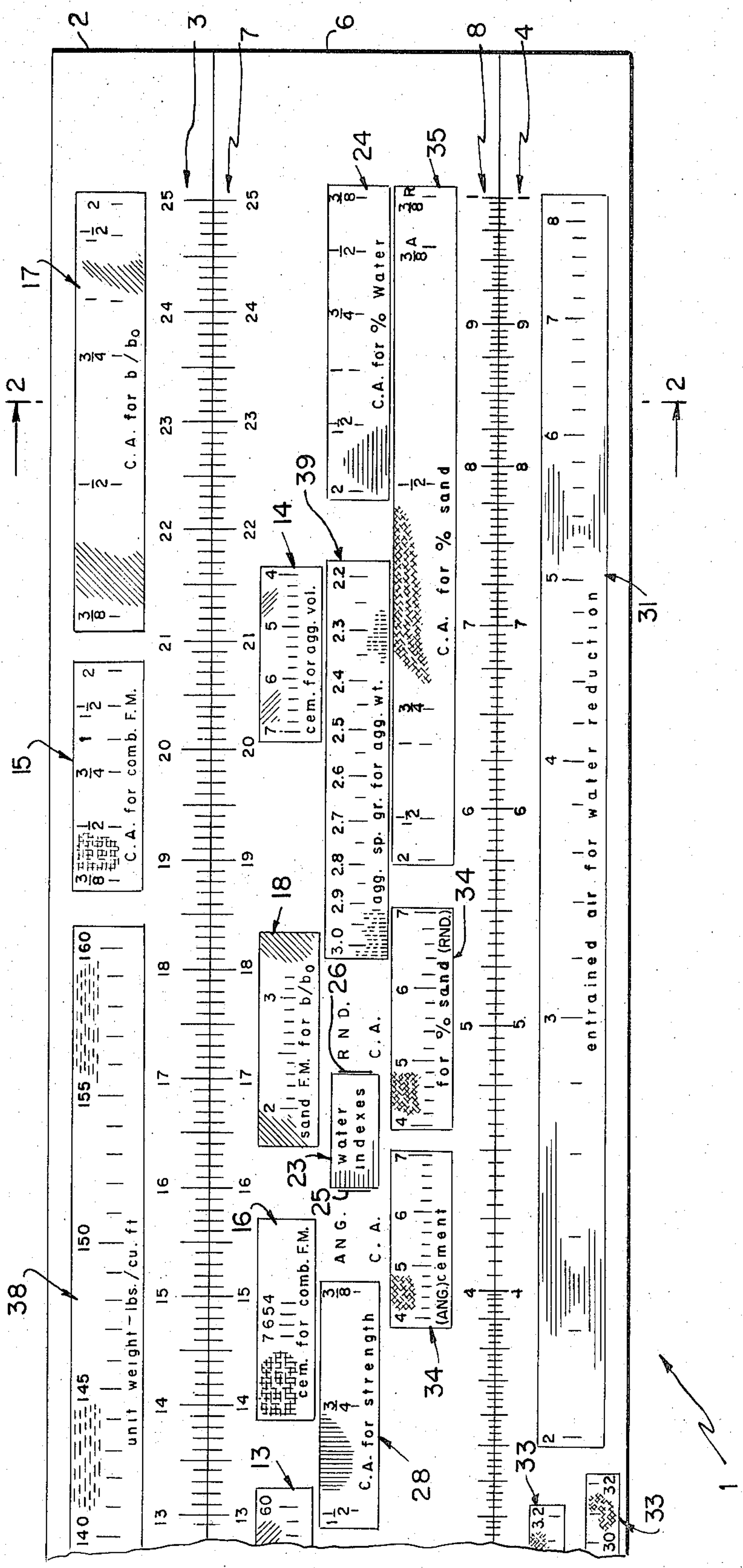
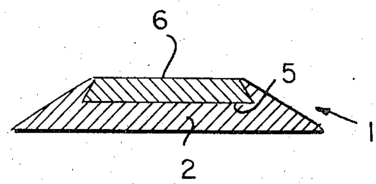

unit weight - lbs./cu. ft
C.A. for comb. F.M.
C.A. for b/bo
cem. for comb. F.M.
sand F.M. for b/bo
cem. for agg. vol.
C.A. for strength
water indexes
agg. sp. gr. for agg. wt.
C.A. for % Water
(ANG.) cement
for % sand (RND.)
C.A. for % sand
entrained air for water reduction

FIG. 1B

FIG. 2



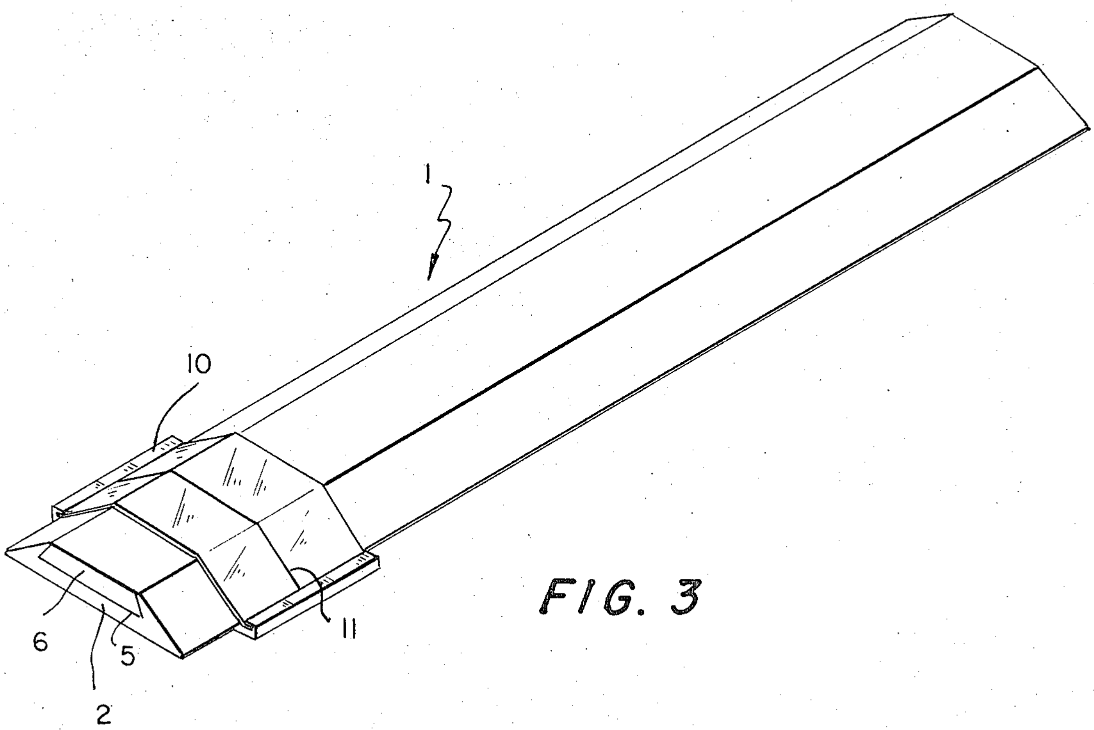


FIG. 3

CALCULATING DEVICE

The present invention is concerned with a calculating device and, more particularly, with a calculator that is useful in determining the relative proportions of ingredients for concrete mixes.

BACKGROUND OF THE INVENTION

Producers of ready-mixed concrete, regardless of the size of their operations, are often required to establish batch weights of concrete ingredients for producing concrete mixes suitable for varied applications. Although standard well-known mixes are common, an important segment of the production involves preparing concrete mixes having specified properties to meet the requirements of a particular job.

The selection of suitable, econimic concrete proportions is a problem which must be solved on an individual basis by each producer. Those skilled in the concrete art will recognize that factors such as fineness modulus of the sand and coarse aggregate as well as the character of the coarse aggregate (whether rounded or angular) will effect optimum proportioning of concrete ingredients. Accordingly, the selection of these and other variables and their relative proportions for use as part of a concrete mix is often difficult and time consuming.

The purpose of the present invention is to provide a device which will assist a concrete producer in estimating the batch quantities of ingredients for concrete mixes. It is well recognized that the variables of materials which make-up a concrete mix, the production methods which may be used to make the concrete mix, and the end uses of the mix are too numerous to permit an advance calculation of optimum proportions of ingredients. However, the device of the present invention, when used as explained hereinafter, will enable one to obtain a good approximation of the required concrete batch quantities in a short period of time, which approximation can be then modified in light of local experience and test results.

It is an object of the present invention to provide the novel and useful calculator adapted to calculate batch quantities of cement, air, water and fine and coarse aggregates for use in preparing concrete mixes.

It is another object of the present invention to provide a calculator which can be employed to determine in a short period of time a good approximation of the quantities of any one or more variables used in the preparation of concrete mixes by reducing the arithmetic needed to compute the proportions of variables for concrete mixes compositions. Other objects and advantages will become apparent from the description taken in conjunction with the drawing herein set forth.

STATEMENT OF THE INVENTION

In accordance with certain of its aspects, the novel calculating device comprises a pair of linear scales, one linear scale being slidably adjustable with respect to the other, a pair of logarithmic scales, one of said logarithmic scales being slidably adjustable with respect to the other, at least one group of concrete mix factors comprising at least two first variables interrelated in an additive or subtractive manner, said first variables being scaled on loci adjacent to and correlatable with said linear scales, at least one group of concrete mix factors comprising at least two second variables interrelated in a direct or inverse multiplicative manner, said second variables being scaled on loci adjacent to and correlatable with said logarithmic scales, and at least one cursor associated with said linear and logarithmic scales and said scaled variables.

DESCRIPTION OF THE INVENTION

Generally speaking, this present invention contemplates a calculating device in the form of a slide rule. This calculating device may comprise a body portion or member, preferably elongated and generally rectangular in shape. Affixed to the body portion, by printing or by any other suitable means, there may be provided a linear scale having scalar lines calibrated in equal increments which preferably extend substantially along the entire length of the body portion. The body portion may also carry a logarithmic scale having scalar lines calibrated in logarithmic intervals which, preferably, also extend substantially along the entire length of the body portion. Preferably the linear scale and the logarithmic scale may be calibrated from 0 to 25 and 1 to 10, respectively; however, such calibration may be modified or changed by those skilled in the art.

The body portion may be provided with an elongated slot which may extend along the entire length of the body portion. Slidable within the body portion along the elongated slot there may be situated a slide member which preferably may be generally rectangular in shape and may be generally equal in length to the body portion. Substantially along its entire length the slide member may carry a linear scale having scalar lines calibrated in equal increments. This linear scale may have identical calibrations to those of the linear scale arranged on the body portion. In similar manner the slide member may also have a logarithmic scale affixed thereto substantially along its entire length so as to, preferably, be identical to the logarithmic scale carried by the body portion.

A plurality of scales smaller in dimensions to the linear and logarithmic scales may be arranged on the body portion and the slide member of the calculating device. These smaller scales may define scalar representations of various concrete mix factors or variables useful in the preparation of concrete mixes as hereinafter described. The smaller scales may extend along the length of both the body portion and the sliding member and may be scaled on loci adjacent to and correlatable with both the linear and logarithmic scales. As previously mentioned, these small scales of different concrete mix factors may be smaller in dimension than the linear or logarithmic scales, that is to say, the scalar lines of the small scales do not extend along the length of the calculating device in lengths greater than or equal to the length of the scalar lines of the linear or logarithmic scales. Further, some of the small scales may include at least one group of concrete mix factors which contain at least two variables that are interrelated in an additive or subtractive manner. Additionally, some of the small scales may, on the other hand, include at least one group of concrete mix factors which contain at least two variables that may be interrelated in a multiplicative or inverse multiplicative manner. The relative positions on the calculator of each scalar representation of each group of concrete mix factors may be determined from experience and from known data available to those skilled in the art. That is to say, in order to determine the relative position of each scalar concrete mix factor scale on the calculator for solving various concrete mix problems, an interrelation or equation may first be developed from known concrete mix data, such as that disclosed in reference text materials. Subsequently, the interrelation may be adjusted to provide value equivalents so that the values in the equation may be easily manipulated by the successive movements of the parts of a slide rule type calculator. Functional members are then developed to replace the equation's actual values derived from known data disclosed in the text materials so that the numbers might fit conveniently on the calculator in scalar arrangements which do not overlap. The functional numbers may then be used in relation to one another on linear or logarithmic scales on the calculators in order to solve the concrete mix problems. The upper and lower limits of each concrete mix factor scale may, of course, be determined by the ordinary and common operating ranges of the concrete mix variables used in concrete mix designs — this is deemed well known to those skilled in the art.

Concrete mix factors useful in the preparation of concrete mixes may include, but are not limited to, the percent of total air in the concrete, gallons of mixing water per cubic yard, sacks of cement per cubic yard, coarse aggregate size, sand fineness modulus, percent entrapped air in the concrete, percent entrained air in concrete, slump in inches of the concrete mixture, water indexes for round and angular aggregate, and water/cement ratio, etc., in order to determine the relative positions of each scalar representation of these concrete mix factors on the calculator for solving various concrete mix problems, either exact or empirical interrelations or equations may be developed that fit the various correlated data shown on the graphs and in the Tables set forth in the circular entitled "Proportioning Ready Mixed Concrete" by Delmar L. Bloem and Stanton Walker, published by the National Sand and Gravel Association and the National Ready Mixed Concrete Association, October 1963, NSGA Circular No. 91 and NRMCA Publication No. 114. Those interrelations that may be correlated on a linear scale may be exact interrelations whereas those correlated on a logarithmic scale may be, for the most part, empirical in nature due to the fact that the latter interrelations were generated for the most part, by a trial and error method. The interrelations correlated with the linear scales may be interrelated in an additive or subtractive manner while the interrelations correlated with the logarithmic scales may be interrelated in a direct or inverse multiplicative manner. The interrelations that are thus developed may be thereafter adjusted to provide value equivalents for the various values set forth in the equations. This may be done simply to modify the equation so that it can be easily solved by the successive movements of the parts of a slide rule type calculator. It is to be understood that such a modification thereby may determine whether the small concrete mix factor scales should be arranged on the movable member or on the fixed member of a slide rule type of calculator. Since there may preferably be a number of concrete mix factors that can be arranged as scales on a calculator in order to perform a variety of common concrete mix calculations, and since the space on an ordinary hand type calculator may be limited, functional numbers may then be developed to convert the known data found in the graphs and tables to numbers which may fit conveniently on the small scales that define scalar representations of concrete mix factors on the calculator without any overlapping of the scales. In other words, the technique of converting the actual numbers to functional numbers for concrete mix factors may be simply done in order to arrange all of the small scales on the calculator in such a way that they will not overlap one another.

A cursor may be arranged to extend about the body portion and the slide member so as to be slidably movable along their entire lengths. The cursor may preferably be transparent so as to enable the scales affixed to the body portion and the slide member to be easily and readily seen even though the cursor may be positioned over the scales. The cursor may carry a hairline which is preferably arranged to extend perpendicular to the length of the linear and logarithmic scales. However, it may be appreciated that the hairline may be arranged in a non-perpendicular manner provided that the small scales are corresponding offset with respect to one another on the body portion and slide member in the same non-perpendicular manner.

It is a feature of the preferred aspect of this invention that a useful calculator may be provided that quickly and efficiently enables an operator to determine proportions of any one or more variables useful in the preparation of concrete mixes by greatly reducing the arithmetic calculations otherwise necessary to compute the above proportions.

It is a feature of this invention that by assembling known data relating to certain concrete mix variables, arranging the data into scalar representations and positioning the scalar representation strategically on a slide rule type calculating device which contains both linear and logarithmic scales, it is thereby possible to quickly and efficiently determine proportions of ingredient for desired concrete mixes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a plan view of a portion of the calculator of this invention;

FIG. 1B is a plan view of the remaining portion of the calculator;

FIG. 2 is a cross-sectional view of the calculator taken along lines 2—2 of FIG. 1B; and

FIG. 3 is a perspective view of the calculator.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, particularly FIGS. 1 to 3, the calculating device, generally indicated by **1**, may comprise an elongated and rectangular body portion or member **2**. A linear scale **3** may be affixed to the body portion **2**. The linear scale **3** may have scalar lines which are calibrated in equal increments, say from 0 to 25, which extend substantially along the entire length of the body portion **2**. The body portion **2** may also carry a logarithmic scale **4** which has scalar lines calibrated in logarithmic intervals, say from 1 to 10, and which also extend substantially along its entire length.

The body portion **2** may be provided with an elongated slot **5** which may extend along the entire length of the body portion **2**. Slidable within the body portion **2** along the elongated slot **5** there may be provided a slide member **6** which may be generally rectangular in shape and may be of equal length to the body portion **2**.

Substantially along its entire length, the slide member **6** may carry a linear scale **7** having scalar lines calibrated from 0 to 25 in equal increments. Scale **7** may be identical in dimension to the scale **3** located on the body member **1.** The slide member **6** may also carry, substantially along its length, a logarithmic scale **8.** The scale **8** may be identical in dimensions to the scale **4** located on the body member **2.**

There may also be situated on the body portion **2** and the slide member **6** of the calculating device **1** a plurality of scales smaller in dimension to the scales **3, 4, 7,** and **8.** These smaller scales may define scalar representations of different concrete mix factors.

A transparent cursor **10** may be situated to extend about both the body portion **2** and the slide member **6.** This cursor **10** may be adapted to be slidably movable along the entire length of the calculating device **1.** The cursor **10** may carry a hairline **11** which may extend perpendicular to the length of the scales **3, 4, 7** and **8.**

Referring now only to the linear scales **3** and **7** on the body portion **2** and sliding member **6**, respectively, there may be associated with these scales a plurality of small scales which may be positioned adjacent thereto and which extend along their lengths. These small scales may carry scalar lines which represent and define scalar representations of different concrete mix factors useful in the preparation of concrete materials. These small scales of different concrete mix factors may be smaller in dimension than the scales **3, 4, 7** and **8,** as previously mentioned. Further, the small scales may include at least one group of concrete mix factors which contain at least two variables that are interrelated in an additive or subtractive manner. That is to say, the concrete mix variables associated with scales **3** and **7** are those variables which can be added or subtracted to provide an answer which can be read on the linear scales **3** or **7.**

The following are some interrelations useful in concrete mix design which may be either additive or subtractive:

1. ft.^{3} of aggregate = 27 − (ft.^{3} of H_2O + Ft.^{3} of air + ft.^{3} of cement)
2. F.M. (comb. agg.) = $K + 0.1C$
   where
   $F.M.$ = fineness modulus of combined aggregate;
   K = a constant for a given nominal size of coarse aggregate; and
   C = the cement content in sack per yd.^{3}.
3. $b/bo = K + 0.1$ F. M sand
   where
   F. M. =fineness modulus of sand;
   K =a constant for a given nominal size of coarse aggregate; and
   b/bp =the apparent volume of coarse aggregate per unit volume of concrete.

EXAMPLE I

To obtain the value of cubic feet of aggregate for a concrete mix, the customary terms used in the concrete trade for defining the quantity of air, water and cement, that is, the percent air, gallons per cubic yard of water and sacks per cubic yard of cement, must first be converted into a single common unit, such as cubic feet. This conversion together with the solution to the equation 1 is automatically performed by use of the calculator as hereinafter described. The above concrete mixed factors are represented by the small scales illustrated in FIG. **1** and include a scalar representation of the total percent of air in the concrete from the practical range of 0 to 10 percent (scale **12**), scalar representation of gallons of mixing water from the practical range of 20 to 60 gallons per cubic yard (scale 13) and scalar representation of sacks of cement from the practical range of 4 to 7 sacks per cubic yard (scale **14**). When employing the calculating device **1** for determining the cubic footage of total aggregate in the concrete, one may set the hairline **11** of the cursor **10** on the appropriate and known percent of air on scale **12** and move slide member **6** so that the appropriate and known gallonage of water on scale **13** appears under hairline **11.** The cursor **10** may then be moved across to the appropriate and known cement content on scale **14** and the volume of total aggregate may then be read under hairline **11** on scale **3.** The physical manipulation of the calculating device as herein set forth automatically converts the commonly used units of air, water and cement into cubic feet units, adds the volume of air, water and cement and subtracts the total from **27** to obtain the total volume of aggregate in terms of cubic feet. It is of course understood that one skilled in the art will readily know whether the answer will be read in tens, hundreds etc. by merely knowing the range of the other variables.

Those skilled in the art will appreciate that, as depicted, the 0 percent air locus on scale **12** is offset on scale **3** by 8.5 units. Such an offset is purely arbitrary and is made for the convenience in positioning the scale **12** on the calculating device as hereinafter explained. It will be appreciated that in an equation of the type similar to equation 1 or those equations hereinafter set forth one can modify the equation without changing the ultimate validity by adding or subtracting any particular quantity from both sides of the equation. In terms of applying this principle to the calculating device, offsetting the 0 percent air locus point reading on scale **12** in relation to scale **3** in the manner shown in the drawings merely adds 8.5 units to one side of equation 1. Compressing of the distance between scales **13** and **14** by 8.5 units acts to add the offset units to the other side of equation 1. Thus the physical position of scales **12, 13** and **14** with respect to one another on the calculator **1** enables an answer to be obtained and read on scale **3** without the necessity for exceeding a reasonable size for the calculating device **1.**

Equation 1 and 2 and the equations hereinafter set forth are adapted from tabular data taken from the circular entitled "Proportioning Ready Mixed Concrete" by Delmar L. Bloem and Stanton Walker, published by the National Sand and Gravel Association and National Ready Mixed Concrete Association, October 1963, under the Nos. NSGA Circular No. 91 and NRMCA Publication No. 114.

EXAMPLE II

In equation 2, K may have values as set forth in Table I below, depending upon maximum size of the coarse aggregate used in the concrete mix.

TABLE I

K	Coarse Aggregate Size
3.5	⅜
4.0	½
4.5	¾
4.8	1
5.1	1½
5.4	2

To find the recommended finenss modulus for the combined aggregate in equation 2, one may use the scalar representations as illustrated in the coarse aggregate size scale **15** and the cement content scale **16** carried on the calculator. Using the calculator of this invention, one may set the hairline **11** of the cursor **10** on the appropriate and known size of coarse aggregate on scale **15**, move slide **6** so that hairline **11** superimposes the appropriate and known cement content in sacks of cement on scale **16** and then read the recommended fineness moduli of the combined aggregate in arbitrary units on scale **3** opposite the zero locus point on scale **7**. Again, the positioning of the scales **15** and **16** automatically changes aggregate size and sacks of cement units to equivalent units for a reading on the scale **7**.

EXAMPLE III

Values of K in equation 3 are set forth in Table II below; the value of K here again varies with maximum size of coarse aggregate.

TABLE II

K	Coarse Aggregate Size
0.19	⅜
0.31	½
0.43	¾
0.48	1
0.54	1½
0.57	2

In order to determine the value of the ratio *b/bo*, one may use the scalar representation as illustrated in the coarse aggregate size scale **17** and the fineness modulus of available sand on scale **18** carried on the calculator. Using the calculator, one may set the hairline **11** of the cursor **10** on the appropriate and known maximum size of coarse aggregate on scale **17**, move the slide **6** so that the experimentally determined fineness modulus for the available sand as set forth on scale **18** appears under hairline **11** and then read the value of the ratio *b/bo* in arbitrary units on scale **3** opposite the zero locus point on scale **7**. Again the positioning and calibration of the scales **17** and **18** on the calculating device **1** automatically convert the aggregate size and fineness modulus into equivalent unit values on the scales **3** and **7**, so as to enable one to directly read the numerical value of the answer on scale **3**.

EXAMPLE IV

In calculating concrete mix proportions, it is initially required to estimate the amount of entrapped air in non-air-entraining mixes, or to specify the total air content of air-entraining mixes. For all practical purposes, the entrapped air content of non-air-entraining mixes and the recommended total air content of air-entraining mixes are largely a function of the maximum size of the coarse aggregate used; that is to say, the larger the coarse aggregate used, the less air should be present in the concrete. Now the calculating device also may include scalar representations of the maximum size of coarse aggregate used that correspond with the estimated entrapped air content of non-air-entraining mixes and the recommended total air content of air-entraining mixes. Referring to a non-air entrained mix, one may set the hairline **11** of the cursor **10** on the maximum size aggregate shown in scale **20** and read directly below on scale **12** the estimated entrapped air content of a non-air-entraining mix. In the same manner, the recommended total air content of an air-entraining mix is found on scale **12** directly below the maximum size aggregate shown in scale **21**.

Referring now only to logarithmic scales **4** and **8** on the body portion **6** and sliding member **2**, respectively, there may be associated with these scales a plurality of small scales which may be positioned adjacent to the scales **4** and **8** and which may extend along the length of the body portion **2** and sliding member **6**. These small scales may also be scalar representations of concrete mix factors. However, groups of these scalar representations may contain variables which are interrelated in a direct or inverse multiplicative manner.

The following are some interrelations useful in concrete mix design which may involve multiplicative or inverse multiplicative operations:

4A. Mixing Water $= K$ (Slump $+ 24$)

4B. Mixing Water $= K$ (Slump $+ 24)/1.1$

Where

mixing water = volume of mixing water in gallons/yd.^{3};

the slump is measured in inches and relates to a measure of the consistency or wetness of the cement mixture;

the equation 4A relates to rounded coarse aggregate;

the equation 4B relates to angular coarse aggregate; and

K is a constant at any given size of coarse aggregate as set forth in Table III below.

TABLE III

K	Size of Coarse Aggregate (in.)
1.669	⅜
1.597	½
1.512	¾
1.444	1
1.381	1½
1.306	2

5. SC_{28} = 1,000Klog^1 [12.893 − $W/C/10$] [100−5ac/100]

Where

SC_{28} =compressive strength after 28 days;

W/C =water-cement ratio in units of gals/yd.^{3} over sacks per yd.^{3}; and

K =a constant at any given coarse aggregate size as set forth in Table IV below. ac = entrained air content in %.

TABLE IV

Coarse Aggregate Size (in.)	K
⅜	1.000
¾	0.905
1½	0.815

6. Water Reduction $= 1.02\ (A - 0.9)^{.55} \times$ Tan [19.7 + 10 (7−C)]°/[Tan 19.7°]

Where

A = entrained air content in %; and

C = cement content in sacks per yd.^{3}

7A. % Sand = 1.000K_1 [(22-C)/(-*)] [(FMs + K_2)/2.65 + K_2]

7B. % Sand = 1.75K_1[(27−C)23] (FMs + K_2)/2.65 + K_2

Where

C = cement in sacks per yard^3;

FMs = fineness modulus of sand;

the equation 7A is used for round coarse aggregate;

the equation 7B is used for angular coarse aggregate; and

K_1 and K_2 are constants at any given size of coarse aggregate as set forth in Table V below.

TABLE V

Size of Coarse Aggregate (in.)	K_1	K_2
2	36.8	1.9
1	36.3	1.9
1	40.7	1.9
¾	41.9	0.9
½	50.7	0.9
⅜ (round)	64.4	0.9
⅜ (angular)	61.3	0.9

The following examples relate to solutions to some of the equations, above set forth, where the concrete mix factors are interrelated in a multiplicative and inverse multiplicative manner and are thus correlatable with the logarithmic scales **4** and **8.**

EXAMPLES V AND VI

To determine the volume of mixing water that preferably may be used per cubic yard of concrete, by applying the relationship of quantities as set forth in equation 4A, one may use scalar representations as illustrated in slump scale **22,** water index scale **23** and coarse aggregate size scale **24** carried on the calculator. The slump scale **22** and aggregate scale **24** are scaled in inches while the water index scale **23** contains an angular coarse aggregate scalar line **25** and a round coarse aggregate scalar line **26** both of which are arranged to make scalar adjustments for the type of coarse aggregate that is used. Knowing the desired slump value in inches, the type of coarse aggregate (angular or round) and the size of the coarse aggregates, the volume of mixing water in gallons per cubic yard may be determined by using the calculator of this invention by first placing the hairline **11** of the cursor **10** over the known slump value as represented on scale **22.** Slide **6** may then be moved until the scalar line **25** or **26,** which indicates the known type of coarse aggregate that is used (round or angular) lies directly under the hairline **11** of the cursor **10.** Then while holding slide **6** fixed, one may move the cursor **10** so that the hairline **11** is positioned over the known size of available coarse aggregate and one may read the volume of mixing water in gallons per cubic yard on scale **4.**

EXAMPLE VII

The calculator is also capable of determining the 28-day compressive strength of the concrete of equation 5 taking into account the fact that, on the average, the compressive strength of concrete is lowered by approximately 5 percent for each percent of entrained air contained on the concrete. In employing the calculator to solve equation 5, the percent entrained air scale **27,** coarse aggregate size scale **28** and water-cement ratio scale **30** carried on the calculator may be used. One may place the hairline **11** of the cursor **10** on the known value of the percent entrained air on scale **27.** Slide **6** may then be moved so that the numerical value of one, on scale **8,** appears under the hiarline **11.** Without moving the slide **6,** the cursor **10** may be moved to the known value of the size of coarse aggregate on scale **28.** Slide **6** may then be moved to place the known value of the water-cement ratio on scale **30** under the hairline **11.** Then one may read the 28-day compressive strength in thousands of pounds per square inch on scale **4** opposite the numerical value one on the scale **8.**

The calculation of the approximate reduction in the mixing water content for air-entrained concrete of a selected cement content, as set forth in equation 6 may be made by the appropriate manipulation of the calculator with reference to scalar representations of the percent entrained air on scale **31** and cement content scale **32** carried on the calculator. The appropriate manipulation of the calculator for the aforementioned calculation may be as follows:

1. Set the hairline **11** of the cursor **10** at the previously calculated or known percent entrained air content on the entrained air for water reduction scale **31.**

2. Move the slide member **6** to align the hairline **11** with the previously calculated or known amount of cement in sacks for water reduction on the cement content scale **32.**

3. Read the water reduction due to entrained air on the logarithmic scale **4** under the left index on logarithmic scale **8.** Also, by the appropriate manipulation of the calculator with reference to equations 7A and 7B, the fineness modulus of sand on scale **33,** cement content on scale **34** and size of coarse aggregate on scale **35** may be used to determine the percent sand contained in the total amount of aggregate. The appropriate manipulation of the calculation for determining the percent sand contained in the total amount of aggregate may be as follows:

1. Set the hairline **11** of the cursor **10** to the known sand fineness modulus on scale **33.** (Use the top scale **33** for 1, 1 ½ and 2 in. coarse aggregate and the bottom scale for ⅜, ½, and ¾ inch coarse aggregate.)

2. Move the slide member **6** to align the hairline **11** with the known number of sacks of cement on the cement content scale **34.** (Use the left cement content scale **34** for angular coarse aggregate and the right scale **34** for round coarse aggregate.)

3. Move the hairline **11** of the cursor **10** to the known size of aggregate on scale **35.**

4. Read the percent sand contained in the total amount of aggregate on logarithmic scale **4** on the hairline **11.** Further, the calculator may further assist the concrete designer by being provided auxiliary scales **36, 37** and **38** for conveniently converting gallons of water per yard to pounds of water, number of cement sacks to pounds, and pounds of concrete per cubic yard to pounds per cubic feet, respectively with the answers being readable on the linear scales.

The calculation of the concrete unit weight using scales **36, 37** and **38** may be made as follows:

1. Set the known coarse aggregate weight on linear scale **7** under the right hand linear scale **3** index.

2. Align the hairline **11** of the cursor **10** with linear scale **7** left hand index.

3. Move the slide member **6** to align the known sand weight on the linear scale **7** with the hairline **11.**

4. Align the hairline **11** with the known mixing water requirement on the water for unit weight scale **36.**

5. Read the mixing water weight on the linear scale **3** under the hairline **11.**

6. Read the number on the linear scale **7** under the indicator.

7. Transfer this number to the linear scale **3.**

8. Align the left index of the linear scale **7** with the number transferred to the linear scale **3.**

9. Move the hairline 11 to the cement content on the cement for unit weight scale 37.

10. The weight of the concrete is read under the hairline **11** on the linear scale **7.**

11. The weight of the concrete per cubic yard, in hundreds of pounds + 2,500 is read under the hairline on the linear scale **3.**

12. The weight of the concrete per cubic foot is read under the hairline on the unit weight scale **38.**

The calculator may also, by appropriate manipulation, determine the weight of the sand in accordance with the following steps:

1. Set the hairline **11** of the cursor **10** over the known sand volume on the logarithmic scale **4.**

2. Move the slide to align the known value of the specific gravity of the sand on the aggregate specific gravity for aggregate weight scale **39** with the hairline **11.**

3. Read the sand weight on the logarithmic scale **4** under the logarithmic scale **8** index.

Still further, the calculator may determine the weight of the coarse aggregate in accordance with the following steps:

1. Set the hairline **11** of the cursor **10** over the known coarse aggregate volume on the logarithmic scale **4.**

2. Move the slide member **6** to align the known coarse aggregate specific gravity on the aggregate specific gravity for aggregate weight scale **39** with the hairline **11.**

3. Read the coarse aggregate weight on the logarithmic scale **4** under the logarithmic scale **8** index.

It is to be understood that each group of variables which are interrelated with each other may be made visibly distinct from the other groups of variables for the convenience of the operator of the calculator. Such distinction may be made by coloring the background of the scales of each group of variables which are interrelatable with the same distinct color. Alternatively, the background of the scales of each group of interrelatable variabls may be appropriately shaded with distinct shade lines, as set forth in the drawings, in order for each group of variables to be made visibly distinct from the other groups.

It is to be understood that the relative positions of each scale representation of each group of concrete mix factors on the calculator, as shown on the drawings, in relation to the linear scales **3** and **7** and the logarithmic scales **4** and **8** may be determined from experience and may be based upon known data set forth in the circular "Proportioning Ready Mixed Concrete", previously identified. An example of how scalar representations of concrete mix factors may be arranged on the calculator may be as follows:

In order to determine the reduction in water in gal./cu. yd. for air-entrained concrete of a given cement factor by using the calculator of this invention, the known data from the aforementioned circular (in particular FIG. **3** on page 32) may be reviewed. Using a trial and error method equation 6 may be developed.

6. Water Reduction $(W.R.) = 1.02\,(A-0.9)^{.55} \times \text{Tan}\,[19.7 + 10\,(7-C)\,]^{\circ}/[\text{Tan}\,19.7^{\circ}\,]$

where

A = entrained air in %

C = cement content in sacks per yd.^{3}

If we let

8. $X = 1.02\,(A - 0.9)^{.55}$ and

9. $1/Y = \text{Tan}\,[19.7 + 10\,(7\text{-}C)\,]^{\circ}/[\text{Tan}\,19.7^{\circ}\,]$

10. then $W.R. = X/Y$

Equation 10 may be solved by easily manipulating the fixed and movable members of a slide rule type of calculator.

The ordinary operating range of the cement content of a concrete mix is between 4.0 and 7.0 sacks per yd.^{3} as shown in FIG. **3** of the circular. Knowing this cement content range, the actual value of 1/Y may be determined by solving equation (9) for various ranges of cement content. Thus for the following known cement content actual values for 1/Y and Y may be calculated (see Table VI below).

TABLE VI

C	1/Y	Y
4.0	3.293	.3037
4.5	2.764	.3618
5.0	2.319	.4312
5.5	1.934	.5168
6.0	1.593	.6277
6.5	1.285	.7782
7.0	1.000	1.000

In order that these actual values may fit on the calculator without any overlapping problem occurring, functional numbers may be used.

Thus if

$W.R. = X/Y$ [see equation 10]

11. then $W.R. = X'/Y'$

12. and $X' = Y'/Y \cdot X$

If we arbitrarily set $Y' = 1.000$ or unity for 4 sack/yd.^{3} then Y' for the other values of C will be as set forth in Table VII Below knowing that $Y'/Y = 3.293$.

TABLE VII

C	1/Y	Y	Y'
4.0	3.293	.3037	1.000
4.5	2.764	.3618	1.192
5.0	2.319	.4312	1.420
5.5	1.934	.5168	1.703
6.0	1.593	.6277	2.67
6.5	1.285	.7782	2.564
7.0	1.000	1.000	3.293

One may then calculate the X values by inserting the ordinary operating range of the percent entrained air as shown in FIG. **3** of the circular into equation 8. The X values may be set forth in Table XIII below:

TABLE XIII

A	X
2	1.075
3	1.534
4	1.900
5	2.216
6	2.499
7	2.758
8	2.998

Knowing the X values, their functional values may then be determined by using equation 12 and the functional values of X may be found in Table IX below:

TABLE IX

A	X	X'
2	1.075	3.54
3	1.534	5.05
4	1.900	6.26
5	2.216	7.30
6	2.499	8.23
7	2.758	9.08
8	2.998	9.87

It will thus be apparent that if the cement from water scale **32** carries a lower limit of 4.0 sacks/cu. yd. and an upper limit of 7.0 sacks/cu. yd. the actual length of scale **32** along logarithmic scale **8** will be such that the

4 sack mark on scale **32** will coincide with the unity mark on scale **8** and the 7 sack mark on scale **32** will coincide with **3.293** mark on scale **8.** This sets the dimension of scale **32.** Likewise for the scale **31,** the limitation of 2 and 8 percent entrained air will coincide with the marks **3.54** and **9.87** respectively on scale **4.** Functional members may then be developed for the other actual data found in the circular in order to locate suitable positions on the calculator for the other small concrete mix factor scales so that they will not overlap one another.

Many embodiments of this invention may be made without departing from the spirit and scope thereof; it is to be understood that the invention includes all such modification and variations as come within the scope of the claims.

I claim:

1. A calculator useful in the determination of portions of ingredients for concrete mixes comprising a body member; a slide member slidably positioned within said body member, said slide member and body member having linear scales extending therealong, said linear scales being coextensive with one another and having the same spacing and range; a set of at least three concrete mix factor scales positioned on said members, said concrete mix factor scales including a total percent of air in concrete for aggregate volume scale (**12**); an amount of mixing water for aggregate volume scale (**13**) and a number of sacks of cement for aggregate volume scale (**14**), said amount of mixing water scale (**13**) and number of sacks of cement scale (**14**) carried on one member and said total percent of air scale (**12**) carried on said other member, said concrete mix factor scales being positioned on the calculator so as to facilitate the determination of the volume of the fine and coarse aggregate of the concrete mix to be read on the linear scale of one of the members; and a cursor mounted on said body member.

2. The calculator of claim **1** wherein said concrete mix factor scales are positioned on the calculator in accordance with the equation

ft.^3 of aggregate $= 27 - (\text{ft.}^3 \text{ of } H_2O + \text{ft.}^3 \text{ of air} + \text{ft.}^3$ of cement).

3. The calculator of claim **1** also including a maximum coarse aggregate for entrapped air scale (**20**), said entrapped air scale (**20**) being positioned on the same member of the calculator as the total percent of air scale (**12**) so as to facilitate the determination of the percent of entrapped air content of a non-air-entraining mix to be read on the total percent of air scale (**12**) knowing the size of the coarse aggregate.

4. The calculator of claim **1** also including a maximum coarse aggregate for total air scale (**21**), said coarse aggregate scale (**21**) being positioned on the same member of the calculator as the total percent of air scale (**12**) so as to facilitate the determination of the total percent of air content of air-entrained concrete to be read on the total percent of air scale (**12**) knowing the size of the coarse aggregate.

5. A calculator useful in the determination of portions of ingredients for concrete mixes comprising a body member; a slide member slidably positioned within said body member, said slide member and body member having linear scales extending therealong, said linear scales being coextensive with one another and having the same spacing and range; a set of at least two concrete mix factor scales positioned on said members, said concrete mix factor scales including a coarse aggregate size for the fineness modulus of the combined aggregate scale (**15**) and the number of sacks of cement for the fineness modulus of the combined aggregate scale (**16**), each of said concrete mix factor scales being positioned on a different member of the calculator so as to facilitate the determination of the fineness modulus for the combined aggregate to be read on the linear scale of one of the members; and a cursor mounted on said body member.

6. The calculator of claim **5** wherein said concrete mix factor scales are positioned on the calculator in accordance with the equation

$F.M.$ (combined aggregate) $= K + 0.1C$

where

$F.M.$ = fineness modulus,

K = a constant for a given nominal size of coarse aggregate, and

C = cement content in sacks per unit volume.

7. A calculator useful in the determination of portions of ingredients for concrete mixes comprising a body member; a slide member slidably positioned within said body member, said slide member and body member having linear scales extending therealong, said linear scales being coextensive with one another and having the same spacing and range; a set of at least two contrete mix factor scales positioned on said members, said concrete mix factor scales including a coarse aggregate for the apparent volume of coarse aggregate per unit volume of concrete scale (**17**) and a fineness modulus of sand for the apparent volume of coarse aggregate per unit volume of concrete scale (**18**), each of said concrete mix scales being positioned on a different member of the calculator so as to facilitate an automatic determination of the apparent volume of coarse aggregate per unit volume of concrete to be read on the linear scale of one of the members; and a cursor mounted on said body member.

8. The calculator of claim **7** wherein said concrete mix factor scales are positioned on the calculator in accordance with the equation

$b/bo = K + 0.1$ F.M. (sand)

where

$F.M.$ = fineness modulus,

K = a constant for a given nominal size of coarse aggregate, and

b/bo = apparent volume of coarse aggregate per unit volume of concrete.

9. A calculator useful in the determination of portions of ingredients for concrete mixes comprising a body member; a slide member slidably positioned within said body member, said slide member and body member having logarithmic scales extending therealong, said logaritymic scales being coextensive with one another and having the same spacing and range; a set of at least three concrete mix factor scales positioned on said members, said concrete mix factor scales including a slump for the volume of mixing water scale (**22**), an angular or round aggregate water index for the volume of mixing water scale (**23**) and a coarse aggregste size for the volume of mixing water scale (**24**), said water index scale (**23**) and coarse aggregate size scale (**24**) carried on one member and said slump for water scale (**22**) carried on said other member, said concrete mix factor scales being positioned on the calculator so as to facilitate the determination of the volume of mixing water for the concrete to be read on the logarithmic scale of one of the members; and a cursor mounted on said body member.

10. The calculator of claim **9** wherein said concrete mix factor scales are positioned on the calculator in accordance with the equation

$M.W.$ (round aggregate) $= K$ (Slump $+ 24$)

where

$M.W.$ = volume of mixing water,

Slump = measure of consistency or wetness of the cement mixture, and

K = a constant for a given size aggregate.

11. The calculator of claim **9** wherein said concrete mix factor scales are positioned on the calculator in accordance with the equation

$M.W.$ (angular) $= K$ (Slump $+ 24)/1.1$

where

$M.W.$ = volume of mixing water,

Slump = measure of consistenty or wetness of the cement mixture, and

K = a constant for a given size aggregate.

12. A calculator useful in the determination of portions of ingredients for concrete mixes comprising a body member; a slide member slidably positioned within said body member, said slide member and body member having logarithmic scales extending therealong, said logarithmic scales being coextensive with one another and having the same spacing and range; a set of at least three concrete mix factor scales positioned on said members, said concrete mix factor scales including a percent of entrained air for strength scale (**27**), a coarse aggregate size for strength scale (**28**) and a water/cement ratio for strength scale (**30**), said coarse aggregate scale (**28**) and water/cement ratio sacle (**30**) carried on one member and said percent of entrained air scale (**27**) carried on the other member, said concrete mix factor scales being positioned on the calculator so as to facilitate the determination of the compressive strength of the concrete to be read on the logarithmic scale of one of the members; and a cursor mounted on said body member.

13. The calculator of claim **12** wherein said concrete mix factor scales are positioned on the calculator in accordance with the equation

$SC_{28} = 1{,}000K1og^{1}\ [12.893 - W/C/10\ ]\ [100 - 5ac/100\ ]$

where

SC_{28} = compressive strength after 28 days,

W/C = water-cement ratio,

ac = entrained air content in percent, and

K = a constant for a given coarse aggregate size.

14. A calculator useful in the determination of portions of ingredients for concrete mixes conprising a body member; a slide member slidably positioned within said body member, and slide member and body member having logarithmic scales extending therealong, said logarithmic scales being coextensive with one another and having the same spacing and range; a set of at least two concrete mix factor scales positioned on said members, said concrete mix factor scales including a percent entrained air for water reduction scale (**31**), and the number of sacks of cement for water reduction (**32**), each of said concrete mix factor scales being positioned on different members of the calculators so as to facilitate the determination of the amount of reduction in the mixing water content for air-entrained concrete to be read on one of the logarithymic scales of one of the members; and a cursor mounted on said body member.

15. The calculator of claim **14** where said concrete mix factors are positioned on the calculator in accordance with the equation

$W.R. = 1.02\ (A - 0.9)^{.55} \times \mathrm{Tan}\ [19.7 + 10\ (7\text{-}C)]\ °/\mathrm{Tan}\ 19.7°\ ]$

where

A = entrained air content in percent and

C = cement content in sacks per unit volume.

16. A calculator useful in the determination of portions of ingredients for concrete mixes comprising a body member; a slide member slidably positioned within said body member, said slide member and body member having logarithmic scales extending therealong, said logarithmic scales being coextensive with one another and having the same spacing and range; a set of at least three concrete mix factor scales positioned on said members, said concrete mix factor scales including a fineness modulus for percent sand scale for percent sand (**33**), a number of sacks of cement for percent sand scale (**34**) and a size of coarse aggregate for percent sand scale (**35**), said number of sacks of cement scale (**34**) and size of coarse aggregate scale (**35**) carried on the same member and said fineness modulus for percent sand scale (**33**) carried on the other member, said concrete mix factor scales being positioned on the calculator so as to facilitate the determination of the percent sand contained in the total amount of aggregate mixture to be read on the logarithmic scale of one of the members; and a cursor mounted on said body member.

17. The calculator of claim **16** wherein said concrete mix factor scales are positioned on the calculator in accordance with the equation

% Sand (round aggregate) $= 1.000K_1\ [(22-C)/18\ ]\ [(FMs + K_2)/(2.65 + K_2)]$

where

C = cement sacks per unit volume,

FMs = fineness modulus of sand, and

K_1 and K_2 are constants at any given size of coarse aggregate.

18. The calculator of claim **16** wherein said concrete mix factor scales are positioned on the calculator in accordance with the equation

% Sand (angular aggregate) $= 1.175K_1\ [(27-C)/23\ ]\ [(FMs + K_2)/(2.65 + K_2)]$

where

C = cement in sacks per unit volume,

FMs = fineness modulus of sand, and

K_1 and $i\ K_2$ are constants at any given size of coarse aggregate.

19. A calculator useful in the determination of portions of ingredients for concrete mixes comprising a body member; a slide member slidably positioned within said body member; said slide member and body member having linear scales extending therealong, said linear scales being coextensive with one another and having the same spacing and range; a set of at least three concrete mix factor scales positioned on said members, said concrete mix factor scales including an amount of water for unit weight scale (**36**), a number of sacks of cement for unit weight scale (**37**) and a unit weight scale (**38**), said water scale (**36**) and unit weight scale (**38**) carried on the same member and said cement scale (**37**) carried on the other member, said concrete mix factor scales being positioned on the calculator so as to facilitate the determination of the weight of the concrete to be read on the linear scales of one of the members; and a cursor mounted on said body member.

20. A calculator useful in the determination of portions of ingredients for concrete mixes comprising a body member; a slide member slidably positioned within said body member, said slide member and body member having linear scales extending therealong, said linear scales being coextensive with one another and having the same spacing and range; at least one concrete mix factor scale positioned on said members, said concrete mix factor scale including an aggregate specific gravity for aggregate weight scale (**39**) carried on the slide member so as to determine the weight of aggregate on sand for the concrete mix knowing the volume of coarse aggregate or sand, respectively, to be used, said weight to be read on the logarithmic scale of one of the members; and a cursor mounted on said body member.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,814,308 Dated June 4, 1974

Inventor(s) Andrew Kolan

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 19, "corresponding" should be -- correspondingly --.

Column 5, line 56, "b/bp" should be -- b/bo --.

Column 8, lines 39 and 40, "[12.893 - W/C/10] [100-5ac/100]" should be

-- $\left(\frac{12.893 - W/C}{10}\right) \left(\frac{100-5ac}{100}\right)$ --;

lines 54 and 55, "$1.02\ (A - 0.9)^{.55}$ X Tan [19.7 + 10 (7-C)]°/[Tan 19.7°]" should be

-- $1.02\ (A - .9)^{.55} \times \frac{\text{Tan [19.7 + 10 (7-C)] degrees}}{\text{Tan 19.7 degrees}}$ --;

lines 59 and 60, "[(22-C)/(-*)] [(FMs + K_2)/2.65 + K_2]" should be

-- $\frac{(22-C)}{18} \frac{(FMs + K_2)}{2.65 + K_2}$ --;

lines 61 and 62, "$1.75K_1$[(27-C)23] (FMs + K_2)/2.65 + K_2" should be

-- $1.175K_1 \frac{(27-C)}{23} \frac{(FMs + K_2)}{2.65 + K_2}$ --.

FORM PO-1050 (10-69)

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,814,308 Dated June 4, 1974

Inventor(s) Andrew Kolan

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 9, line 8, first column in TABLE V - second numeral down - "1" should be -- 1-1/2 --;

line 54, "on" should be -- in --.

Column 12, line 29, "Y'/Y · X" should be -- $\frac{Y'}{Y} \cdot X$ --;

in TABLE VII - last column, five lines down - near line 39 - "2.67" should be -- 2.067 --.

Column 13, line 15, "modification" should be -- modifications --.

Column 15, lines 45 and 46, "[12.893 - W/C/10] [100 - 5ac/100]" should be

$$--\left(\frac{12.893 - W/C}{10}\right) \left(\frac{100 - 5ac}{100}\right)--;$$

line 55, "and" (first occurrence) should be -- said --;

line 66, "calculators" should be -- calculator --.

ORM PO-1050 (10-69)

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,814,308 Dated June 4, 1974

Inventor(s) Andrew Kolan

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 16, line 39, before "sack" the word -- in -- was omitted;

line 51, before "K_2" the "i" should be omitted.

Column 18, line 5, before "sand" the word "on" should be -- or --.

Signed and sealed this 19th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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