July 11, 1961 H. S. MORTON 2,991,934

NOMOGRAPH CALCULATOR

Filed Feb. 19, 1958 2 Sheets-Sheet 1

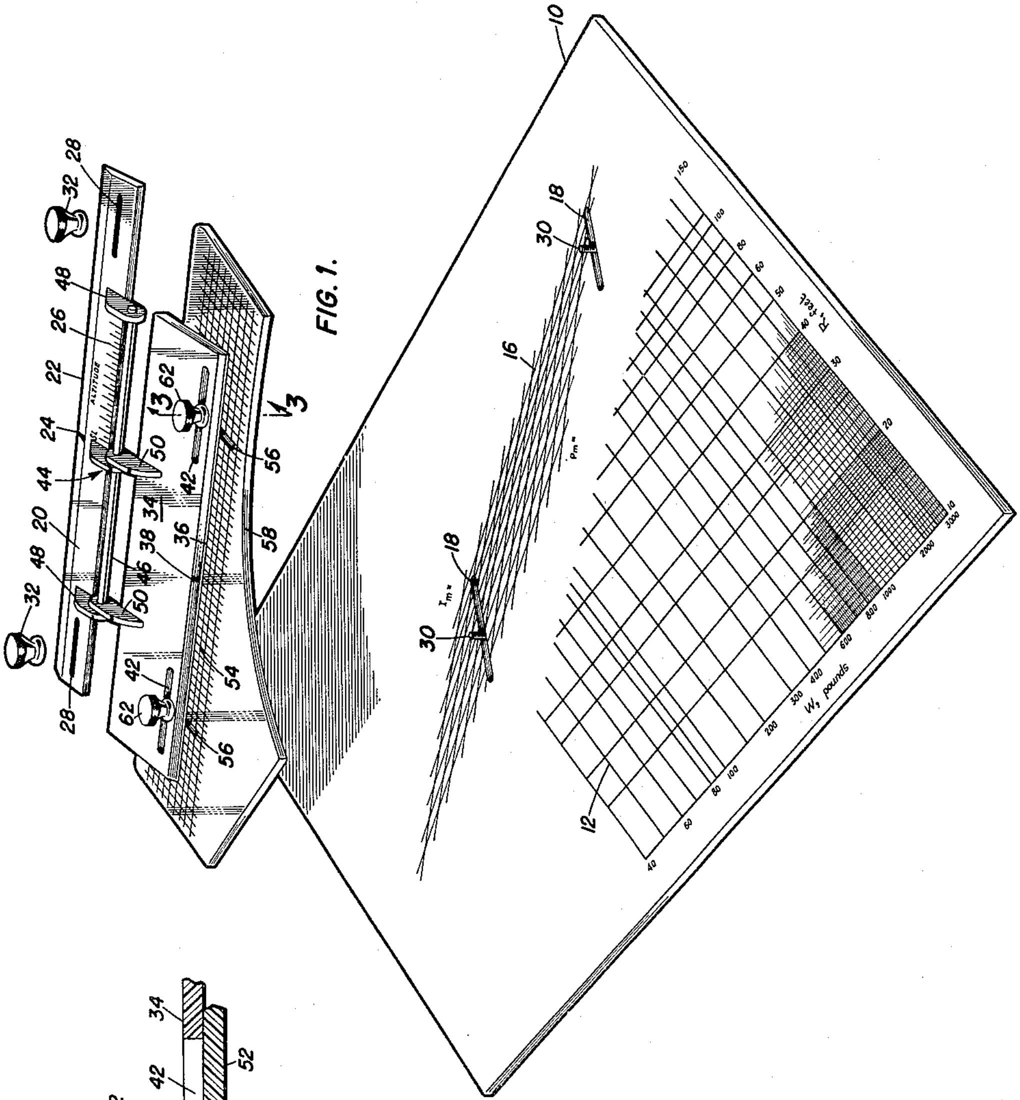

FIG. 1.

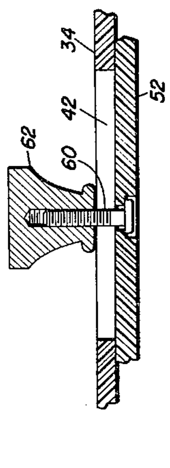

FIG. 3.

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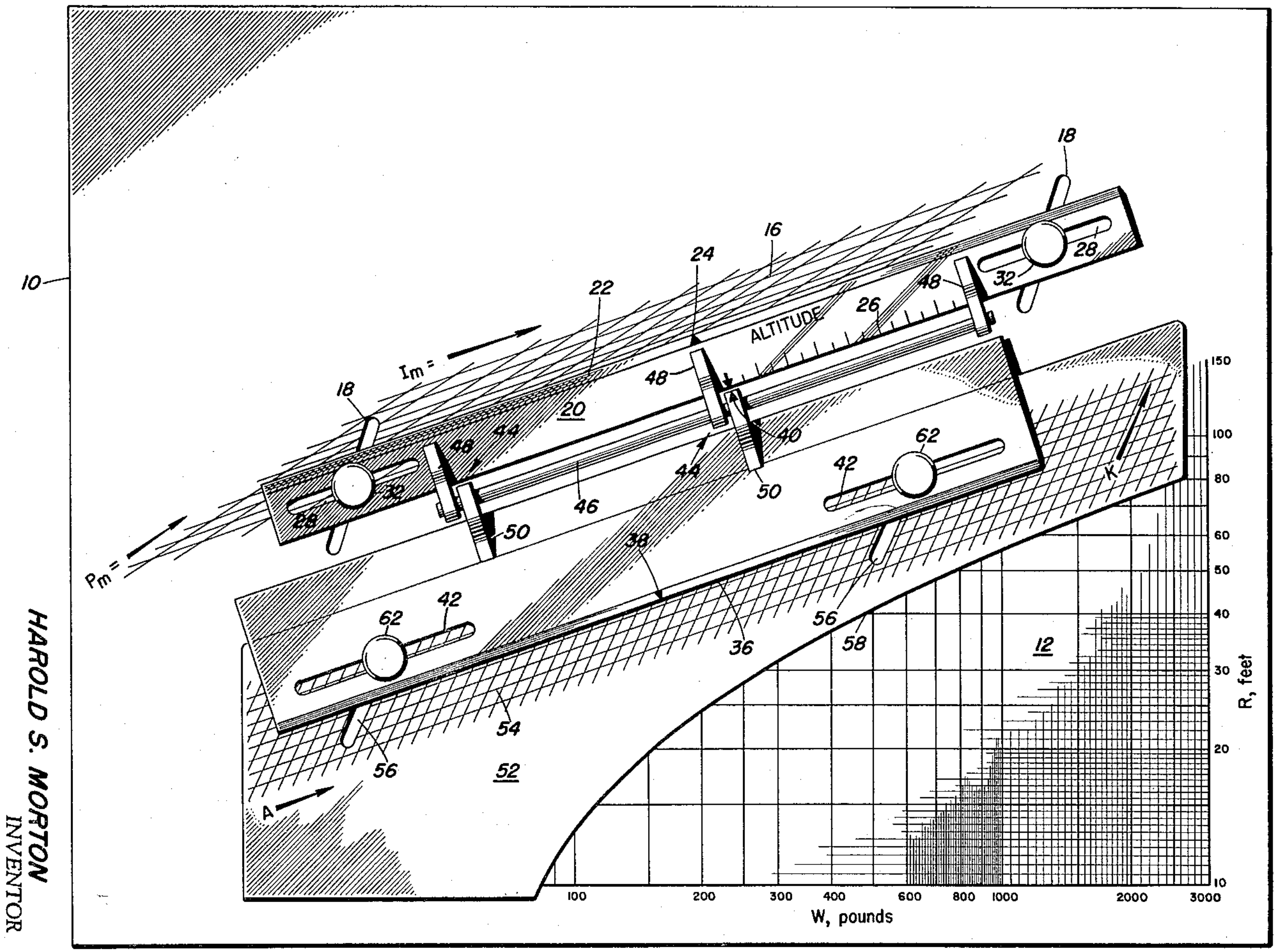
FIG. 2.



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NOMOGRAPH CALCULATOR

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4 Claims. (Cl. 235—61)

This invention relates generally to calculators and more particularly to a nomogram calculator especially adapted to the scaling of damage which would probably be inflicted by missile warheads of various types.

The calculator disclosed herein provides a device which will analytically determine the damage inflicted on an aircraft or other flying target solely by the blast resulting from the detonation of high explosive charges in warheads. The probability that the trajectory of a missile carrying a warhead will pass within a sufficient range for the blast of the explosive to destroy the target can be determined precisely by known methods, by integrating a probability function for each target, each explosive and at each altitude for which information is desired. This is an altogether unsatisfactory procedure, however, since it requires a separate computation for each target, explosive and altitude.

In firing a missile carrying a warhead it is important to know the range from the point of detonation to target for a specified weight of a particular explosive or conversely to know the weight of a particular explosive required at a particular range to destroy the target. Once these have been established the trajectory for the missile can be determined. It is then only a matter of proper fuzing to destroy the target.

It is therefore an object of the invention to provide a universal nomogram calculator for scaling blast damage.

Another object of the invention is to provide a mechanical linkage system which, when employed with charts embodying known parameters of target, explosive and altitude will provide a universal nomogram for scaling blast damage.

A further object of the invention is to provide computing means for combining the logarithmic values of known target, explosive and altitude parameters to enable the estimation of the probable damage that a specified explosive charge will inflict upon a specified target.

Other objects and many of the attendant advantages of the invention will be readily apparent as the same becomes understood by reference to the following detailed description and claims, taken in conjunction with the accompanying drawings wherein:

FIG. 1 is an exploded perspective of the present invention;

FIG. 2 is a plan view of the assembled device; and

FIG. 3 is a section through one of the locking devices of the calculator.

Generally the invention consists of a calculator in which a number of adjustable elements are mechanically linked so that their positions relative to each other determine the location of a template having a shaped edge on a blast damage chart. The elements are adjustable over logarithmically-calibrated charts for explosive and target parameters and a logarithmic scale for altitude. The elements are positioned according to preselected target, explosive and altitude conditions to determine blast damage for any range and weight of explosive.

The destruction of a particular target by explosive blast is caused by the work done on the target by the impingement thereon of either the pressure or the impulse value of shock waves, or a combination thereof, produced by detonation of a high explosive charge and propagated through the ambient air to the surface of the target. The degree of such destruction is dependent upon four elements: the toughness of the target, the atmospheric conditions at the target altitude, the characteristics of the particular explosive employed, and the weight of and range from the target of the explosive charge. Of these four elements, the first two are normally not under the control of the personnel desiring destruction of the target. Further, only a limited number of explosives will normally be available for use. Therefore, the fourth element is of chief importance, the weight of the explosive charge and the range from the point of detonation to the target being within the control of such personnel.

It is known that the same degree of target destruction may be obtained by employing a large explosive weight at a long range from the target as by employing a smaller explosive weight at a lesser range. Because it is often necessary to vary either the weight of the explosive or the range thereof from the target, a means of determining what combination of explosive weight and explosive range will give a specified degree of target destruction is not only desirable but often a necessity.

The weight of the explosive and the range thereof from the target to obtain a specified degree of destruction is determined by a combination of four elements: the toughness of the target to be destroyed, the ambient conditions at the target altitude, the characteristics of the explosive employed, and the amount of work necessary to obtain the desired destruction. The relationship of these four elements to the weight of the explosive and the range thereof from the target may be expressed in the form of functional equations.

Thus:

$$W = f_W\text{ (target)} \times f_W\text{ (altitude)} \times f_W\text{ (explosive)} \times f_W\ (\epsilon)$$
$$R = f_R\text{ (target)} \times f_R\text{ (altitude)} \times f_R\text{ (explosive)} \times f_R\ (\epsilon)$$

Where:

W=weight of explosive required to obtain the desired destruction

R=range of the explosive from the target to obtain the desired destruction

f_W (target),
f_R (target)=factors related to the toughness of the target to be destroyed

f_W (altitude),
f_R (altitude)=factors related to the ambient conditions at the target altitude

f_W (explosive),
f_R (explosive)=factors related to the characteristics of the particular explosive employed

f_W (ϵ),
f_R (ϵ)=factors related to the amount of work necessary to obtain the desired destruction. As is hereinafter explained, these two factors are directly related to W and R and hence contain a relationship therebetween.

From experimental data and the known behavior pattern of blast effects it has been possible to derive equations for each of the above factors.

Thus:

The equations for the first factor are:

$$f_W\text{ (target)} = \frac{I_m^3}{P_m^{1.1}};\ f_R\text{ (target)} = \frac{I_m}{P_m^{0.7}}$$

Where:

I_m=the minimum blast-generated impulse that will assure that target deformation continues until sufficient damage takes place to constitute a "kill" (lb./in.^{2}—msec.)

P_m=the minimum blast-generated unit pressure that exceeds the yield point of the target material and results in continuous permanent deformation (lb./in.^{2})

The values of I_m and P_m for a variety of targets are determined experimentally.

The equations for the second factor are:

$$f_W\text{ (altitude)}=\frac{(C_a/C_0)^3}{P^{.9}};\ f_R\text{ (altitude)}=\frac{C_a/C_0}{P^{.3}}$$

Where:

C_a=velocity of sound in ambient air at target altitude (ft./sec.)
C_0=velocity of sound in sea level air (ft./sec.)
P=ambient pressure at target altitude (in atmospheres).

The equations for the third factor are:

$$f_W\text{ (explosive)}=\frac{K^{0.98}}{(2)^{1.62}A^3};\ f_R\text{ (explosive)}=\frac{K^{0.76}}{(2)^{0.44}A}$$

Where K and A are dimensionless constants characteristic of particular explosives, the following table listing values of K and A for several explosives.

Explosive	K	A
TNT	1160	31.65
Tritonal (80/20)	1220	33.6
Comp.-B	1270	32.7
HBX-1	1340	35.1
HBX-3	1300	36.0
50/50 Pentolite	1320	38.6
H-6	1390	38.1

The equations for the fourth factor are:

$(\epsilon \leq 0.5)$ $(\epsilon \geq 0.5)$

$$f_W(\epsilon)=\frac{\epsilon^{1.1}}{\left(1-\frac{4}{3}\epsilon\right)^{3/2}} \qquad f_W(\epsilon)=\frac{(0.433)^3}{\epsilon^{0.4}(1-\epsilon)^{9/2}}$$

$$f_R(\epsilon)=\frac{\epsilon^{0.7}}{\left(1-\frac{4}{3}\epsilon\right)^{1/2}} \qquad f_R(\epsilon)=\frac{(0.433)\epsilon^{0.2}}{(1-\epsilon)^{3/2}}$$

Where:

ϵ=an experimentally-determined dimensionless parameter defined as the ratio of P_m to P_p (P_p being the peak blast-generated unit pressure at the target). ϵ must always be less than 1.0 when any damage whatever occurs, and will always be greater than zero for positive values of P_p.

It has been found that for explosive weights up to the order of 1000 pounds at sea level, and to several tons at higher altitudes, ϵ is less than 0.5. Further, for very large explosive weights it has been found that ϵ is more than 0.5. The equations involving ϵ are, as is evident from the above equations, different for values of $\epsilon \leq 0.5$ and values of $\epsilon \geq 0.5$.

Substitution of the above equations into the functional equations for W and R will result in mathematical equations by which W and R can be determined.

Thus:

For values of $\epsilon \leq 0.5$,

$$W=\left(\frac{I_m^3}{P_m^{1.1}}\right)\left(\frac{(C_a/C_0)^3}{P^{.9}}\right)\left(\frac{K^{0.98}}{(2)^{1.62}A^3}\right)\left(\frac{\epsilon^{1.1}}{\left(1-\frac{4}{3}\epsilon\right)^{3/2}}\right)$$

$$R=\left(\frac{I_m}{P_m^{0.7}}\right)\left(\frac{C_a/C_0}{P^{.3}}\right)\left(\frac{K^{0.76}}{(2)^{0.44}A}\right)\left(\frac{\epsilon^{0.7}}{\left(1-\frac{4}{3}\epsilon\right)^{1/2}}\right)$$

For values of $\epsilon \geq 0.5$,

$$W=\left(\frac{I_m^3}{P_m^{1.1}}\right)\left(\frac{(C_a/C_0)^3}{P^{.9}}\right)\left(\frac{K^{0.98}}{(2)^{1.62}A^3}\right)\left(\frac{(0.433)^3}{\epsilon^{0.4}(1-\epsilon)^{9/2}}\right)$$

$$R=\left(\frac{I_m}{P_m^{0.7}}\right)\left(\frac{C_a/C_0}{P^{.3}}\right)\left(\frac{K^{0.76}}{(2)^{0.44}A}\right)\left(\frac{(0.433)\epsilon^{0.2}}{(1-\epsilon)^{3/2}}\right)$$

While the above equations are capable of mathematical solution, such is difficult and time consuming. The present invention provides a nomograph for the solution thereof, the function of the entire device being to present and solve graphically the above general equations for explosive weight, W, and range from explosive to target, R.

An examination of the mathematical equations for W and R reveals that, for any specified target, altitude and explosive, the first three factors of the equations will be constants. Therefore, it is evident that the relationships between various values for W and R must be set forth in the fourth factor of the equations, that involving ϵ. That such is the case is easily shown.

As above explained, ϵ is defined as the ratio of P_m to P_p. Both of P_m and P_p are known to be dependent upon the weight of the explosive employed and its range from the target. Thus it is seen that the basic functional relationships between damage distance R, and charge weight W, are all embraced in the functions of ϵ. If the logarithm of $f_R(\epsilon)$ is graphed against the logarithm of $f_W(\epsilon)$ for ϵ values up to 0.5, and the logarithm of $f_R(\epsilon)$ against the logarithm of $f_W(\epsilon)$ for ϵ values of 0.5 and above, the resulting curve is a completely general relationship between functions of R and functions of W. If this curve is correctly oriented upon a chart containing the logarithm of R as the ordinate and the logarithm of W as the abscissa, it will show all combinations of R and W (within the range of the scales) which produce the same degree of target damage.

The calculator illustrated in FIGS. 1 and 2 consists of a rectangular base **10** having a chart **12** printed on its lower right-hand corner which has a logarithmic scale for range R as ordinate and a logarithmic scale for explosive weight W as abscissa. On the upper left-hand portion of the base **10** there is a logarithmically-calibrated chart **16**, representing the target parameters, which is an oblique coordinate system for minimum peak pressure P_m and for minimum impulse I_m. The values of P_m decrease in the direction of the arrow P_m, and the values of I_m increase in the direction of the arrow I_m.

Two spaced parallel slots **18** are located in the base in the proximity of chart **16** at angles sufficient to maintain an adjustable element **20** at a slope of ⅓ with respect to the abscissa of chart **12**. The element **20**, located above chart **16**, has a straight upper edge **22** and a reference point, or index, **24** on the same edge. A logarithmic scale **26** representing altitude appears along the lower edge of element **20**, and a pair of slots **28** are disposed therein parallel to the straight edge **22**. The element **20** is adjustably secured to the base **10** by means of screws **30** and nuts **32** passing through slots **18** and **28**.

A second element **34** is adjustably secured parallel to element **20** by a hinge assembly **44**. The second element **34** is provided with a straight lower edge **36** with a reference point, or index, **38** thereon, a pointer, or index, **40** and a pair of slots **42** extending parallel to the straight edge **36**. The hinge **44** is composed of brackets **48** and **50** pinned together by a rod **46**. The element **34** may then be moved longitudinally to align pointer **40** with the altitude scale **26** while the lower edge **36** is maintained parallel to straight edge **22**.

A template **52** having a shaped lower edge **58** is adjustably secured to element **34** by screws **60** passed upwards through parallel slots **56** in said template and extending through the slots **42** in element **34**. The screws **60** are surmounted by nuts **62**. The hinge connection **44** allows the template and element **34** to be swung away from the base, thereby facilitating adjustment of the position of the template relative to said element **34** as well as easing the removal of foreign matter accumulating under the template. The basic R versus W shaped edge **58** represents the functions of ϵ and conforms to a graph of the logarithm of the function of ϵ with respect to range ($f_R(\epsilon)$) against the logarithm of the function of ϵ with respect to explosive weight ($f_W(\epsilon)$).

It will be noted that horizontal displacement of the basic R versus W shaped edge **58**, derived from parametric equations for $f_R(\epsilon)$ and $f_W(\epsilon)$ add to or subtract from the values of log W, and similarly, vertical movements add to or subtract from the values of log R.

The logarithms of the first three factors given above determine the extent and direction of horizontal and vertical displacements necessary to correlate the basic R versus W shaped edge **58**, with a specific target, a specific altitude, and a specific explosive.

As stated hereinabove the altitude factors for W and R are respectively:

$$f_W\text{ (altitude)}=\frac{(C_a/C_0)^3}{P^{.9}}$$

$$f_R\text{ (altitude)}=\frac{(C_a/C_0)}{P^{.3}}$$

wherein:

C_a=sound velocity at the known altitude
C_0=sound velocity at sea level
P=pressure of ambient air

It will be noted that the logarithm of f_W (altitude) changes exactly three times as fast as the logarithm of f_R (altitude), and in the same sense, so that the effect of altitude changes is to displace any point positioned on the basic R versus W shaped edge **58**, and, hence, the edge **58** itself, along a line with a slope of ⅓. Both R and W, for a given point on the curve, increase as altitude increases.

A convenient correlation is known to exist between the ratio C_a/C_o and the ambient pressure p, which permits the velocity-of-sound correction to be approximated by a function of p with excellent precision from sea level to 35,000 feet altitude, and with reasonable accuracy to higher altitudes. This correlation is:

$$C_a/C_o=p^{0.095}$$

Thus, the equations for the second factor may be expressed entirely in terms of ambient pressure p, which is determined by altitude. This permits the second factor to be represented conveniently solely in terms of altitude.

Standard handbook values are utilized for the values of the terms of the factors involving altitude (the second factor in each equation), which values are assumed to be constant for a specific altitude.

In the calculator the basic R versus W shaped edge **58**, constitutes the lower right edge of the moveable element **52**, a scale **26**, calibrated logarithmically, from left to right, in altitudes from sea level to fifty or sixty thousand feet, or more, is provided along a line of slope ⅓ to govern displacements for altitude changes.

The target toughness factors are:

$$f_W\text{ (target)}=\frac{I_m^{3}}{P_m^{1.1}}$$

$$f_R\text{ (target)}=\frac{I_m}{P_m^{0.7}}$$

When P_m (minimum peak pressure) is constant and I_m (minimum impulse) varies, the displacement of the R versus W shaped edge **58** takes place along a line of slope ⅓ and both R and W increase as I_m increases, with log R increasing ⅓ as fast as log W.

If I_m is constant and P_m varies, the displacement of the R versus W curve takes place along a line of slope 0.636 with both R and W increasing as P_m decreases.

Variations in the target toughness parameters are, therefore, taken care of by the chart **16** properly scaled along a line of slope ⅓, with R and W increasing as I_m increases, and similarly scaled along a line of slope 0.636, with R and W decreasing as P_m increases. For a given target this means that a particular target is uniquely represented by a point on the oblique coordinate system **16**, of con-

stant P_m lines of slope ⅓ and constant I_m lines of slope 0.636.

The factors defining explosive characteristics are:

$$f_W\text{ (explosive)}=\frac{K^{0.93}}{(2)^{1.62}A^3}$$

$$f_R\text{ (explosive)}=\frac{K^{.76}}{(2)^{0.44}A}$$

If A remains constant and K varies, the displacement of the R versus W shaped edge **58**, takes place along a line of slope 0.775 with both R and W increasing as K increases.

If K remains constant and A varies the displacement of the R versus W shaped edge **58** takes place along a line of slope ⅓ with both R and W decreasing as A increases.

Variations in explosives parameters are, therefore, taken care of by the chart **54** properly scaled logarithmically along a line of slope 0.775, with R and W increasing as K increases, and similarly scaled along a line of slope ⅓, with R and W decreasing as A increases. The values of K decrease in the direction of the arrow K, and the values of A increase in the direction of the arrow A.

The factors for the dimensionless parameter ϵ are:

$(\epsilon\leq 0.5)$ $\qquad$ $(\epsilon\geq 0.5)$

$$f_W(\epsilon)=\frac{\epsilon^{1.1}}{\left(1-\frac{4}{3}\epsilon\right)^{3/2}}\qquad F_W(\epsilon)=\frac{(0.433)^3}{\epsilon^{0.4}(1-\epsilon)^{9/2}}$$

$$f_R(\epsilon)=\frac{\epsilon^{0.7}}{\left(1-\frac{4}{3}\epsilon\right)^{1/2}}\qquad F_R(\epsilon)=\frac{.433\epsilon^{0.3}}{(1-\epsilon)^{3/2}}$$

The logarithms of the above equations are graphed to produce the outline for the shaped edge **58**.

As is evident from the above, the charts **16** and **54** and the scale **26** must be so positioned with respect to each other that: (1) the abscissa (I_m values) and the ordinate (P_m values) of chart **16** are disposed at slopes of ⅓ and 0.636, respectively, with respect to the abscissa of chart **12**, (2) the abscissa (A values) and the ordinate (K values) of chart **54** are disposed at slopes of ⅓ and 0.775, respectively, with respect to the abscissa of chart **12**, and (3) the scale **26** is disposed at a slope of ⅓ with respect to the abscissa of chart **12**. The spacing between the charts **12**, **16** and **54**, the scale **26** and the basic R versus W edge **58** is dependent solely on the size of the elements employed in the device and as such is a matter of design, it being understood that the above angular relationship must be maintained. The specific spacings for use with any given size of elements, as well as the scales for the various charts and the scale and the positions of the reference points **24**, **40** and **38**, are determined by plotting a number of mathematical solutions of the general equations for W and R in the manner well known to those familiar with graphic representation of mathematical equations.

To operate the calculator empirical values for the target toughness parameters, P_m and I_m and the explosive parameters A and K must be established. Once the target is known the operator aligns element **20** to the target toughness parameters with the straight edge **22** aligned with minimum pressure P_m and the reference point **24** with minimum impulse I_m. Element **20** is then secured to the base **10** by locking device **30**, **32**. The explosive to be used being known, the template **52** is aligned with element **34** so that the explosive parameter K is aligned with straight edge **36** and the explosive parameter A is aligned with reference point **38**. The template is then secured to element **34** by the locking device **60**, **62**. The element **34** with template **52** attached is moved longitudinally along rod **46** to the proper altitude on scale **26**. The template is then held in place and a line drawn along shaped edge 58 on chart 12. The operator then can read from the curve drawn on chart 12 the weight of explosive required to kill a specified target at any specified range.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A nomogragh calculator including a base having a first, rectangular coordinate bearing logarithmically calibrated chart and a second, oblique coordinate bearing logarithmically calibrated chart on the surface thereof, a first element disposed upon said base and having a straight edge along one side thereof, a first index, said first index being disposed upon said first element adjacent to and medially of said straight edge thereon, means slidably connecting said first element to said base so that said first index may be aligned with a point on said second chart, a second element also disposed upon said base and having a straight edge along one side thereof, a second index, said second index being disposed upon said second element adjacent to and medially of said straight edge thereon, a logarithmically calibrated scale on said first element disposed to confront said second element, a third index, said third index being disposed upon said second element and positioned to confront said scale, means slidably connecting said second element to said first element so that said third index may be aligned with a point on said scale, a template having a third, oblique coordinate bearing logarithmically calibrated chart thereon, means slidably connecting said second element to said template so that said second index may be aligned with a point on said third chart, whereby the position of said template with respect to said first chart is governed by the alignment of said first index with a point on said second chart, the alignment of said third index with a point on said scale, and the alignment of said second index with a point on said third chart.

2. A nomograph calculator including a base, a first, rectangular coordinate bearing logarithmically calibrated chart and a second, oblique coordinate bearing logarithmically calibrated chart on said base, a first element disposed upon said base and having a straight edge along one side and a logarithmically calibrated scale along the opposite side, a first index, said first index being disposed upon said first element adjacent to and medially of said straight edge thereon, means slidably connecting said first element to said base so that said first index may be aligned with a point on said second chart, a second element also disposed upon said base and having a straight edge along one side thereof facing opposite to said straight edge of said first element, a second index, said second index being disposed upon said second element adjacent to and medially of said straight edge thereon, a third index, said third index being disposed upon said second element and positioned to confront said scale, means coupling said second element to said first element for limited relative sliding movement therebetween in a plane parallel to that of said first element, said means including a coupling element and a linkage permitting swinging of said second element away from said base and limited movement of said third index along said scale, a template, a third, oblique coordinate bearing logarithmically calibrated chart on said template, means slidably connecting said second element to said template so that said second index may be aligned with a point on said third chart, whereby the position of said template with respect to said first chart is governed by the alignment of said first index with a point on said second chart, the alignment of said third index with a point on said scale, and the alignment of said second index with a point on said third chart.

3. A nomograph calculator including a rectangular base having a first, rectangular coordinate bearing logarithmically calibrated chart and a second, oblique coordinate bearing logarithmically calibrated chart on the surface thereof, and having a pair of spaced slots disposed in planes parallel to each other and at an angle to an edge of said base, a first element disposed upon said base, said first element having a straight edge along one side, a logarithmically calibrated scale along its opposite side, and a pair of slots in the opposite end portions threof lying in a plane parallel to said straight edge, a first index, said first index being disposed upon said first element adjacent to and medially of said straight edge thereon, means passing through said first and second mentioned slots slidably connecting said first element to said base so that said first index may be aligned with a point on said second chart, a second element also disposed upon said base, said second element having a straight edge along one side thereof facing opposite to said straight edge of said first element and having a pair of slots disposed at opposite ends thereof in a plane parallel to said straight edge thereon, a second index, said second index being disposed upon said second element adjacent to and medially of said straight edge thereon, a third index, said third index being disposed upon said second element and positioned to confront said scale, means coupling said first element to said second element for limited longitudinal sliding movement therebetween, said means including a coupling element and a hinge permitting swinging of said second element away from said base and limited movement of said third index along said scale, a template having a third, oblique coordinate bearing logarithmically calibrated chart thereon, said template having a pair of spaced slots therein disposed in planes parallel to each other, means passing through said slots in said second element and said template slidably connecting them for limited longitudinal movement so that said second index may be aligned with said third chart, whereby the position of said template with respect to said first chart is governed by the alignment of said first index with a point on said second chart, the alignment of said third index with a point on said scale, and the alignment of said second index with a point on said third chart.

4. A nomograph calculator including a rectangular base having thereon a first, rectangular coordinate bearing logarithmically calibrated chart and a second oblique coordinate bearing logarithmically calibrated chart spaced from said first chart, and having therein a pair of spaced slots disposed in planes parallel to each other and at an angle to an edge of said base, a first element disposed upon said base and having a straight edge along one side thereof and a pair of slots in the opposite end portions thereof, a first index, said first index being disposed upon said first element adjacent to and medially of said straight edge thereon, means passing through said first and second mentioned slots slidably connecting said first element to said base so that said first index may be aligned with a point on said second chart, a second element also disposed upon said base and having a second straight edge along one side thereof facing opposite said straight edge of said first element, there being a pair of slots disposed at opposite ends of said second element in a plane parallel to said straight edge thereon, a second index, said second index being disposed upon said second element adjacent to and medially of said straight edge thereon, a logarithmically calibrated scale on said first element disposed to confront said second element, a third index, said third index being disposed upon said second element and positioned to confront said scale, means slidably coupling said first element to said second element for limited longitudinal sliding movement so that said third index may be aligned with a point on said scale, a template, a third, oblique coordinate bearing logarithmically calibrated chart on said template, a shaped edge along one side of said template, means for slidably con-

necting said second element to said template so that said second index may be aligned with a point on said third chart, whereby the position of the shaped edge of said template with respect to said first chart is governed by the alignment of said first index with a point on said second chart, the alignment of said third index with a point on said scale, and the alignment of said second index with a point on said third chart.

References Cited in the file of this patent

UNITED STATES PATENTS

1,536,574	Du Mond	May 5, 1925

FOREIGN PATENTS

911,601	France	July 16, 1946
24,761	Great Britain	Nov. 23, 1898