March 15, 1927. 1,621,394

C. F. J. M. BERTIN

MECHANICAL INTEGRATING DEVICE AND APPLICATIONS OF THE SAME, CHIEFLY TO A NAVIGATION COURSE RECORDER

Filed June 27, 1924 4 Sheets-Sheet 1

Fig. 1

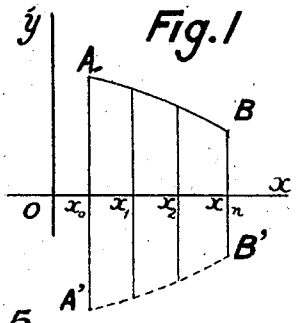


Fig. 2

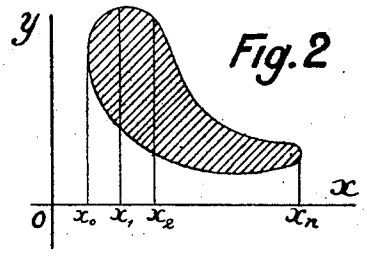


Fig. 5.

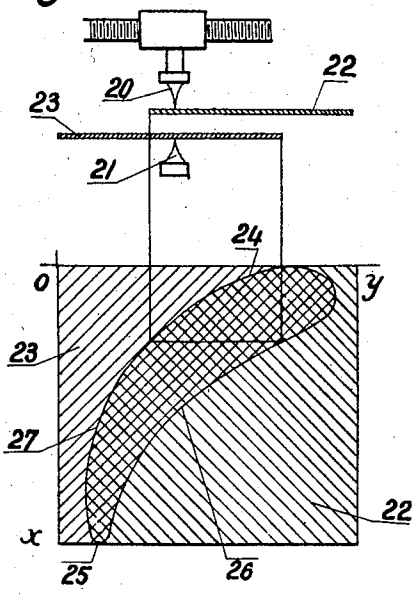


Fig. 8.

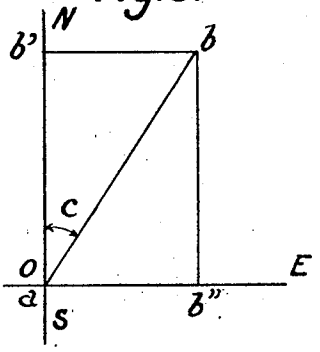


Fig. 6.

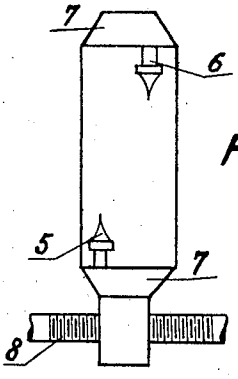
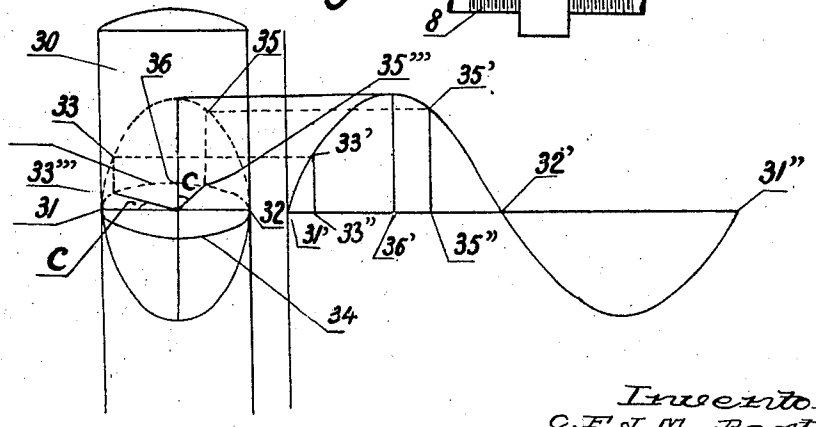


Fig. 9.



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Fig. 3

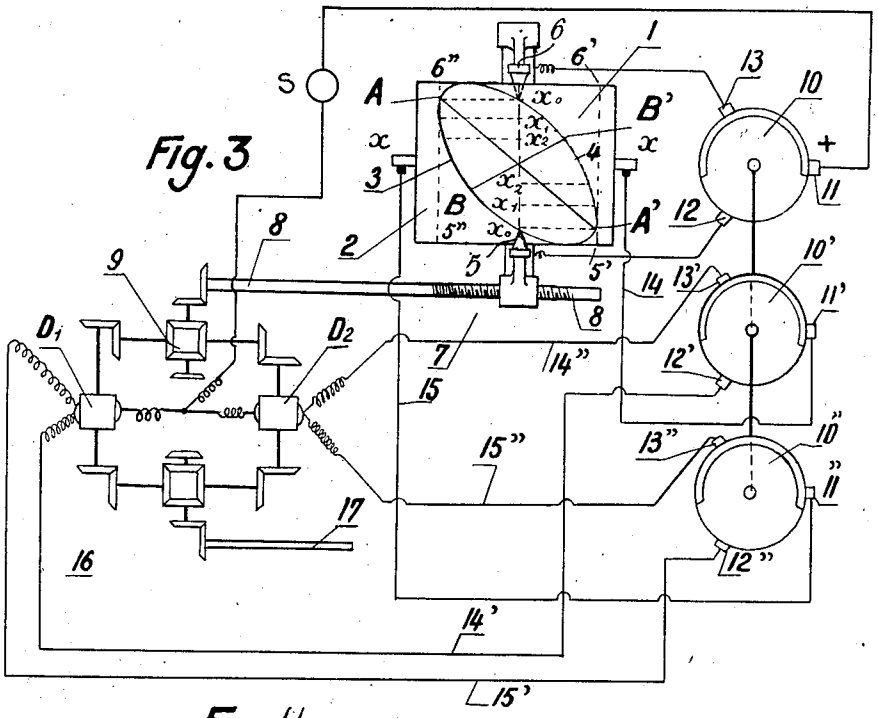


Fig. 11.

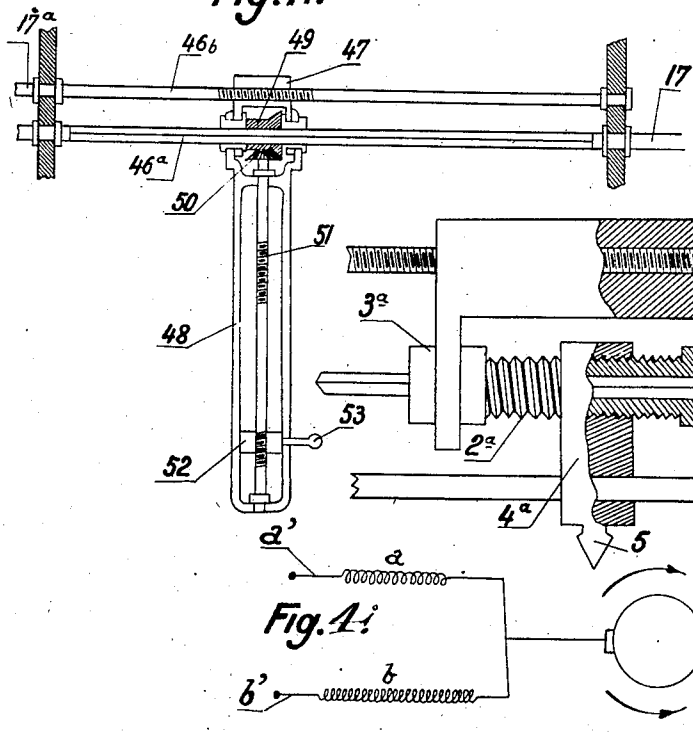


Fig. 7.

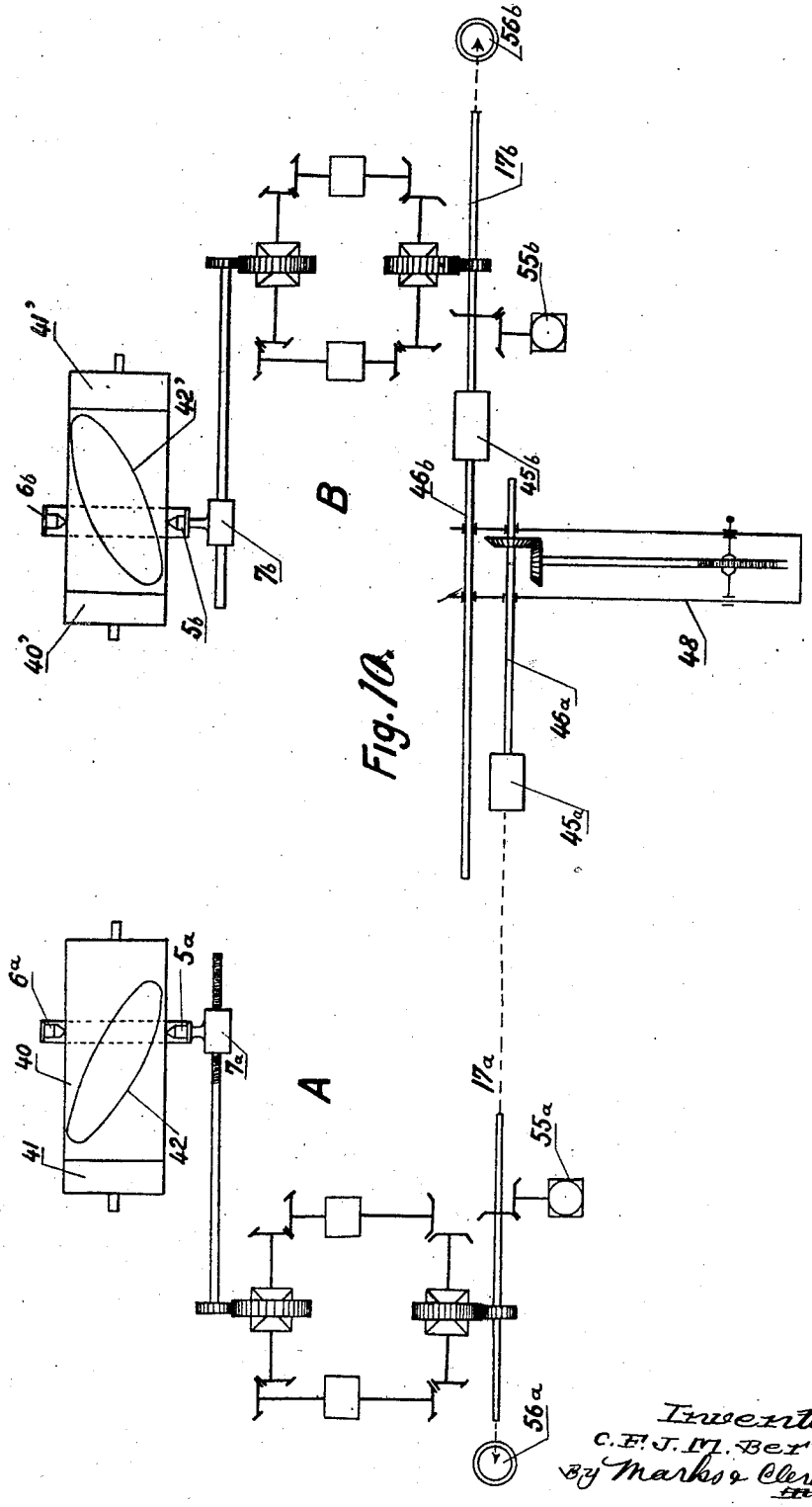
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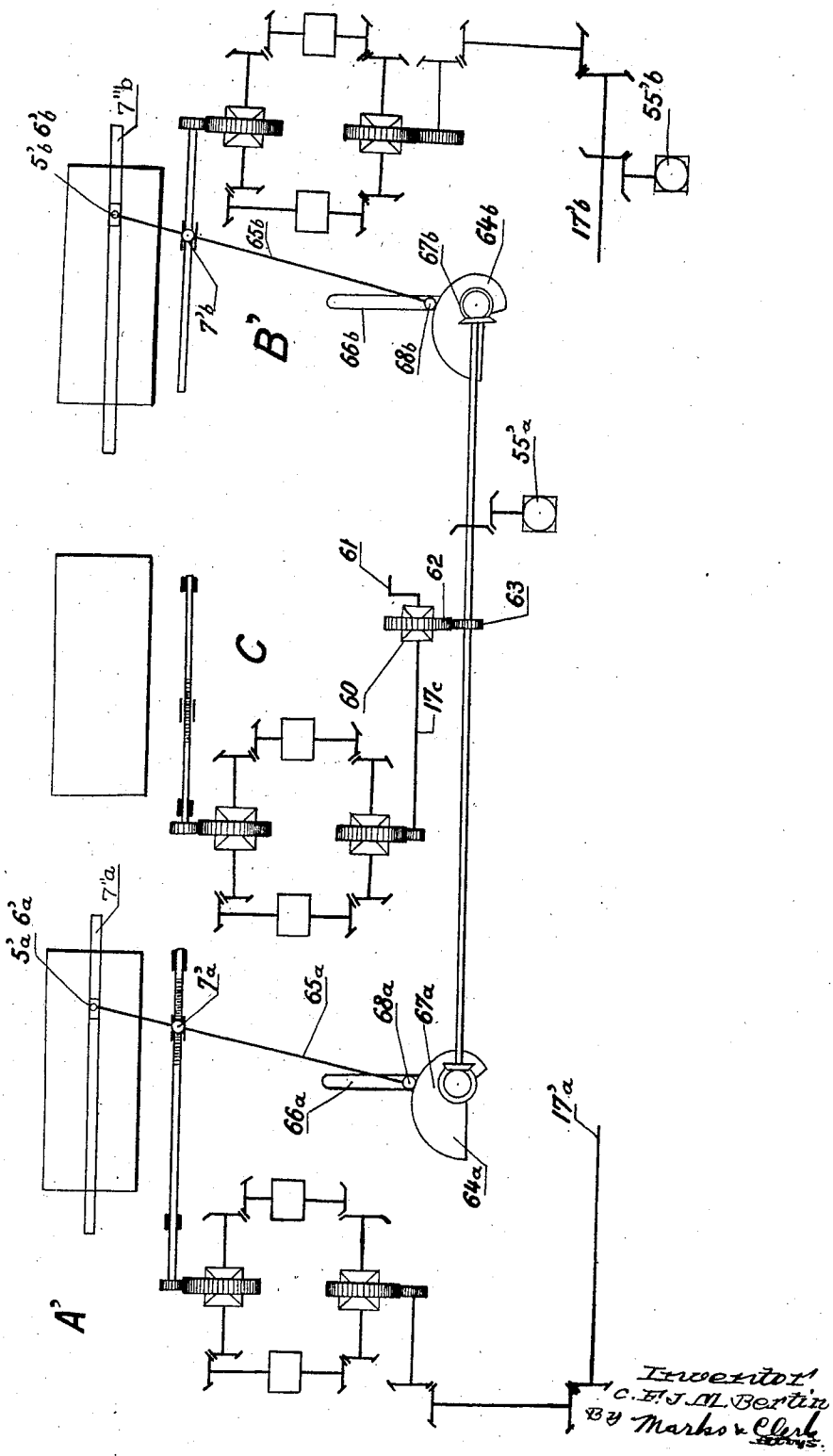
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MECHANICAL INTEGRATING DEVICE AND APPLICATIONS OF THE SAME, CHIEFLY TO A NAVIGATION COURSE RECORDER

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Fig. 12.



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Patented Mar. 15, 1927. 1,621,394

UNITED STATES PATENT OFFICE.

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MECHANICAL INTEGRATING DEVICE AND APPLICATIONS OF THE SAME, CHIEFLY TO A NAVIGATION-COURSE RECORDER.

Application filed June 27, 1924, Serial No. 722,834, and in France June 30, 1923.

Present invention has for object the mechanical integration of a function $f(x)$ of a variable x between the limits x_0 and x_n. This result is achieved by the algebraical addition of the several values $f(x_0), f(x_1), f(x_n)$ of the function for a number of values of x chosen in the interval from x_0 to x_n the sub-intervals between two such successive values being very small.

My integrating (or algebraically adding) device comprises a controlling element, movements of which depend upon the variations of x and an actuated element giving the sum $f(x_1)+f(x_2)+\ldots+f(x_n)$, the curve $y=f(x)$ having been previously traced on said controlling element.

The principle underlying invention is the following. The integration of curve $y=f(x)$ drawn in A B (Fig. 1) with reference to rectangular coordinates gives, as is well known, the area of surface A B x_0 x_n. In case of Fig. 2 on which a closed curve is shown the integration will give area of surface enclosed by same. It is in this way that the area of a diagram is commonly used for measuring the power of a piston steam machine. Value of integral is, if one supposes x_0 x_1 . . . x_n to be successive values of x, very near

$$f(x_0)(x_0-x_1)+f(x_1)(x_2-x_1)+\cdots+f(x_n-1)(x_n-x_{n-1}).$$

If the small intervals

$$(x_0-x_1)\cdots(x_n-x_{n-1})$$

are all equal to h, it is very near

$$h[f(x_0)+f(x_1)+\cdots+f(x_n-1)]$$

or proportional to

$$f(x_0)+f(x_1)+\cdots+f(x_n-1).$$

Therefore algebraically adding device described hereinbelow and giving said sum is also an integrating device.

The accompanying drawings illustrate by way of example, an integrating device according to invention and a course recorder working of which is based on use of said integrating device.

Figs. 1 and 2 show, as stated hereinabove, examples of functions to be integrated. Fig. 3 is a diagrammatic view of an integrating device and Fig. 4 shows a series motor used with same and provided with two field windings. Figs. 5, 6 and 7 show modifications of details of integrating device. Figs. 8 and 9 are diagrams explaining principle of the course recorder. Fig. 10 is a diagrammatic view of same recording on a chart of the type wherein the scale of distances is the same for all points of the chart. Fig. 11 is a detail view thereof. Fig. 12 shows a modified form of course recorder adapted for recording upon a chart with variable scale such as Mercator's chart.

Fig. 3 illustrates diagrammatically integrating device: two movable conducting surfaces 1 and 2 comprised for example on the same cylinder, are electrically separated and bounded by the curve 3 representing the function $y=f(x)$ on the developed cylinder and by the curve 4, obtained by rotation through a certain angle round axis of cylinder of the symmetrical curve of the curve 3 with reference to a perpendicular section of cylinder (the axis of x being a development of periphery of said perpendicular section and the axis of y a generatrix). The two said curves are joined together by suitable curves in cases where extremities of same do not coincide. A set of two brushes 5 and 6 is brought to bear upon said surfaces, said brushes being movable along generatrices of cylinder either in one direction or the other as explained hereinbelow. The said set of brushes is mounted upon a slide 7 forming a nut upon the screw 8. The angular distance between the two brushes upon the cylinder is equal to the above mentioned angular rotation of the symmetrical curve of the curve 3 round axis of cylinder necessary to obtain curve 4. On Fig. 3 brushes are shown 180° apart and the two curves which are two ellipses are turned 180° apart from their symmetrical position and thus coincide.

Two electric motors D^1 and D^2 fed by the supply 5 control the screw shaft 8 by means of the differential gear shown diagrammatically at 9; each motor may rotate in either direction according as it receives current through 15′ or 14′ for the motor D^1, or through 15″ or 14″ for the motor D^2. The said motors are for instance series motors with two fields, and are so constructed (Fig.

4) that when the current enters through a', the field a is excited and the armature rotates in the direction F; but when the current enters through b', the field b is excited and the armature rotates in the direction G. A current distributor 10, 10', 10'' makes one-half revolution at predetermined intervals. The said distributor operates three commutators; in the first, the contact piece 10 which is constantly supplied by the brush 11, is connected alternately with the contact pieces 12 and 13 which are respectively connected to the brushes 5 and 6. In the second, a contact piece 10' which is in constant connection through the brush 11' with the surface 1, is alternately connected to the brushes 12' and 13' which respectively supply the two fields of the motors D^1 and D^2 through 14' and 14''. In the third, a contact piece 10'' which is constantly connected by the brush 11'' with the surface 2, is alternately connected to the brushes 12'' and 13'' supplying respectively the two fields of the motors D^1 and D^2 through 15' and 15''; the other terminals of the two motors are connected to the negative pole.

Thus the connections are so disposed that, on whichever conducting surface the brushes may bear, the brush 5 shall always be moved towards the insulating curve 3 by motor D_1 when actuated and the brush 6 proceeds similarly towards the curve 4, under influence of motor D^2. The cylinder carrying the surfaces 1, 2 rotates on its axis according to the variations of x in such manner that the abscisses x_0, x_1, x_2, etc. . . . of the curves 3 and 4 will be brought successively under the corresponding brushes 5 and 6 spacing of which is equal to that of curves, when x passes successively through these values. The motors D_1 and D_2 also control a differential gear shown diagrammatically at 16 working as an additive device and actuating a driven shaft 17 termed herein the integrating or adding shaft. It should be noted both differential gears 9 and 16 are shown on drawing diagrammatically as actuated by bevel gears. In practice these would preferably be changed to worm gears.

The integrating device provides for one or the other of the two brushes to remain on one of the curves except at each half revolution of distributor as explained hereinbelow: suppose the brush set is as shown on Fig. 3 in the middle of its path at the moment when the generatrix of the cylinder under each of the brushes corresponds to the value x_0 of x, said value being read for each of the curves 3 and 4 on the axis of x which is, as stated before, the periphery of a perpendicular section of cylinder. In the present case of coinciding ellipses, the origins of the abscisses for the two curves are 180° apart. When brush set is at aforementioned position let up suppose the distributor 10, 10', 10'' is caused to be in the position which allows current to flow, if brush 6 has a tendency to move towards surface 1, through said brush 6, the surface 1 and the conductor 14'' to the motor D^2. The latter, through its differential 9, rotates the threaded shaft 8 and displaces the slide 7 until the brush 6 reaches the curve at A, after having travelled the length $6A=f(x_0)$. The cylinder continuing to rotate, the brush 6 will, under the influence of the motor D_2, follow curve, for if it had a tendency to move out of this curve, either on to the surface 1 or on to the surface 2, the motor D_2 would be fed either through the conductor 14'' or through the conductor 15'' and bring it back on to the curve. At next half-revolution of distributor occurring as aforesaid at predetermined intervals, x will have reached a value x_1, and the slide will have travelled a further distance $f(x_1)-f(x_0)$. The distributor, having made a half turn, will feed the motor D_1 through the intermediary of the brush 5, the surface 2 on which the said brush is then bearing and the conductor 15'. The slide operated by the motor D_1 will move towards the right until the brush 5 has reached the curve 4, after having travelled a distance equal to $2f(x_1)$, and so on. Thus each brush alternately will move along a small portion of the curves whilst the surface moves so that the guided brush shall be in contact with generatrix corresponding to the actual value of x.

If x continuously increases or decreases the brushes will alternately be guided along curve after each half revolution. The rotations of the two motors being added algebraically on the shaft 17, the latter will have turned proportionately to

$$f(x_0)+[f(x_1)-f(x_0)]+2f(x_1)+[f(x_2)-f(x_1)]+2f(x_2) \ldots$$

The quantities such as $[f(x_1)-f(x_0)]$ annul one another. The rotation of shaft 17 is therefore proportional to $2f(x_1)+2f(x_2)$.

Fig. 5 shows a modification of device described hereinbefore wherein the two brushes 20, 21 move upon two parallel plane surfaces 22, 23. The conducting part of the surface 23 is bounded by the curve 24—26—25. In these conditions, the connections being the same as in Fig. 3, the set of brushes will have a reciprocating motion parallel to the axis of y between these two curves each time that x passes through the values $x_0, x_1 \ldots$ If at the same time the two plates are moved together parallel to the axis of x according to the law of variations of x, the totalizing shaft 17 will give the area of the closed curve.

As concerns the device shown in Fig. 3, it was specified above that the set of two brushes was rigid, the two brushes being situated in the plane of a given perpendicular

section, and having a constant angular spacing (e. g. 180°). Without any change in the cylinder or the remainder of the device, one may displace the two brushes parallel to the axis of the cylinder on either side of their initial position by any suitable quantity $\frac{a}{2}$ (Fig. 6).

Referring to previous explanations, it will be observed that the integrating shaft 17 will totalize:

$$(f(x_0)+a)+(f(x_1)+a)+(f(x_2)+a)\ \ldots$$

This value a may be itself variable, or for instance $a=f_1(z)$, and in this case the totalization will be:

$$(f(x_0)+f_1(z_0)+(f(x_1)+f_1(z_1)+(f(x_2)+f_1(z_2)\ \ldots$$

z may be made without inconvenience a linear function of x.

The controlling device is designed to operate to this effect, and it comprises for example a square shaft (Fig. 7) guiding the slide 7; a screw 2_a, centered upon the said square shaft and slidable thereon, is maintained by the journals 3_a upon the slide 7; said screw drives the brush 5 in either direction, through the medium of the suitably guided nut 4_a. The device is identical for the brush 6. I may also provide an angular displacement of the brushes. The reciprocating brush device shown in Fig. 5 may provide for a longitudinal and a transverse displacement of the brushes.

The course recorder, working of which is based upon integrating device such as that shown on Fig 3 is described hereinafter. It is proposed to register on the chart, as soon as it has been covered, each element of the course having a fixed and determined length (e. g. $\frac{n}{100}$ of a nautical mile) covered in the direction C which is supposed to be constant during the whole time required to cover said course element. The time taken to cover the said course element depends solely upon the speed of the vehicle (e. g. upon a vessel it is found by means of a log). The instant at which the vessel has completed these successive course elements will be automatically indicated by a log totalizing the distance covered, and actuating periodically for instance through an electromagnet controlling a catch device the current distributor 10, 10′ 10″ so as to make it revolve each time the vessel has covered a predetermined distance, the intervals between the succeeding revolutions becoming of course smaller when the speed of the vessel increases.

If it is supposed, Fig. 8, that this course element is set off at ab upon the chart, it is observed that its components are a north-south course element ab' and an east-west course element ab'' (Fig. 8) whose values in miles will be

$$\frac{n}{100}\cos C \text{ and } \frac{n}{100}\sin C.$$

These quantities depend solely upon the variable C.

At any time the total course followed will be the sum of the course elements followed. The north-south and east-west components of this course will be equal to the sum of the components of the course elements followed, that is to say

$$\frac{n}{100}\cos c \text{ and } \frac{n}{100}\sin c.$$

The first problem which arises is to record these sums by means of above-described integrating device.

Let it be supposed in the first place that the chart is a chart wherein the scale of miles is the same for all points of the chart.

The mechanical determination of the components of the elementary line ab, for example of the north-south component $a'b'$, is effected as follows (Fig. 9):

If upon a cylinder 30 one takes an oblique section which will be an ellipse whose small axis is 31—32, and if after having cut the said cylinder along the generatrix 31 one develops it upon a plane, it is known that the ellipse will produce the sinusoid 31′ 32′ 31″. If any point 33 is taken upon the ellipse, this point after the development will be located at 33′, and the ordinate 33′ 33″ will be proportional to the sine of an angle measured by the distance 31′ 33″, i. e. by the length of the arc 31—33‴ upon the cylinder, and is hence proportional to the sine of the angle C apex of which is at the center.

If one considers upon the perpendicular section of the cylinder the point 35‴ line joining which to the center of the section is perpendicular to the line joining said center to the point 33‴, this point 35 will correspond to a point 35 on the ellipse which, in the development, is located at 35′. The ordinate 35′ 35″ is proportional to the cosine of an angle which is equal to the length 36′ 35″, 36′ being the point corresponding to the vertex of the sinusoid, i. e. to the point 36 of the perpendicular section of the cylinder which is at right angles to the point 31, i. e. to the cosine of the angle C.

It will thus be observed that if a suitably inclined ellipse is drawn upon a cylinder 30, the lengths of the generatices comprised between the perpendicular section passing through the small axis and the ellipse will be respectively proportional to

$$\frac{n}{100}\sin C \text{ and } \frac{n}{100}\cos C$$

if they are supposed to be situated in dia-

metral planes making respectively the angle C with the diametral planes containing respectively the small axis and the large axis of the ellipse.

In an integrating device such as is shown in Fig. 3, the sliding contact takes place upon a cylinder the position of which corresponds to that of the head of the ship by means of a suitable transmission device controlled by the compass and whereof the two conducting parts are separated by the above-mentioned ellipse. The course recorder thus devised will thus afford the integration of the components of the elements of the course in the north-south or the east-west direction, or more generally, according to a suitable system of ordinates. This can be obtained by altering the spacing of the two ellipses forming the curves 3 and 4 as mentioned hereinabove together with the angular spacing of the brushes, both of which spacings must have same value (180° in the present instance where the two ellipses coincide).

In practice, instead of using two sets of brushes spaced 90° apart upon the same cylinder, it will be more convenient to use two like cylinders both of which are under the control of the compass and effecting (by means of suitably spaced brushes) the integration of the north-south components by means of one cylinder, and the integration of the east-west components by means of the other cylinder.

An apparatus of this type shown in Fig. 10 comprises a first integrating device A for the integration of the components of the north-south courses and a second integrator B for the integration of the east-west courses. Each of the said devices comprises a cylinder 40—40′ which is rotated by the receiver 41—41′ of a device under the control of the compass. Each of the two cylinders 40 and 40′ is formed—as stated for the integrating device Fig. 3—of two conducting surfaces separated by an oblique section 42—42′. The two oblique sections 42 and 42′ have their small axes spaced at 90° apart, whilst the two pairs of brushes are situated in parallel planes. In the two integrating devices A and B, the elements which are the same as used in the integrating device Fig. 3 are designated by the same letters as in Fig. 3, but with the addition of the letters a or b to numerals of parts belonging to device A or B. The integrating shaft 17^b of the integrating device B which gives the east-west components controls—through the medium of an adjustable reducing device 45^b—a shaft 46^b upon which a slide 47 such as is shown on Fig. 11 may be displaced.

In like manner, the integrating shaft 17^a of the device A controls—through the medium of an adjustable reducing device 45^a—a square shaft 46^a serving to guide the slide 47. The said slide 47, Fig. 11, supports in the known manner the frame 48 extending in the direction perpendicular to the shafts 46^a and 46^b; this device is herein characterized by the fact that the frame 48 is pivoted upon journals centered on the square shaft 46^a, allowing the frame 48 to be raised without interfering with the operation of the apparatus. Within the slide 47 is mounted upon the square shaft 46^a a bevel gear 49 engaging a like gear 50 secured to a screw 51 mounted on the frame 48 and upon which is movable the guided nut 52 carrying the tracing point 53.

The operation of the said course-recording device is as follows: when an element $\frac{n}{100}$ of the course, has been covered, a log or clockwork, as aforementioned, actuates through suitable connection the distributor which is caused to rotate 180°. At this moment, the control devices of the compass 41—41′ have rotated the cylinders 40—40′ in such manner that the parallel planes one containing the axis of cylinder 40 and the major axis of the ellipse 42 and the other the axis of cylinder 40′ and the minor axis of the ellipse 42′ shall form (respectively) with the planes in which are situated the brushes 5^a, 6^a, and 5^b, 6^b, an angle equal to actual value of C, which may be considered with an altogether negligible error as the mean value or vessel direction during covering of said course element. The commutators similar to the commutator 10, 10′, 10″ of Fig. 3 of the two integrating devices A and B, will start the necessary motors in these devices in order that the brushes shall be displaced in the proper direction until they meet with the ellipse after having moved over distances which are proportional to the components north—south$=a\,b'$ and east—west$=a\,b''$ of the course element $\frac{n}{100}$. The speed-reducing devices 45^a, 45^b are regulated according to the scale of the chart upon which they are to effect the recording, in such manner that the displacements of the tracer, on the one hand upon the north-south screw 51 and on the other hand upon the east-west screw 46^b shall be equal to the components of the element of the course to be recorded. By raising the frame 48, one may operate upon the recording table.

I may add to the said apparatus the counters 55^a and 55^b, Fig. 10, indicating at each instant the course covered in miles north-south and in miles east-west. In like manner, I may utilize the shafts 17^a, 17^b in order to actuate the transmitters 56^a, 56^b for controlled transmission whereof the receivers (disposed in another station) may control an apparatus for repeating the record of the course, said apparatus consisting solely of the parts such as are shown in Fig. 11.

A diagrammatic view of a course recording device is shown in Fig. 2, and it is adapted to register the course upon a chart whose scale is not the same in its different regions. This is the case for example in the marine charts of the Mercator type. In these charts, the length which represents one mile upon the chart depends upon the latitude. It is thus necessary that the components of the recorded elements should be multiplied by a certain factor corresponding to the latitude occupied. For this purpose, a first integrating device is provided with a counter which indicates at each instant the latitude occupied. In Fig. 12 the said latitude counter is shown at C. It is similar to device A of Fig. 10, and it totalizes upon the shaft 17^c the components of the elements of the north-south course; said shaft actuates the pinion of a differential 60 whereof the other pinion, serving to make an initial record of the latitude of departure on the apparatus is controlled by a hand crank 61. The planetary pinions of the said differential control—through gearing 62, 63—the two like cams 64^a and 64^b. At A′ and B′ are situated two integrators of the type shown in A and B on Fig. 10, and integrating shafts $17'^a$ and $17'^b$ of which actuate a recording slide device such as the one represented in Fig. 11. The brushes $5'^a$, $6'^a$ and $5'^b$, $6'^b$ of the two devices A′ and B′, instead of being mounted directly upon the slides $7'^a$ and $7'^b$, are guided in slots $7''^a$, $7''^b$ through holders on which rods 65^a, 65^b are slidably mounted. Said rods are also slidably mounted upon slides $7'^a$ and $7'^b$. On the ends of the said rods are disposed rollers which—guided in the slots 66^a, 66^b—are caused to bear upon the cams 64^a, 64^b; the radii of the said cams, such as 67^a, 67^b, are so calculated that the ratio between the distances from the roller 68 to the slide 7 and to the brushes 5, 6 shall be such for each latitude that the distance covered by the brushes—whose length is determined by the ellipse recorded upon the cylinders—will correspond to a distance covered by the slide 7 which is reduced in the ratio corresponding to the reduction of the length of the mile upon the chart for the latitude occupied. The counters $55'^a$ and $55'^b$ may indicate the latitude and longitude.

What I claim is:

1. A course recorder adding algebraically successive values of components y along a given direction of successive course elements of predetermined length making a variable angle with said direction comprising an electric circuit, a movable element, means whereby said element moves in proportion with the variations of x, means whereby said electric circuit is temporarily closed each time a course element of predetermined length has been covered, a motor fed by said electric circuit, means whereby the position of the movable element causes the rotation of motor to be proportional to the value of y at the time of the closing of the circuit and means for adding the successive rotations of the motor.

2. A course recorder adding algebraically successive values of components y along a given direction of successive course elements of predetermined length making a variable angle x with said direction comprising an electric circuit, a movable surface upon which is drawn the curve $y=\cos x$ electrically distinct from remainder of surface, a brush movable along an ordinate of said surface and inserted in circuit, means whereby the variations of x causes movable surface to move and ordinate corresponding to actual value of x to be brought under brush, means whereby electric circuit is closed each time a course element of predetermined length has been covered, a motor fed by electric circuit, means whereby motor actuates brush along ordinate, means whereby brush opens circuit on arriving upon curve after having travelled a distance proportional to corresponding value of y, means whereby successive rotations of motor are added together.

3. A course recorder adding algebraically successive values of components y along a given direction of successive course elements of predetermined length making a variable angle x with said direction comprising two electric circuits, a movable surface upon which is drawn the curve $y=\cos x$ electrically distinct from remainder of surface, a set of two brushes movable each along an ordinate of said surface, both travelling equal distances along said ordinates and inserted each in one of the circuits, means whereby the variation of x causes movable surface to move and ordinate corresponding to actual value of x to be brought under one of the brushes, means whereby one of electric circuits alternately is closed each time a course element of predetermined length has been covered, a motor fed by each electric circuit, means whereby each motor actuates corresponding brush along ordinate, means whereby each brush opens corresponding circuit on arriving upon curve after having travelled a distance proportional to corresponding value of y, an adding gear system meshing with shafts of both motors, an integrating shaft actuated by said system rotation of which is proportional to sum of successive values of y.

4. A course recorder adding algebraically successive values of components y along a given direction of successive course elements of predetermined length making a variable angle x with said direction comprising two electric circuits, a movable surface upon which is drawn the curve $y=\cos x$ electrically distinct from remainder of surface, a set of two brushes movable each along an ordinate of said surface, both travelling

equal distances along said ordinates and inserted each in one of the circuits, means whereby the variation of x causes movable surface to move and ordinate corresponding to actual value of x to be brought under one of the brushes, means whereby one of electric circuits alternately is closed each time a course element of predetermined length has been covered, a motor fed by each electric circuit, a nut upon which is mounted set of brushes, a screw-threaded shaft parallel to ordinates actuating said nut and actuated by either motor, rotation imparted by motors being of opposite direction, means whereby each brush opens corresponding circuit on arriving upon curve after having travelled a distance proportional to corresponding value of y, an adding gear system meshing with shafts of both motors, an integrating shaft actuated by said system rotation of which is proportional to sum of successive values of y.

5. A device for algebraically adding successive values of components y along a given direction of successive course elements of given length making a variable angle x with said direction, comprising two electric circuits, a rotatable cylinder, the surface of which is electrically conducting, an insulating ellipse drawn on said surface ordinates of which taken with reference to a given generatrix and to a straight section give corresponding values of respectively x and y, a set of two brushes movable along opposite generatrices of cylinder and inserted each in one of the circuits, means whereby cylinder is moved under control of the compass so that generatrix corresponding to actual value of x is brought under one of the brushes, a switch closing one of electric circuits alternately when a course element of predetermined length has been travelled, a motor fed by each electric circuit, a nut upon which is mounted set of brushes, a screw threaded shaft parallel to generatrices of cylinder actuating said nut and actuated by either motor, rotation imparted by motors being of opposite direction, means whereby each brush opens corresponding circuit on arriving upon insulating ellipse after having travelled a distance proportional to corresponding value of y, means whereby motors compel brushes to remain on ellipse during travel over each course element, an adding gear system meshing with shafts of both motors, an integrating shaft actuated by said system, rotation of which is proportional to sum of successive values of y.

6. A course recording apparatus for vehicles comprising two devices as claimed in claim 5 switch of two devices being common to these and ordinates of ellipses taken with reference to a plane section of cylinders corresponding respectively to the north-south and the east-west components of each course element, and means whereby said devices control the corresponding displacements of a recording point upon the chart.

7. A course recording apparatus for vehicles comprising two devices as claimed in claim 5, switch of two devices being common to these and ordinates of ellipses taken with reference to a plane section of cylinders corresponding respectively to the north-south and the east-west components of each course element, both integrating shafts being disposed parallelly, a slide forming a nut upon the integrating shaft of one of the devices and slidably mounted on integrating shaft of the other, a frame carried by slide, pivotable round journals centered on latter integrating shaft and perpendicular to shafts, a screw threaded arm borne by said frame, means whereby rotation of said latter shaft causes rotation of arm, a nut on said arm, a recording point on said nut.

8. A device for algebraically adding successive values of components y along a given direction of successive course elements of given length, making a variable angle x with said direction, comprising two electric circuits, a rotatable cylinder, the surface of which is electrically conducting, an insulating ellipse drawn on said surface ordinates of which taken with reference to a given generatrix and to a straight section give corresponding values of respectively x and y, a set of two brushes movable along opposite generatrices of cylinder and inserted each in one of the circuits, a holder holding both brushes, a slotted member along which holder is movable, means whereby cylinder is moved under control of the compass so that generatrix corresponding to actual value of x is brought under one of the brushes, switch closing one of electric circuits alternately when a course element of predetermined length has been travelled, a motor fed by each electric circuit, a rod slidably mounted on brush holder, a fixed slot in which end of rod is adapted to move, a nut in which said rod can slide, a screw threaded shaft parallel to generatrices of cylinder actuating said nut, and actuated by either motor, rotation imparted by motors being of opposite direction, means whereby each brush opens corresponding circuit on arriving upon insulating ellipse after having travelled a distance proportional to corresponding value of y, means whereby motors compel brushes to remain on ellipse during travel over each course element, an adding gear system meshing with shafts of both motors, an integrating shaft actuated by said system, rotation of which is proportional to sum of successive values of y.

9. A course recording apparatus for vehicles for use with a chart of the Mercator type comprising two devices as claimed in claim

8, switch of two devices being common to these and ordinates of ellipses taken with reference to a plane section of cylinders corresponding respectively to the north-south and the east-west components of each course element, both integrating shafts being disposed parallelly, a slide forming a nut upon the integrating shaft of one of the devices and slidably mounted on integrating shaft of the other, a frame carried by slide, pivotable round journals centered on latter integrating shaft and perpendicular to shafts, a screw-threaded arm borne by said frame, means whereby rotation of said latter shaft causes rotation of arm, a nut on said arm, a recording point on said nut, a third device according to claim 5 adding north-south components of course elements, cams actuated by integrating shaft of said device and controlling position of extremity of rods of the two other devices in their slot.

In witness whereof I have hereunto set my hand.

CHARLES FREDERIC JEAN MARIE BERTIN.