Feb. 25, 1947. A. A. WELLINGS 2,416,363

ATTACK COURSE COMPUTER

Filed April 6, 1944 3 Sheets-Sheet 1

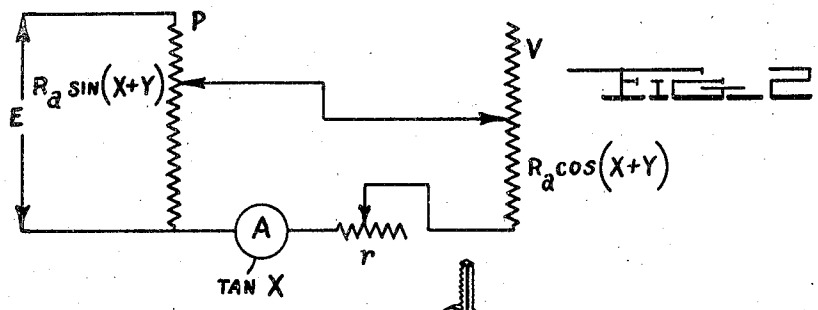


FIG. 2

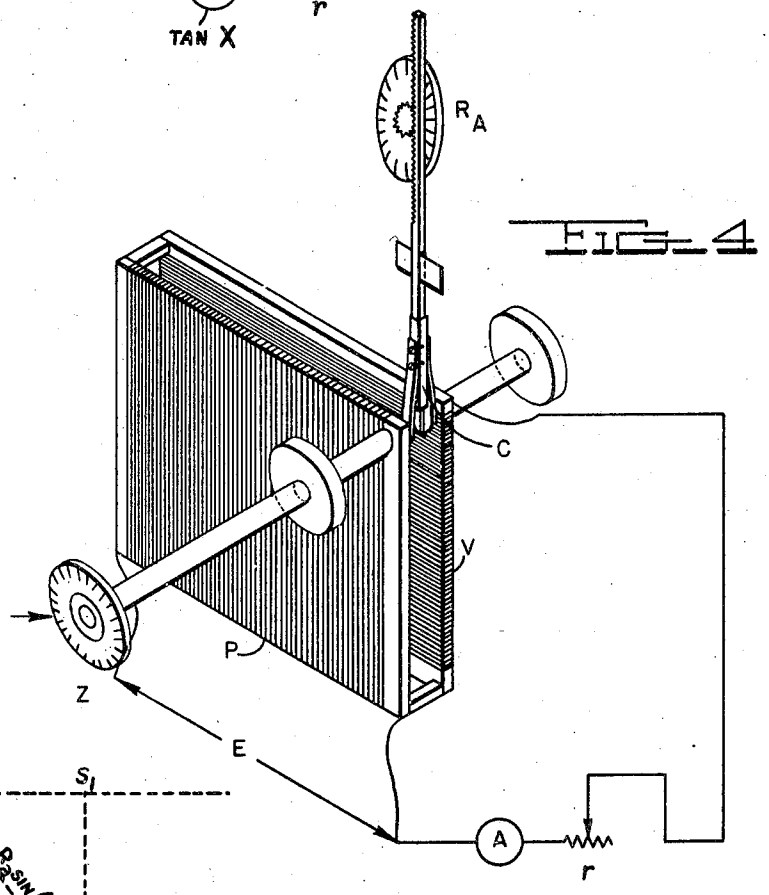


FIG. 4

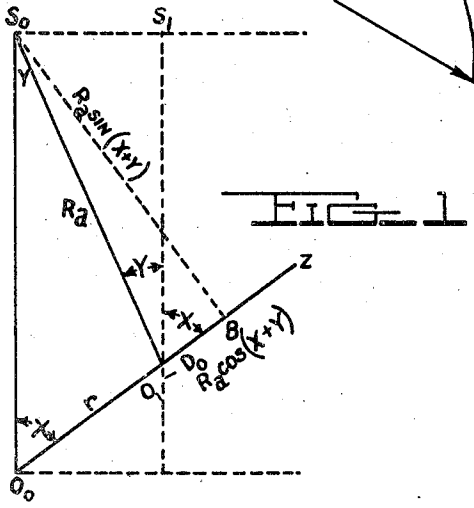


FIG. 1

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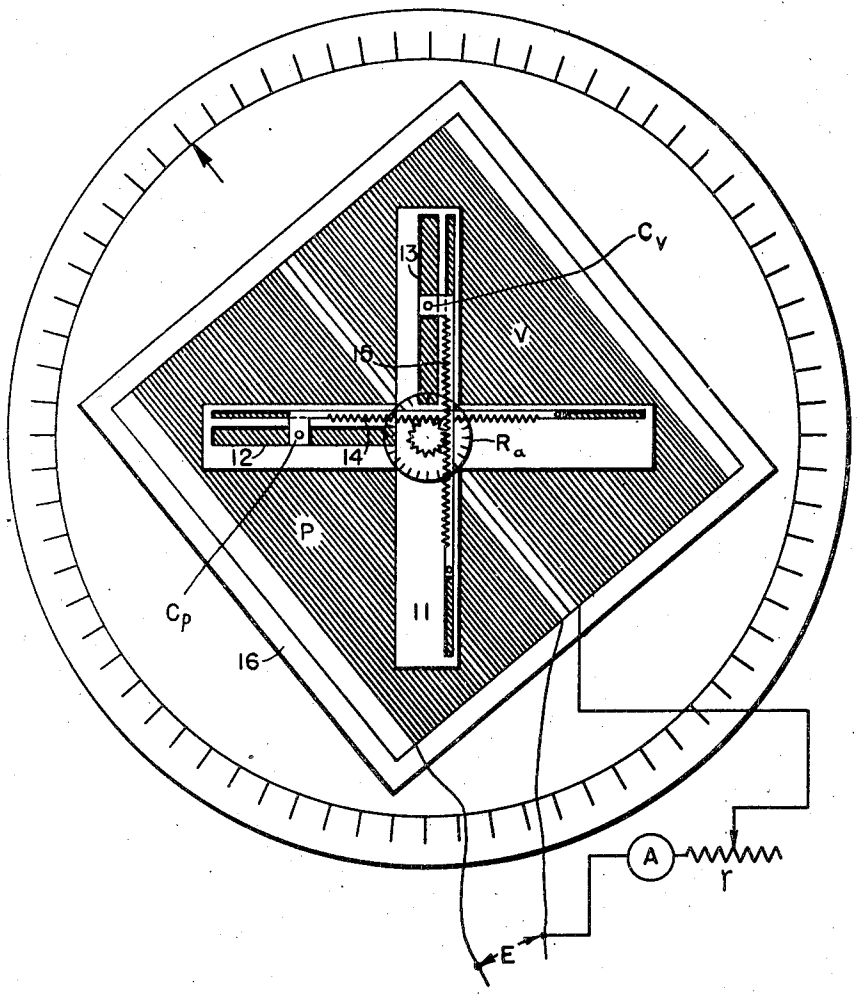
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FIG. 3



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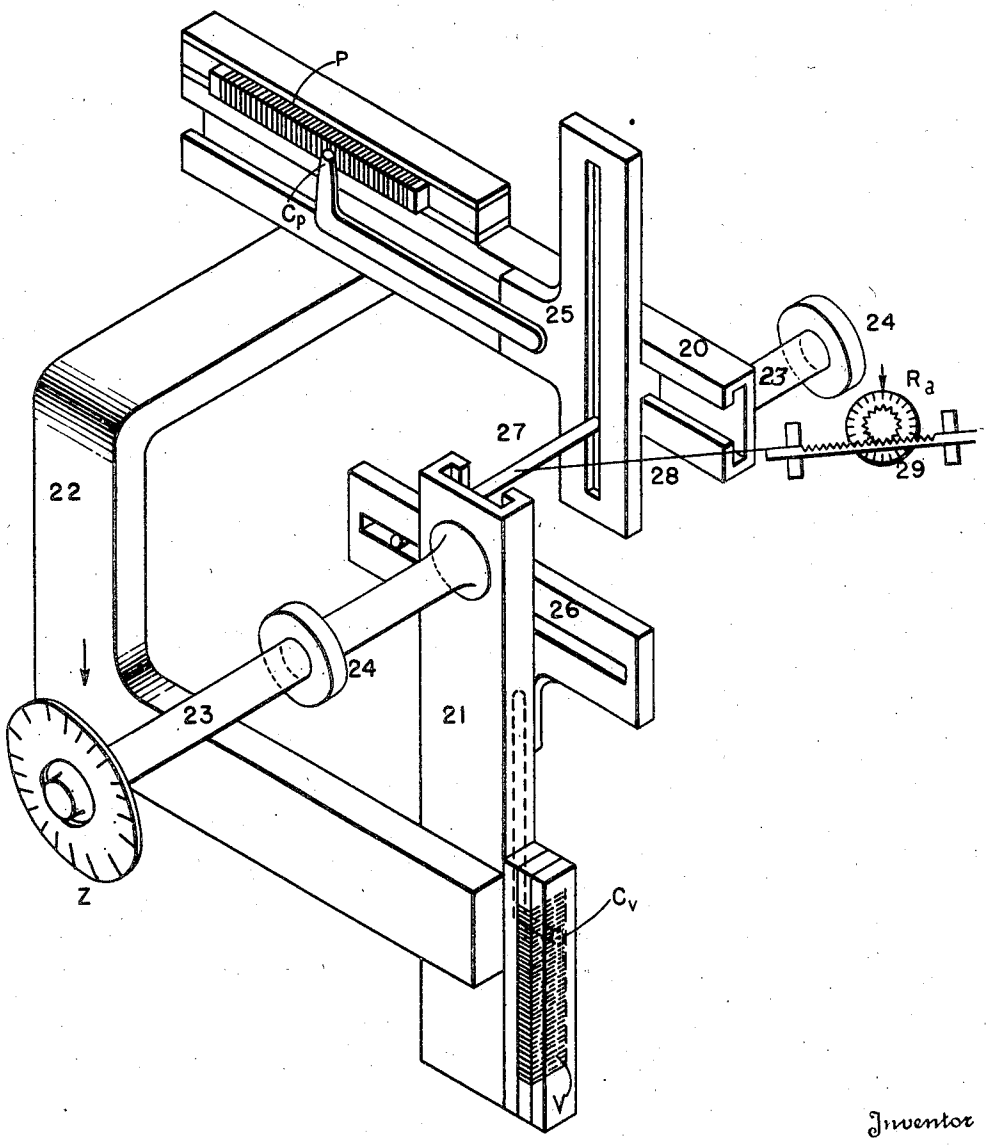
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FIG. 5



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2,416,363

ATTACK COURSE COMPUTER

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Application April 6, 1944, Serial No. 529,762

16 Claims. (Cl. 201—63)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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This invention relates to a computing device or more particularly to a device for indicating the correctness, or the incorrectness, of the course of a vessel which is carrying an attack to a stationary or moving submerged target. By its indications the device facilitates the selection of the correct attack course and verifies the correct course, if it has been selected successfully.

In making an attack, as by the use of stern dropped depth charges, upon a submerged target, the conning or navigating officer of the attacking vessel is presented with a unique navigational problem. The explosion point of a depth charge released by the attacking vessel is some number of yards astern of the vessel, the distance depending upon the progress of the vessel along its course in the time interval between the release of the charge and its detonation. It is this "trailed" explosion point astern of the vessel which must collide or nearly collide with the target, if the attack is to result in damage to or destruction of the target. The problem of the conning or navigating officer is to set the course of the attacking vessel for a collision or near collision between this "trailed" explosion point and the submerged target. This problem must be solved from the bearings and the ranges of the target which are perforce observed from a point on the attacking vessel.

For a solution of the problem heretofore, reliance has had to be placed entirely on the skill of the conning or navigating officers. These officers could obtain the requisite skill only through extensive experience which was necessarily restricted to a relatively small number of men.

It is the object of this invention to provide a method of and means for facilitating the determination of the correct course in an attack.

It is another object of this invention to provide means for determining the correct attack course more or less mechanically and to avoid the necessity for long training in order to successfully direct attacks on submerged targets.

It is a further object of this invention to provide means for solving automatically, mathematical formulae of various sorts.

The above and other objects of this invention will become clearer upon consideration of the

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following specification taken in connection with the accompanying drawings, in which

Fig. 1 is a diagram illustrating the plotting for an attack on a submerged submarine;

Fig. 2 is an elementary circuit for solving the equation established in connection with Fig. 1;

Fig. 3 is a schematic diagram of a device adapted to operate to solve the attack problem;

Fig. 4 is a schematic diagram of a preferred embodiment of the present invention, and,

Fig. 5 is a schematic diagram of an alternative arrangement.

Attention now is invited more particularly to the drawings with particular reference to Fig. 1. In this figure O_0 represents the initial position of a trailed explosion point, **O**, being trailed at a distance r behind attacking vessel D, having an initial position D_0. The projected course of the explosion point **O** and the towing vessel D is O_0Z which makes a relative angle X with the line connecting O_0 and S_0, the latter being the initial point of the submarine target S. The target has an initial range R_a and a relative bearing $X+Y$ from D at D_0. The course and speed of the target are unknown, but by the time the trailed explosion point has reached D_0 or O_1, if the course of the attacking vessel is properly adjusted to insure a collision between the target and the trailed explosion point, S_1, the new location of the target must lie on the line D_0S_1, which makes with the projected course O_0Z an angle X which is the same as the original angle X between the projected course and the line between O_0 and S_0.

In other words, if the attack course is properly set to insure a successful attack, the angle X will remain constant.

It will be appreciated that it is impossible to measure directly the relative bearing of the submarine target from the trailed point **O**. However, if the attacking vessel is on the proper course to insure collision between the explosion point and the submarine, the angle X may be computed readily and the present device has been devised for indicating this angle. Since, if the course is not correct, the angle X will progressively change, the present device will indicate a change of X and, by an appreciation of the sense of the change, the course may be corrected readily until the indicated X remains constant and a collision is assured.

From point S_0 in Fig. 1, drop a perpendicular S_0B upon the projected course 0_0Z. Then it is evident that by construction $S_0B=R_a \sin (X+Y)$ and $D_0B=R_a \cos (X+Y)$. Furthermore,

$$\tan X=\frac{R_a \sin (X+Y)}{r+R_a \cos (X+Y)}$$

It is recognized that the current I of an electric circuit will vary in accordance with the voltage E divided by the resistance R of the circuit. The formula for expressing this,

$$I=\frac{E}{R}$$

is analogous to the above formula. Accordingly, referring to Fig. 2, if a voltage proportional to $R_a \sin (X=Y)$ is picked off the potentiometer P and the rheostat V is adjusted to include a resistance proportional to $R \cos (X+Y)$ and the resistance r is adjustable to include a resistance proportional to the distance between the attacking vessel and the trailed explosion point, then the current flowing through the circuit composed of the rheostat V, resistor r and ammeter A, will be proportional to tan X, and changes of the indications made by A, as the setting of P and V are changed in accordance with changes in the range R and the bearing $X+Y$ of the submerged target S from the attacking vessel D, will indicate an error in the course of the attacking vessel.

To make a successful attack, therefore, it is only necessary to alter the course until the indications made by A are constant as the range and bearing of the target vary.

It should be noted that in order to make the system accurate, the resistance of the resistor V should be very high with reference to the resistance of the potentiometer P.

In carrying out the objects of this invention the circuit shown in Fig. 2 is arranged as shown schematically in Fig. 3 or Fig. 4 which chiefly show the provision made for simultaneously adjusting the potentiometer P and the resistor V to include resistances proportional to $R_a \sin (X+Y)$ and $R_A \cos (X+Y)$ respectively. To accomplish this, there is provided a pair of flat resistors P and V, mounted for rotation about an axis perpendicular to their surfaces. Each of these resistors is so arranged that variations in the position of a movable contact parallel to one edge will vary the resistance directly with variations in position whereas variations in a direction parallel to the other edge will make little or no change in the resistance. Thus, the resistance will vary with motion of the movable contact in a manner depending upon the relative angle of motion of the contact with the edges of the resistor. By causing the contact to move across one resistor at an angle which is complementary to the corresponding angle made across the other resistor, the resistance in one resistor will be proportional to the sine of the direction whereas the resistance in the other resistor will be proportional to the cosine.

With particular reference to Fig. 3, the contacts C_P and C_V which operate on potentiometer P and variable resistance V respectively are arranged to move at right angles to each other across their respective resistor surfaces by sliding in slots 12 and 13 of the grid member 11. They are simultaneously actuated by means of rods 14 and 15, one lying above the other and co-acting with different parts of a pinion on the shaft of a control knob R_a to set the resistances in accordance with the range of the target. The block 16 upon which the resistors P and V are mounted may be moved relative to grid 11 to adjust for the angle $X+Y$, the relative bearing of the target.

An equivalent operation may also be accomplished by presenting the operating faces of the two resistors to each other as shown in Fig. 4 and disposing them so that the corresponding edges are at right angles to each other. Then with the two plates adjusted by Z to an angle corresponding to the relative bearing of the submarine, a movable contact C having opposed points for contacting both resistor plates P and V will, upon setting the dial R_a to the range, adjust the potentiometer P to include a voltage proportional to $R_a \sin (X+Y)$ while the resistor V is simultaneously adjusted to a resistance proportional to $R_a \cos (X+Y)$.

The resistors P and V may be of any of several constructions. For example, rectangles of insulating material may be closely wound with resistance wire. Another possibility is that commutator bars may be imbedded in a resistance compound to form the resistance blocks, or as in the preferred embodiment, a series of insulated commuator strips may be each connected to adjacent strips through resistors of the desired value. A substitute for this would be to separate the commutator strips by high resistance separators instead of insulators as is the case when using commutator bars connected through resistors. Any means which will provide a surface having an aeolotropic resistance characteristic of such a degree that there is substantially no variation of resistance in one direction and the fullest degree of resistance variation in a direction at right angles thereto would be suitable for use in the present device.

Alternatively, the resistor and potentiometer may be of ordinary construction and there may be provided mechanical means for actuating them to set the resistances thereof to values which are proportional to the cosine and sine respectively of the angle representing the bearing of the target. Such an arrangement is shown in Fig. 5 in which corresponding parts are correspondingly designated. In this figure the potentiometer P and the resistor V are mounted with their operating mechanisms toward each other and are arranged to be swung as a unit by knob Z to a position corresponding to the bearing of the target. In any position their values are adjusted to correspond to the sine and cosine respectively by means of pin 27, actuated to set the resistors to a value proportional to the range by means of the rack-pinion gearing shown diagrammatically at 29 and controlled by knob R_a.

It will be understood that the rack, and the rod 28 connecting the rack with the pin 27, are constrained to move in a straight line parallel to the plane of rotation of the resistances about the shaft 23 as a whole and the vertical planes of the guide slots in the carriages 25 and 26. This constrains the pin 27 to move along the line of movement of the rod 28 parallel to said planes. In the adjustment shown in Fig. 5, the rotational adjustment of the shaft 23 with respect to the rod 28 is such that the rod 28, which extends radially from the pin 27, is not parallel to either of the guide slots of the carriages 25 and 26 but makes an angle of a little more than 45 degrees with the slot in carriage 25 and a little less than 45 degrees with the slot in 26.

Having thus described my invention, atten-

tion is called to the fact that I am not to be considered as limited to the specific forms I have shown but solely by the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. An electrical resistor including a movable contact and a surface having aeolotropic resistivity characteristics, said contact engaging said surface over a relatively small, substantially constant area, the resistivity characteristics of said surface being of such a degree that the resistance included between a point of said surface and said contact will vary directly with the distance between said point and said contact in one direction and will not vary in a direction at right angles thereto.

2. A compound variable electrical resistor including two surfaces at least one of which has aeolotropic resistivity characteristics, a movable contact bearing upon each of said surfaces and means for moving said contacts in a correlated manner along a straight line across said surfaces.

3. A compound variable electrical resistor including two contact surfaces at least one of which has aeolotropic resistivity characteristics, a movable contact bearing upon each of said surfaces whereby the resistance included between one of said contacts and a point on said contact surface will vary directly with the distance between said point and said contact in one direction and will not vary in a direction at an angle thereto, means for moving said contacts across said surfaces along a straight line in a given direction, and means for altering the direction of motion of said contacts.

4. A compound variable electrical resistor including two contact surfaces each of which has aeolotropic resistivity characteristics, a movable contact bearing upon each of said surfaces whereby the resistance included between each of said contacts and a point on the corresponding surface will vary directly with the distance between said point and said contact in one direction and will not vary in a direction at right angles thereto, and means for moving said contacts in a correlated manner along a straight line across said surfaces.

5. A compound variable eelctrical resistor including two contact surfaces each of which has aeolotropic resistivity characteristics, a movable contact bearing upon each of said surfaces whereby the resistance included between each of said contacts and a point on the corresponding surface will vary directly with the distance between said point and said contact in one direction and will not vary in a direction at right angles thereto, means for moving said contacts along a straight line across said surfaces so that the resistance included in one of said resistors will vary proportionally to the sine of the angle of direction of movement whereas the resistance included between the other contact and a point on the corresponding resistor will vary as the cosine of the same angle, and means for adjusting the angle of direction of motion of said contacts.

6. A compound variable electrical resistor including two contact surfaces each of which has aeolotropic resistivity characteristics, a movable contact bearing upon each of said surfaces whereby the resistance included between each of said contacts and a point on the corresponding surface will vary directly as the distance between the said point and said contact in one direction and will not vary in a direction at right angles thereto, and means for simultaneously moving said contacts in different directions relative to the aeolotropic characteristics of their respective resistance surfaces such that resistances proportional to different triogonometric functions of the same angle will be included between said contacts and points on the respective resistor surfaces.

7. A variable electrical resistor having a rectangular contacting surface composed of bared resistance wire wound parallel to one edge of said surface, and a contact for coaction therewith at any point on said surface to the exclusion of all other points on the surface whereby the resistance included between a point and said contact varies with the distance of said contact from said point differently in different directions.

8. A variable electrical resistor comprising a form having a rectangular surface, and a contact for coaction therewith, movable to contact said resistance at any point upon the said rectangular surface to the exclusion of all other points on the surface whereby the resistance included between a point on said surface and said contact varies with the distance of said contact from said point, negligibly in the direction of the winding and to a full extent at right angles thereto.

9. In an electric circuit and indicating device, an adjustable resistance, a variable resistance and a potentiometer, said variable resistor and said potentiometer comprising a compound variable resistor including two rectangular contact surfaces each of which has aeolotropic resistivity characteristics, a movable contact bearing upon each of said surfaces, a single means for simultaneously moving each of said contacts in a straight line from a given point over said surfaces and means for permitting said motion at any angle, whereby the voltage imposed upon said circuit by said potentiometer will be proportional to the product of R_a and the sine of $X+Y$, the resistance of said circuit will be proportional to r plus the product of R_a and the cosine of $X+Y$, and the current in said circuit will be proportional to

$$\frac{R_a \sin (X+Y)}{r+R_a \cos (X+Y)}$$

where R_a equals the extent of the said straight line motion, $X+Y$ equals the angle of motion of the contact across the resistance surface and r equals a given constant value of the adjustable resistance.

10. In an electric circuit, means for supplying a voltage proportional to the product of a distance and the sine of an angle and adjusting the resistance to a value which is proportional to the product of a distance and the cosine of the angle, whereby the current is proportional to the tangent of the same angle, said means comprising a compound resistor having a variable potentiometer section and a variable resistor section, each of said sections including a contact surface having aeolotropic resistivity characteristics, a movable contact for each section and means for simultaneously adjusting the position of said contacts at an angle across the resistance contact surfaces said angle corresponding to the aforementioned angle.

11. In an electric circuit means for supplying a voltage proportional to a trigonometric function of an angle and adjusting the resistance of said

circuit to a value which is proportional to a different trigonometric function of the angle, whereby the current is proportional to a third trigonametric function of the same angle, said means comprising a compound resistor having a variable potentiometer section and a variable resistor section, each of said sections including a contact and a contact surface and means for simultaneously adjusting the resistance of said sections to be proportional to the respective trigonometric functions of said angle.

12. In an electric circuit, means for supplying a voltage proportional to a trigonometric function of an angle and adjusting the resistance to a value which is proportional to another trigonometric function of the angle, whereby the current is proportional to a third trigonometric function of the same angle, said means comprising a compound resistor having a variable potentiometer section and a variable resistor section, each of said sections including a contact and a contact surface having aeolotropic resistivity characteristics and means for adjusting the contacts to include a resistance which is proportional to the trigonometric functions of said angle.

13. In an electric circuit means for supplying a voltage proportional to the product of a distance and the sine of an angle and adjusting the resistance of said circuit to a value which is proportional to the product of the same distance and the cosine of the same angle, whereby the current in said circuit is proportional to the tangent of the same angle, said means comprising a compound resistor having a variable potentiometer section and a variable resistor section, and means for simultaneously adjusting said potentiometer and said resistor to have values proportional to the said functions of the same angle.

14. In an electric circuit, means for supplying a voltage proportional to the product of a distance and a trigonometric function of an angle and adjusting the resistance of said circuit to a value which is proportional to the product of the same distance and another trigonometric function of the angle, whereby the current in said circuit is proportional to a third trigonometric function of the same angle, said means comprising a variable potentiometer, a variable resistor and means to adjust simultaneously said potentiometer and said resistor to the aforementioned values.

15. A compound resistive device comprising two variable resistors and means for simultaneously adjusting said resistors whereby the resistances thereof are varied in proportion to the product of a distance and different trigonometric functions respectively.

16. A compound resistive device comprising two variable resistors having movable contacts mounted for adjustment in a direction at right angles to each other, an operating device for simultaneously adjusting said movable contacts, and means for varying the angle between the direction of movement of both of said movable contacts and said operating device whereby the resistance of said resistors are simultaneously adjusted to values proportional to the cosine and sine of the said angle.

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