Dec. 27, 1932. H. H. GORRIE 1,892,183

INTEGRATING MECHANISM

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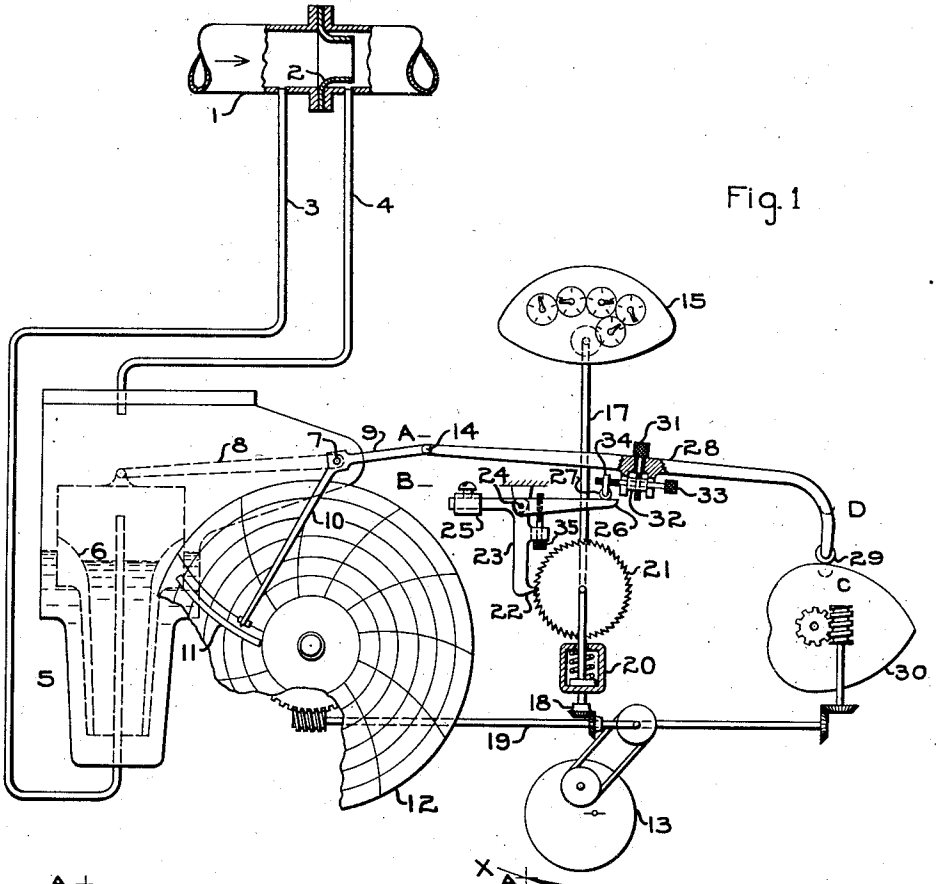


Fig. 1

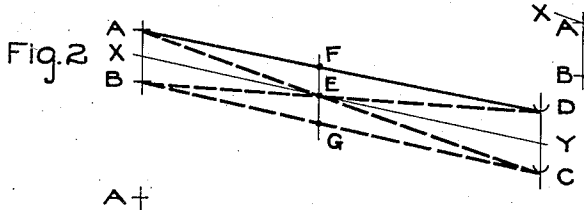


Fig. 2

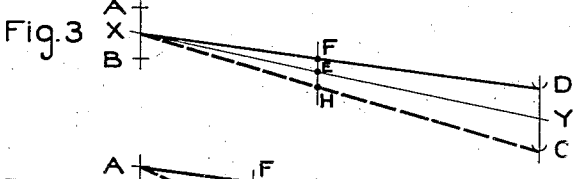


Fig. 3

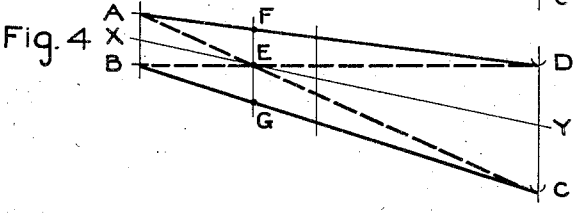


Fig. 4

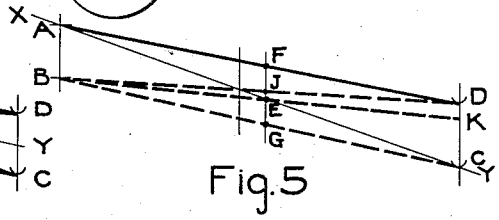


Fig. 5

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UNITED STATES PATENT OFFICE

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INTEGRATING MECHANISM

Application filed August 10, 1931. Serial No. 556,153.

This invention relates to improvements in mechanisms for the integration of variables, especially for integrating variables with respect to time, and where such variables may be of a physical, chemical, electrical, hydraulic or other nature.

It is known to provide a continuous integration through an integrator of the planimeter or friction contact type wherein, for example, a disc is rotated at a constant speed, while across a radius of the disc is moved a wheel or roller in frictional engagement therewith and adapted to drive a counter or register. The speed of operation of the register varying in accordance with the value of the variable, while the time of operation of the register is continuous. The positioning of the roller along the radius between the center and the periphery of the disc by the variable to be integrated with respect to time, the arrangement being such that if the value of the variable is zero, then the roller remains at the center of the constantly rotated disc, and the register receives no motion; while if the value of the variable is a maximum, then the roller is positioned to a maximum distance from the center of the disc and the register is driven at a corresponding speed.

It is further known to obtain a total over any period of time or integrate with respect to time a variable by periodically determining the value of the variable and causing a movement of a register in proportion to the value of the variable. The value of the variable may be determined at some point of time within the period or interval, and the magnitude of the increments of movement of the register may be of a time length percentage of the time period or interval proportional to the value of the variable. The time increment of movement of the register for a maximum value of the variable may or may not be the complete time length of the interval but is the same for all intervals of the particular construction. Likewise the value of the variable may be taken at the beginning of the interval or at some predetermined or other point of the interval.

The two classes of integrators mentioned differ basically in that the first has its register operated continuously but at a speed varying with the value of the variable, whereas the second has its register operated at a constant speed, but for lengths of time varying with the value of the variable. It is further known that an integrator of the second class may have provision for locking in position a member whose position indicates the value of the variable during the time of actuation of the register, and the integration is on the assumption that the value of the variable remains the same throughout the time period or interval during which the register is being actuated.

The present invention is in the nature of an improvement to known means of obtaining an integration of a variable with respect to time, which known means may be of the above or other general classes. The invention comprises in general an arrangement somewhat similar to the second class described, wherein predetermined time intervals are chosen and the driving means for the register is operated at a constant speed, but the value of the variable at a particular instant during the time interval is not the determining factor of the amount of actuation of the register during said time interval as in the second class described, nor is there a continuous actuation of the register at different speeds of the register as in the first example; but in my present invention I employ a modification of the two wherein the length of actuation of the register during each interval of time chosen is in accordance with the value of the variable at a particular instant during that interval of time, modified by the value of the variable throughout the time of actuation. This in general is accomplished through allowing the value of the variable to change during the time or through that part of the interval of time wherein is accomplished the actuation of the register.

One object of my invention is to provide an improved integrating mechanism of the type disclosed.

Another object is to provide a means for integrating a variable with respect to time

which allows the variable to change during the integration.

A further object is to provide an integrating mechanism which does not have the possibility of slipping and consequent inaccuracy inherent in the planimeter type of integrator, and at the same time comprises improvements over the class of integrator generally known as the periodic, variable time length, constant speed integrator.

In the drawing:

Fig. 1 is a somewhat diagrammatic representation of my invention in connection with a rate of flow meter for fluids.

Figs. 2, 3, 4 and 5 are diagrams representing positions and movements of parts of the integrating mechanism of Fig. 1.

A variable such as the rate of flow of a fluid through the conduit 1 is desirably integrated with respect to time to give a total quantity of the fluid passing a given point during a specified interval of time such as the interval between two readings of a register. I show positioned within the conduit 1, a flow nozzle 2, forming a restriction to flow through the conduit and for creating thereby a pressure differential across the flow nozzle bearing a known relation to the rate of fluid flow therethrough. From the conduit 1, at opposite sides of the flow nozzle 2, I lead the pressure pipes 3 and 4 to a rate of flow meter indicated in general at 5.

Such a rate of flow meter may be of the liquid sealed bell type as disclosed in the patent to Ledoux No. 1,064,748 granted June 17, 1913, wherein the bell is shaped and has walls of material thickness, to the end that the positioning of the bell is in direct proportion to the rate of fluid flow, thereby correcting for the quadratic relation which exists between rate of fluid flow through such a flow nozzle and differential pressure resulting therefrom. The bell is shown at 6 diagrammatically in dotted lines, and may be sealed by a liquid such as mercury whose approximate level within and without the bell is indicated.

Pressure within the conduit 1 ahead of the flow nozzle 2 is effective through the pipe 3 upon the interior of the bell 6, while pressure at the outlet of the flow nozzle 2 is effective through the pipe 4 upon the exterior of the bell 6, to the end that the bell is positioned vertically by the pressure differential across the flow nozzle and in linear relation to the rate of flow of the fluid.

Such vertical positioning of the bell results in an angular positioning, about a fixed fulcrum point 7, of an arm 8 for transmitting motion from the bell to the shaft of the fulcrum 7, for positioning an arm 9 whose function will be explained hereinafter, and for positioning an indicating pen or pointer 10 cooperating with an index 11. The pen 10 is further adapted to record over a circular chart 12 which is desirably driven uniformly at a constant speed by a motor 13 which may be a spring wound motor such as a clock, or an electric motor.

I have shown the flow meter 5 in a position indicating a rate of flow approximately 20% of maximum, wherein the free end 14 of the arm 9 is in the shown position intermediate the positions A and B respectively indicating the position of the point 14 at zero rate of flow and at maximum rate of flow.

I provide in connection with the flow meter 5, a register 15 having graduated dials and pointers moving in conjunction therewith, for affording a continuously available means of reading the accumulated total of the flow of the fluid through the conduit 1, which total flow for any desired interval may be obtained by subtracting the reading of the dials of the register 15 at the beginning of the interval from the reading of the dials at the end of the interval, the difference between such readings representing the total flow between the beginning and the end of the interval of time. The arrangement being such that the total is the integration of the rate of flow of fluid with respect to time.

For driving the register 15 which in itself contains the necessary gear reduction between dials, I provide a driven integrating shaft 17 driven through the bevel gears 18 by a constant speed normally operating driving shaft 19 which in turn is continuously driven by the motor 13.

Interposed in the shaft 17 is a friction means 20 wherein the shaft 17 is actually broken but the two parts held in frictional engagement by means of a spring, to the end that if that part of the shaft 17 connected to the register 15 is locked or held against rotation, the friction means will slip, allowing the motor 13 to continue to rotate the shaft 19 and that part of the shaft 17 connected thereto through the bevels 18.

To provide a means for locking or unlocking that part of the shaft 17 connected to the register 15, I provide a locking wheel 21 positioned on the shaft 17 between the friction means 20 and the register 15 and adapted to turn with the shaft 17 when unlocked through disengagement of a pawl 22. The pawl 22 forms an extension of a part 23 pivoted at a fixed fulcrum 24 and having an adjustable counterweight 25 so that normally the pawl 22 is in engagement with the teeth of the locking wheel 21 for holding the locking wheel against rotation.

The arrangement is such that to allow an actuation of the register 15, I unlock the locking wheel 21 by mechanically moving out of engagement therewith the pawl 22, and when the locking wheel is unlocked, the friction means 20 causes a driving of the register at a constant rate of speed by the motor 13. I desirably unlock the locking wheel periodi-

cally and for a time portion of each period, of a length determined not only by the value of the variable (rate of fluid flow) at the beginning of the period, but modified by any change in the value of the rate of flow during that portion of the period when the locking wheel is unlocked. That is, at the beginning of each period of time I cause an unlocking of the locking wheel and the portion of the period during which the locking wheel is unlocked for driving is determined by the rate of flow at the beginning of the period, but the portion is modified by any change in the rate of flow which occurs during the portion.

To unlock the locking wheel, by causing a disengagement therefrom of the pawl 22, I provide the part 23 with an extension 26 against which bears a roller 27 having an actuating point or point of engagement and carried by a freely floating member 28 capable of being positioned along a definite path in a single plane in space. The member 28 is pivotally connected at one end to the arm 9 of the flow meter at 14 so that that end of the member 28 is at the position A when there is zero flow through the conduit 1 and at a position B when there is maximum flow through the conduit 1, thus traversing a predetermined path in a single plane in space.

The opposite end of the member 28 carries a roller 29 which by gravity bears against and in contact with the surface of a cam 30 in a manner such that that end of the member 28 is continually reciprocated at a substantially uniform speed between the limits of travel C and D by rotation of the cam 30 as driven by the motor 13. The chart 12, for example, may be arranged to make one revolution in 24 hours, while the speed of the cam 30 might be in the nature of one revolution in 10 seconds, and the actuation of the register 15 at intermediate or other speeds as determined by the internal gear reduction of the register and the ratio of gears 18. It will be seen, then, that the member 28 is arranged for positioning along a definite path, within limits of travel, in a single plane and such that movement of the member is angularly about either end by the positioning of the opposite end between definite limits of travel, to the end that the actuating point 27 assumes a position between limits of travel independence upon the position of the point 14 and of the roller 29.

Thus at any given rate of flow corresponding to a definite position of the point 14, the actuating point 27 is reciprocated along a definite path in the plane of movement of the member 28 and by the reciprocation between the limits C and D of the roller 29. When the rate of flow is zero and the point 14 is at the location A, then the reciprocation of the roller 27 through reciprocation of the roller 29 will not cause engagement between the actuating point and the arm 26. However, when the point 14 is at B, then the roller 27 may bear against the arm 26 throughout the entire or major portion of the reciprocation between the points C and D of the roller 29.

It will be seen that when the actuating point engages the arm 26, the pawl 22 is disengaged from the locking wheel 21, and the friction means 20 allows the motor 13 to drive the register 15. Thus the length of time through which the locking wheel is unlocked and the register 15 is being driven, is determined by that portion of the time cycle of the cam 30 through which the actuating point engages the arm 26, and such portion is determined by the position of the point 14 along the path A—B.

As the cam 30 is rotated, the position of the point 14 determines what portion of such rotation is used for driving the register 15, but the drive is continually modified through the fact that the point 14 is free to change its position along the path A—B during actuation of the register 15. Thus the increment of movement of the register 15 for each revolution of the cam 30, i. e., for each time interval, is a function of the rate of flow throughout that interval.

A certain definite relationship desirably exists between the location of the actuating point of the roller 27, the point 14 and the point of contact of the roller 29 with the cam 30, as well as between the actuating point and the extension 26. Such relationship and its effect upon the actuation of the mechanism is diagrammatically shown in Figs. 2, 3, 4 and 5 to be described in detail hereinafter. To effect movement or positioning of the actuating point 27 relative to the member 28 I provide on the member 28 adjusting means for moving the actuating point relative to the ends of the member as well as at right angles to such movement.

Through the member 28 passes a thumbscrew 31 threaded through a block 32 which is guided in a manner such that rotation of the thumbscrew 31 causes a shifting of position of the block 32 toward or away from the member 28. Through the block 32, at right angles to the thumbscrew 31 and in parallelism with the member 28 is a second thumbscrew 33 threaded through a block 34 carrying the roller 27. A turning of the thumbscrew 33 causes a movement of the roller 27 and its actuating point toward one end of the member 28 and away from the other end of the member.

In Figs. 2, 3, 4 and 5 I show diagrammatically preferred relationships between the actuating point 27, the extension 26, and the travel of the two ends of the member 28. I illustrate in these four figures the limits of travel of the point 14, namely A and B, and the limits of travel of the contact point of

the roller 29 and the cam 30, namely C and D, as in Fig. 1. I have illustrated by single straight lines the effective length and position of the member 28, such lines joining the point 14, the actuating point 27 and the point of engagement of the roller 29 with the cam 30.

In Fig. 2 the solid line AFD represents the position of the member 28 when the rate of fluid flow is zero and the roller 29 at its uppermost point (in the drawing) of its reciprocation by the cam 30. With the rate of flow remaining zero, the reciprocation of the cam 30 moves the member 28 to the dotted line position AEC. If the rate of flow is a maximum or 100%, the point 14 moves to the position B, and the dotted lines BED and BGC represent the travel of the member 28 through reciprocation of the roller 29.

A line XY joins the midpoint of travel AB with the midpoint of travel CD, coinciding at the point E with the crossing of the diagonals AEC and BED.

I have designated on the member 28 the actuating point of the roller 27 as F in Figs. 2, 3 and 4 and in Fig. 2 the actuating point will move along a path FE when the rate of flow is zero and along a path EG when the rate of flow is 100. At E the actuating point F just engages the extension 26 so that when the rate of flow is zero the movement of the actuating point F between the limits F, E causes no movement of the extension 26 or correspondingly, no actuation of the register 15. As the rate of flow increases from A to B, the movement of the actuating point F along the path FG will be a part of the definite distance FG, substantially one-half of such distance, and such part will lie along the path FG relative to the point E in accordance with the rate of fluid flow.

For example, considering Fig. 3, I have shown the rate of fluid flow as 50% or one half way between the limits A, B, and in this position the solid line XD and the dotted line XC represent the total extreme positions of the member 28 through reciprocation of the roller 29. The travel of the actuating point F being the part substantially one half the distance FG (namely the distance FH of Fig. 3) and it will be seen that a portion of such part lies beyond or below the predetermined point E at which the actuating point engages the extension 26. Such portion of the travel of the actuating point F as is indicated at EH will then cause an unlocking of the pawl 22 from the locking wheel 21 for actuation of the register 15.

The predetermined point E relative to which the actuating point F becomes effective for an actuation of the register 15, moves along the line XY with the crossing of diagonals, between the limits of travel of the ends of the member 28 so as to coincide with such crossing point of the diagonals, so long as the actuating line of the extension 26 (XY) is parallel to the line of points of the member 28 when the member is at its mid-travel position, namely when the left-hand end is midway A—B and when the right-hand end is midway C—D. By line of points of the member 28 I mean a line connecting the point 14, the actuating point, and the point of contact of the roller 29 with the cam 30.

Should I move the actuating point F along the line XY, then I must readjust the travel of one end or the other of the member 28 or my conditions of travel do not balance. If, for example, in Fig. 2 I shifted the point F to the left, then the flow would have to increase to a substantial amount greater than zero before the actuating point F would engage the line of contact XY, namely the upper surface of the extension 26, and I would have the condition wherein from 0 to some substantial rate of flow no actuation of the register would occur. Furthermore, as the rate of flow approached a maximum, a condition would obtain beyond which to the maximum no change in maximum rate of actuation of the register would exist. Thus full actuation or range of actuation of the register would be accomplished in a rate of flow travel distance less than the distance A—B, and to satisfy correctly a condition of moving the actuating point F to the left in Fig. 2 along the line XY I must either decrease the distance A—B, namely the throw of the point 14, or increase the throw of the cam, namely increase the distance C—D. Conversely, should I change the dimensions A—B or C—D I find that the predetermined point E or crossing point of diagonals shifts one way or the other from that shown in Fig. 2, and that the actuating point F should be correspondingly shifted. It will be understood that while I have illustrated in Fig. 1 a cam 30 of definite contour, I might arrange the mechanism in a manner such that the throw of the cam would be doubled, and the travel C—D of one end of the member 28 varied from that shown. Furthermore, I could readily move the member 28 to the right, thus lengthening the arm 9, and for the same angular travel of the arm 8 of the flow meter 5, to increase the travel A—B, or by shortening the arm 9 I could decrease the travel A—B.

In Fig. 4 I show a condition wherein the throw of the cam 30 has been doubled to that illustrated in Figs. 1, 2 and 3 and the distance CD materially greater than the distance AB. I illustrate such conditions to show that the predetermined point E shifts toward the shorter of the two distances AB or CD. The total limits of travel of the actuating point F is between points F and G, and that part of the travel FE or EG, if the rate of flow is zero or a maximum respectively, is as in Figs. 1, 2 and 3, substantially one-half of the dis-

tance FG. Furthermore, the portion of the part which is effective in actuating the register 15 is that portion which falls below the predetermined point E in the path FG of the actuating point F, as in the case of the other figures.

I find that certain advantages may be obtained through varying the inclination of the actuating line XY relative to the line of points of the member 28. In Figs. 2, 3 and 4 I illustrate the line XY as parallel to the position of the line of points of the member 28 when the member is in mid-travel position. To change the position of the line XY relative to the line of points I provide on the part 23 a projection through which passes a threaded thumbscrew 35 into the extension 26. The extension 26 being pivoted at 24 and held to move with the part 23 around the fulcrum 24 by the joining of the thumbscrew 35. By means of the thumbscrew 35 I may vary the relative position of the extension 26 to the part 23 and correspondingly the inclination of the contact surface of the extension 26 which is represented in the diagram as the line XY.

In Fig. 5 I illustrate diagrammatically the shifting, through adjustment of the thumbscrew 35, of the line XY to a position parallel to the zero position of the line of points, namely with the left-hand end of the member at A (representative of zero flow) and with the right-hand end of the member at C. I assume that the travel A—B and C—D are as in Figs. 1 and 2, and that the distance C—D is representative of the travel of that end of the member 28 for one-half of the cycle of the cam 30. Also that with 100% flow, continuous rotation of the locking wheel 21 and continuous actuation of the register 15 would obtain. On such an assumption the register might read, for example, 100,000 pounds accumulated over a period of one hour, as indicating a flow of fluid through the conduit 1 of amounts equaling 100,000 pounds in a time interval of one hour.

In the diagram of Fig. 5 I shift the predetermined point E which represents the point of contact of the actuating point F with the contact surface XY to the right of the diagonal crossing point. With zero flow the member assumes the position represented between the lines AFD and AEC, wherein no actuation is accomplished of the register 15 because at full reciprocation along the line C—D the actuating point F just comes to the point E but does not depress it. As, however, the flow increases from A to B, the actuating point F engages the contact line XY to depress it and actuate the register 15 for amounts varying with the rate of flow. When maximum rate of flow is accomplished, then reciprocation of the beam is between the lines BJD and BGC. However, only that part of the travel of the actuating point F, namely EG, is effective to actuate the register 15, while that part of its travel EJ is not so effective, for during the travel EJ the actuating point F does not engage the line XY. If, then, the distance C—D and correspondingly the distance G—J represented 100,000 pounds per hour on the register 15, so the distance C—K and correspondingly G—E may represent some value such as 80,000 pounds per hour.

It will be apparent that the actuating point F may be shifted as in Fig. 5 to the right of its position illustrated in Fig. 2 when the line XY is parallel to the line AC, and such shifting may be continued until the distance C—K decreases to zero. Thus for a register gear ratio representing a certain maximum reading within a given time interval as represented by the distance C—D, I may vary such maximum and desirably attain maximum readings which are odd values or values not within the possibilities of change gears.

In general, through the adjustment provided, namely the thumbscrews 31, 33 and 35, I have a means of shifting the relation of the line XY to the line of points of the member 28 and further of shifting the position of the actuating point lengthwise of the beam or relative to the line of points, closer or further away, and through such various adjustments as well as the possibility of varying the throw A—B or the travel C—D I can take care of practically any desired conditions.

When I speak of one end of the member 28 being reciprocated between predetermined definite limits of travel C—D, I mean that the point of contact of the roller 29 with the cam 30 moves between the limits C—D.

When I speak of the other end of the member 28 being positioned or reciprocated between the limits of travel A—B, I mean on that end the pivot point 14 which in its extremes of travel lies on the line A or the line B.

By the reciprocation of the actuating point I mean that movement of the point of contact between the roller 27 and the arm 26.

It will be understood that in referring to reciprocation I do this broadly, and do not limit myself to reciprocation along an exactly straight line in both directions, but mean such reciprocation modified by angularity or similar effects as is well known in the type of linkage connections and arrangement disclosed herein. For example, while I state that the contact point of the roller 29 with the cam 30 is reciprocated between the limits C and D, the point of contact does not definitely follow a single straight line between these limits, for this depends upon the position of the pivot point 14 between its limits of travel at the time of reciprocation of the other end of the member 28. However, for the purpose of illustration the reciprocation between the limits C—D is substantially

along a single straight line. The positioning of the pivot point 14 between the limits A—B follows substantially a single path, but the movement of the actuating point may vary slightly from a straight line, dependent upon relative positions of the two ends of the member 28. To all intents and purposes the movements of the two ends of the member and of the actuating point are along single straight lines in the plane of movement of the member 28, for I can readily take care of correcting for angularity or other well known effects through proportioning of moment arms, design of the cam 30, etc.

While I have illustrated and described a certain preferred embodiment of my invention, it is to be distinctly understood that I am not to be limited thereby except as to the claims appended hereinafter in view of prior art. For example, it is not necessary that the variable which I desire to integrate be rate of fluid flow, nor must such variable necessarily be integrated with respect to time. Furthermore, the mechanical construction and features as illustrated and described may be departed from, as will be readily understood by those familiar with the art, while still maintaining the features of the invention, and still being capable of performing any integration of a variable with respect to an independent variable as represented by the expression:

$$\int_a^b f(x)\,dx$$

It will be apparent further that my invention accomplishes an actuation through a positioning of an actuating point such as the point of contact of the roller 27 with respect to the extension 26, and that such actuation need not necessarily move a clutch away from a clutch wheel but might accomplish the closing or opening of an electric circuit or otherwise initiate an action or movement representative of a desired relation, which in the present embodiment is between rate of fluid flow and time, and in general, of a variable relative to an independent variable.

What I claim as new, and desire to secure by Letters Patent of the United States, is:—

1. Mechanical apparatus for integrating a variable with respect to time comprising in combination, a member positioned responsive to the value of the variable, means actuated at a substantially uniform time rate, and mechanical means for periodically accumulating time increments of individual value dependent upon the first-named means.

2. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, and mechanical means for periodically operating the integrating shaft by the said driving shaft, said means positioned according to a linear function of a variable to be integrated.

3. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, and mechanical means for periodically connecting said shafts, said means positioned according to a linear function of a variable to be integrated.

4. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, friction means interconnecting said shafts, and means for periodically releasing said friction means.

5. In an integrator, a constant speed driving shaft, a driven integrating shaft, friction means connecting said shafts, and means responsive to the value of a variable to be integrated for periodically releasing said friction means.

6. In an integrator, a constant speed normally operating driving shaft, a register, a normally inoperative driven integrating shaft for operating the register, friction means connecting the shafts, locking means for the integrating shaft whereby when such shaft is locked the friction means slips, and means positioned by a variable to be integrated for periodically releasing the locking means.

7. In an integrator, a constant speed normally operating shaft, a normally inoperative driven integrating shaft, friction means interconnecting said shafts, and means for effecting an operation of the integrating shaft, said means responsive to an independent variable and to the value of a variable to be integrated with respect to the independent variable.

8. Apparatus comprising a member adapted to be freely positioned within limits in a plane for effecting an actuation, one end of the member reciprocated at a substantially uniform rate along a given path in the plane, the other end of the member positioned between limits in accordance with a function of a variable, the duration of the actuation proportional to an instantaneous value of the variable modified by change in such value during the actuation.

9. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, and mechanical means including a member for periodically operating the integrating shaft by the said driving shaft, said member positioned in linear relation to a variable to be integrated.

10. Apparatus comprising in combination, a constant speed normally operating driving shaft, a normally inoperative driven shaft, a device adapted to be operated by said driven shaft, friction means connecting the shafts, locking means for the normally inoperative driven shaft, and means for releasing said locking means whereupon the driving shaft operates the device at a constant speed, said

last-named means responsive to a member positioned by time and by a variable.

11. Apparatus comprising in combination, a constant speed normally operating driving shaft, a normally inoperative driven shaft, a device adapted to be operated by said driven shaft, friction means connecting the shafts, locking means for the normally inoperative driven shaft, and means for releasing said locking means whereupon the driving shaft operates the device at a constant speed, said last-named means responsive to a member positioned by a variable and by an independent variable.

12. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, a register adapted to be operated by said driven shaft, friction means connecting the shafts, locking means for the integrating shaft, and means for releasing said locking means whereupon the driving shaft operates the register at a constant speed, said last-named means responsive to a member positioned by an independent variable and by a variable, whereby the variable is integrated with respect to the independent variable.

13. In an integrator for fluid flow, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, a register adapted to be operated by the driven shaft, friction means connecting the shafts, locking means for the integrating shaft, a rate of flow meter of the fluid, said meter responsive to pressure differences bearing quadratic relation to rate of fluid flow, the meter comprising means for producing motion bearing a linear relation to rate of fluid flow, a member positioned by said last-named means, and means actuated by the member for releasing the locking means whereupon the driving shaft operates the register at a substantially constant speed for a given portion of a predetermined interval of time, the magnitude of the portion dependent upon the rate of fluid flow.

14. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, a register adapted to be operated by the driven shaft, friction means connecting the shafts, locking means for the integrating shaft, means for releasing the locking means whereupon the driving shaft operates the register at a substantially constant speed, said last-named means comprising a member adapted to be positioned along a definite path in one plane, one end of the member periodically reciprocated at a substantially uniform rate between limits of travel, the other end of the member positioned within limits of travel and proportional to the value of a variable to be integrated with respect to time, the member intermediate its ends having an actuating point for effecting the release of said locking means, said actuating point of the member reciprocated periodically a distance substantially one-half the definite distance between its limits of travel, said definite distance determined by the total travel of the two ends of the member and the location of the actuating point of the member relative to the ends of the member, that portion of the distance moved by the actuating point beyond a predetermined point in its path of movement being effective for releasing the said locking means, and means for varying the effective actuation of the register.

15. An integrating mechanism for a fluid flow meter comprising a member positioned in one plane by two components namely rate of fluid flow and time, a register, means for periodically actuating the register, means controlled by said member for varying the extent of said actuation, and automatic means operated in synchronism with the first-named means for periodically locking the register against movement.

16. An integrating fluid meter comprising in combination, a device for creating a pressure difference bearing a known relation to the rate of fluid flow, a liquid sealed bell positioned responsive to said pressure difference, indicating means of the bell position, a member positioned between limits in one plane by said indicating means, the member further positioned by a time responsive element, the resultant instantaneous position relative to space of an actuating point of the member being determined as a component of flow and time, registering means for accumulating movements representing quantities of fluid flowing in increments of time, and driving means of the register made effective by said member.

17. An integrating device comprising in combination, a register, a constantly rotating driving means, a shaft for transmitting motion from the driving means to the register, a friction means interposed in said shaft, a locking wheel carried by the shaft and between the friction means and the register, a pawl for locking the locking wheel against rotation, and a member adapted to release said pawl whereby the driving means may actuate the register through the shaft and friction means, said member comprising a beam capable of being positioned along a definite path in one plane, one end of the beam reciprocated at a substantially uniform rate along a given path in the plane, the other end of the beam positioned between limits in accordance with a function of a variable to be integrated with respect to time.

18. An integrating device comprising in combination, a register, a member adapted to be positioned between limits in a plane, a measuring apparatus of a variable for positioning one end of the member and in amounts proportional to the value of the variable to be

integrated with respect to time, and a constantly driven cam for periodically reciprocating the other end of the member at a substantially uniform rate between limits in the plane, the member intermediate its ends adapted to actuate the register.

19. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, a register adapted to be operated by said driven shaft, friction means connecting the shafts, locking means for the integrating shaft, and means for releasing said locking means whereupon the driving shaft operates the register at a constant speed, said last-named means comprising a member adapted to be positioned along a definite path in a plane, one end of the member periodically reciprocated at a substantially uniform rate between definite limits of travel, the other end of the member positioned proportional to the value of a variable between definite limits of travel, whereby the variable is integrated with respect to time.

20. An integrating device comprising in combination, a register, a constantly rotating driving means, a shaft for transmitting motion from the driving means to the register, a friction means interposed in said shaft, a locking wheel carried by the shaft and between the friction means and the register, a pawl for locking the locking wheel against rotation, and a member adapted to release said pawl whereby the driving means may actuate the register through the shaft and friction means.

21. An integrating mechanism having a member movable in proportion to one of the factors of a variable to be integrated, comprising an element contacting with said member and whose point of contact is positioned along a predetermined path in a given plane proportional to the value of the variable to be integrated, a register, means for actuating the register at periodic intervals, means whereby the duration of such actuations varies in correspondence with the position of the member, and means for automatically locking the register against movement at periodic intervals which bear a definite relation to the periodic intervals before mentioned.

22. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, a register adapted to be operated by the driven shaft, friction means connecting the shafts, locking means for the integrating shaft, and a member having an actuating point thereof for effecting an unlocking of the locking means whereupon the driving shaft operates the register at a substantially constant speed, means causing a reciprocation of said actuating point along a path between limits of travel and in amount approximately one-half the distance between the limits, a time responsive element and an element whose position is representative of the value of a variable to be integrated with respect to time for positioning said last-named means, the reciprocation of the actuating point representing a definite time interval, the actuating point effective in unlocking the locking means for a portion of the time interval, the magnitude of the portion and its location in the interval being a function of the variable.

23. Apparatus for effecting an actuation, comprising in combination, a constant speed normally operating driving shaft, a normally inoperative driven shaft, a device adapted to be operated by the driven shaft, friction means connecting the shafts, locking means for the driven shaft, and means for releasing the locking means whereupon the driving shaft operates the device at a substantially constant speed, said last-named means comprising a member having an actuating point for effecting the release of said locking means, said actuating point of the member adapted for movement over a distance substantially one-half the definite distance between its possible limits of travel, said definite distance determined by the total travel of the two ends of the member and the location of the actuating point of the member relative to the ends of the member, that portion of the distance moved by the actuating point beyond a predetermined point in its path of movement being effective for releasing the said locking means.

24. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, a register adapted to be operated by the driven shaft, friction means connecting the shafts, locking means for the integrating shaft, and means for releasing the locking means whereupon the driving shaft operates the register at a substantially constant speed, said last-named means comprising a member adapted to be positioned along a definite path in one plane, one end of the member positioned between limits of travel by an independent variable, the other end of the member positioned within limits of travel and proportional to the value of a variable to be integrated with respect to the independent variable, the member intermediate its ends having an actuating point for effecting the release of said locking means, said actuating point of the member positioned within a distance substantially one-half the definite distance between its possible limits of travel, said definite distance determined by the total travel of the two ends of the member and the location of the actuating point of the member relative to the ends of the member, that portion of the distance moved by the actuating point beyond a predetermined point in its path of movement be-

ing effective for releasing the said locking means.

25. In an integrator, a constant speed normally operating driving shaft, a normally inoperative driven integrating shaft, a register adapted to be operated by the driven shaft, friction means connecting the shafts, locking means for the integrating shaft, and means for releasing the locking means whereupon the driving shaft operates the register at a substantially constant speed, said last-named means comprising a member adapted to be positioned along a definite path in one plane, one end of the member periodically reciprocated at a substantially uniform rate between limits of travel, the other end of the member positioned within limits of travel and proportional to the value of a variable to be integrated with respect to time, the member intermediate its ends having an actuating point for effecting the release of said locking means, said actuating point of the member reciprocated periodically a distance substantially one-half the definite distance between its limits of travel, said definite distance determined by the total travel of the two ends of the member and the location of the actuating point of the member relative to the ends of the member, that portion of the distance moved by the actuating point beyond a predetermined point in its path of movement being effective for releasing the said locking means.

26. An integrator of the character described in claim 25, in which the predetermined point lies on a line connecting the midpoints of travel of the two ends of the member.

27. An integrator of the character described in claim 25, in which the predetermined point is the intersection of diagonals joining the limits of travel of the two ends of the member.

28. An integrator of the character described in claim 25, in which the predetermined point lies on a line connecting the midpoints of travel of the two ends of the member, the said actuating point spaced midway between the ends of the member when the total travel of one end equals that of the other.

29. An integrator of the character described in claim 25, in which the predetermined point lies on a line connecting the midpoints of travel of the two ends of the member, the said actuating point spaced nearer the end of the member whose travel is the lesser when the total travel of one end is less than that of the other.

30. An integrator of the character described in claim 25, in which the predetermined point is the intersection of diagonals joining the limits of travel of the two ends of the member, the location of the actuating point coinciding with the said predetermined point when the member is in diagonal position between limits of travel of the two ends of the member.

31. An integrator of the character described in claim 25, in which the predetermined point lies on a line connecting the midpoints of travel of the two ends of the member, said actuating point lying on the same line when the member is in diagonal position between limits of travel of the two ends of the member.

32. An integrator of the character described in claim 25, including means for varying the definite distance between the limits of travel of the actuating point.

33. An integrator of the character described in claim 25, including means for varying the effectiveness of the actuating point in releasing the locking means.

34. An integrating device comprising in combination, a register, a member adapted to be positioned between limits in a plane, a measuring apparatus of a variable for positioning the member and in amounts proportional to the instantaneous value of the variable to be integrated with respect to time, and a constantly driven time cam also effective in positioning the member, the member adapted to effect actuation of the register.

35. An integrating mechanism for a fluid flow meter comprising a member positioned in one plane by two components namely rate of fluid flow and time, a register, means for periodically actuating the register, and means controlled by said member for varying the extent of said actuation.

36. Apparatus comprising in combination, a constant speed normally operating driving shaft, a normally inoperative driven shaft, a deivce adapted to be operated by said driven shaft, and means for operatively connecting said shafts, said means responsive to a member positioned by a variable and by an independent variable.

37. Apparatus comprising a member positioned in accordance with the value of a variable and responsive to an independent variable for periodically effecting an actuation whose duration is proportional to an instantaneous value of the variable modified by change in such value during the actuation.

In witness whereof, I have hereunto set my hand this 25th day of July, 1931.

HARVARD H. GORRIE.