PATENT SPECIFICATION

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352,065

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COMPLETE SPECIFICATION.

Improvements in and relating to Semi-automatic Method and Apparatus for Tracing Diagrams from Indications Read on a Measuring Apparatus.

We, LE MATERIEL ELECTRIQUE S.W., of 32, Cours Albert 1er, Paris, France, a body corporate organised under the laws of France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Apparatus has already been proposed for the transcription of visual indications of measuring apparatus and comprising a recording device of known type having a band of paper carried by a drum or other suitable support. In such apparatus the recording device is strictly associated with the apparatus by means of which the measurements it is desired to record are made, the said measuring apparatus comprising for this intimate association a movable pointer rigidly connected to the marking member of the recording device.

Such a device can only be employed under strictly determined conditions in which it is proposed to make a plain transcription to the scale of the variations, that is to say without any possibility of effecting a transformation of any kind in size or in nature.

The present invention relates to a method and an apparatus for permitting indications read upon a measuring apparatus of any kind, to be transformed instantaneously either in size or in nature with a view to obtaining graphical representations which may be other than the plain transcription of the variations indicated by the measuring apparatus. In other words, the invention permits the variations furnished by a measuring apparatus to be amplified, reduced or transformed automatically according to a given law even when these variations follow each other in rapid succession; these transformations according to the invention are effected automatically, as if by means of a calculating machine, without any intervention or any additional work on the part of the operator and without the personal factor of the latter entering into consideration.

The indications read on a measuring apparatus at intervals which are sometimes very small are transformed in the sense indicated above into a graph on rectangular coordinates in which the abscissæ (x) are graduated in time (t) and in which the ordinates (y) characterise the phenomenon the variations of which it is proposed to record.

The values of (y) are, according to the case, either proportional to the values h, read on the measuring apparatus or proportional to any function $\phi(h)$. Similarly the abscissæ (x), although graduated in time are not necessarily proportional to them, but may also be proportional to a function $f(t)$ of time.

In general, the recording point by point at very close intervals of time on a suitably graduated graph is an extremely difficult operation and in the absence of a completely automatic apparatus, which is generally complicated and costly, one has to be satisfied with marking each point, an operation which requires two readings to be made simultaneously, and immediately followed by two recording operations each time.

It is necessary in fact:

1. to read the indication on the measuring apparatus.

2. to read the hour or mark the moment at which the indication is produced on a chronometer or other time measuring apparatus.

3. to mark on the graph the abscissa corresponding to the instant required.

4. to follow the ordinate corresponding to this abscissa on the graph as far as the horizontal representing the value of the indication read on the measuring apparatus and then mark it.

Without sustained attention, which is most laborious, and on account of the necessity sometimes of recording rapidly succeeding indications, such a manner of working allows numerous errors to occur. Moreover, this method makes it practically impossible to transform indications

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read on the measuring apparatus, whereas such transformations may sometimes be of use.

The object of the present invention is to simplify considerably this known method while permitting a curve traced point by point at very close intervals, that is to say a practically continuous curve to be obtained with great facility and without any fatigue on the one hand and on the other hand interesting transformations of the indications read on the measuring apparatus to be effected if required without additional work or attention.

The method forming the subject of the present invention is semi-automatic in the sense that:

a) the apparatus can be set for time instantly or that at least the origin of the "times" characterising the commencement of each recording period can be marked thereon, the times being then recorded automatically, so that there is no longer any necessity to occupy oneself with the factor "time".

b) the operator, who may be inexperienced, has only a small amount of work to do, which simply consists in maintaining the inscribing member of the device in agreement with the indications read on the measuring apparatus after having started the apparatus working at the desired hour.

c) when it is necessary to transform in size and nature the indications read, these transformations are effected automatically, by suitably graduating on the one hand the recording band and on the other hand a rod which the apparatus comprises, according to the desired law of transformation.

Such a device essentially comprises in a general manner, as shown diagrammatically in Figure 1 in the accompanying drawing:—

1. A recording band driven along the axis of the abscissæ by means of an electrical, mechanical or other clockwork mechanism, either proportionally to time (t) that is to say at a constant speed, or proportionally to a function of time $x=f(t)$, which is a continuous or discontinuous periodic function. The speed of the band then varies according to a law derived from the law $x=f(t)$, this variation in speed obtained by known suitable electrical, mechanical or other means.

In any case the abscissæ are graduated in "time" in order to permit the device to be set at the hour. In the case when the speed is constant equal intervals of time Δt are represented on the graph by equal intervals along the abscissæ, while in the case when the speed is variable the constant intervals of time Δt are, as is the case in the diagram shown in Figure 1, represented by different intervals along the abscissæ, varying according to the law $x=f(t)$.

The ordinates y of the recording band represent either the values of h read on the measuring apparatus or the values of a function $y=\phi(h)$, as is the case shown in the diagram in Figure 1.

2. A graduated rule, provided if desired with a device for displacing the origin and arranged parallel to the ordinates of the recording band. This rule is always graduated in values of h read on the measuring apparatus, but either proportional to h or proportional to a function $\phi(h)$ which then expresses the transformation effected by the recording device starting from the indications read on the measuring apparatus.

Under these conditions various combinations are possible according as the functions $x=f(t)$ and $y=\phi(h)$ are or are not proportional respectively to t and to h.

A particularly interesting case is that in which this proportionality to t and to h exists. The driving movement of the recording band is then effected at constant speed and the graduation of the rule is identical with that of the ordinates of the recording band but for the origin.

By way of example a particularly interesting application of the method forming the subject of the present invention relates to the case of acoustic submarine soundings when the measurements of depth are translated by visual indications appearing uniformly and following each other in fairly rapid succession on an indicating apparatus.

The new method permits practically continuous sounding lines to be traced in a very simple manner with a minimum of attention by the operator.

The advantages and features of such a device are made evident in the following description, which relates to an example of a form of construction shown in Figures 2, 3, 4, and 5.

Figure 2 represents a longitudinal section through the apparatus.

Figure 3 is a corresponding plan view.

Figures 4 and 5 are details of practical forms of construction.

The device essentially comprises:

1. A mechanism for driving a paper recording band 1. This mechanism is assumed to be driven electrically but it may also be actuated by a clockwork movement or by any other equivalent device. 2 is a driving roller, 3 is a roller driven by the preceding roller.

These rollers are both covered in the known manner with a layer of rubber or any other material giving a good adherence. The recording band 1 passes between these two rollers and is driven by them.

The numeral 4 indicates guide rollers for the band. 5 is an unwinding roller which may, as indicated in Figure 5, in the accompanying drawing, be provided with guide plates 6 and upon which the recording band is stored. The roller 5 is braked by two constant action brakes formed for example by flexible blades 7 which press on the bosses 8 (Figure 5) of the roller 5 and give a determined tension, which is always the same, to the recording band at all times. The driving mechanism proper comprises an electric motor 9, suitable speed reducing gears 10 and a clutch device 11, controlled for example by a lever 11^1. The wheel of the last train of reducing gears drives the roller 2. The motor is supplied through a current terminal 32.

By way of modification the recording band may be perforated on the edges in order to permit it to be driven by toothed rollers instead and in place of the friction rollers.

2. A rule 12, graduated in depths, arranged at right angles to the direction of displacement of the band and carrying a movable curser 13, which in its turn is provided with a reference mark 14, and a device 18 for perforating the band which is described hereinafter and shown in detail in Figure 4 in the accompanying drawing.

In this rule slides a small rod 15 adapted to displace the origin of the graduation in depth according to whether it is desired to record depths counted from the surface or from the level of the sounding apparatus placed in the hull of the vessel.

3. A horizontal tablet 16 rigid with the frame of the apparatus and comprising a groove 17 parallel to the rule and situated along the ordinate along which the perforating device 18, carried by the cursor 13 is displaced. This groove permits the perforating point 19 (Figure 4) to pierce the band suitably. The tablet 16 further comprises two guiding members 20 the position of which may be regulated in such a way as to be placed in agreement with the guiding end plates 6 of the braked roller 5.

The perforating device 18, shown in detail in Figure 4 in the accompanying drawing comprises the following elements:

A rigid support 33 integral with the curson 13 carrying a member 34 having a cylindrical cavity and a vertical axis. The latter is screw threaded at its two ends. At the upper end of this member is screwed a cap 35 perforated at its centre, while at its lower part is screwed a member 36 comprising a central canal in which can move the perforating point 19 which in the example considered is a simple pin. This pin is guided in the channel in the member 36 and in a small piston 37 which slides in the interior of the member 34. The head of the pin bears upon the hollow piston 37 which rests on a return spring 38 which in its turn bears against the bottom of the member 36.

The perforating device further comprises at its upper part a push button 39 in which is screwed the rod 40 of a solid piston 41 the body of which has the same diameter as the hollow piston 37 and can consequently move with the latter within the member 34. On its part the rod 40 of the solid piston 41 can slide through the cap 35. Finally the piston 41 comprises at its lower part a small hemispherical cavity 42 which follow the form of the head of the pin and imprisons this head between the two pistons.

The perforating device described above permits the band to be perforated perfectly vertically by simply pressing on the push button 39 which drives the two pistons 37 and 41 together with the pin 19 downwards, compressing the spring 38, thus lowering the point 19 by an amount equal to the stroke d of the push button 39 which is limited by the abutment of the latter against the cap 35. Consequently the stroke d of the pin 19 is limited and less than the distance D so that with a suitable adjustment of the length of the pin the latter perforates the band without abutting upon the bottom of the groove 17. Thus the point 19 does not risk becoming dull.

As soon as the push button 39 is released, the spring 38 immediately returns the whole movable equipment upwards. In this return movement the band cannot lift because the lower member 36 comes almost flush with the surface of the band. The point 19 is thus disengaged cleanly after each perforation, so that no tearing of the band can occur in the movement of the latter between two successive perforations.

The method of mounting described above further permits the pin 19 to be changed very rapidly: it is sufficient in fact to unscrew the cap 35 which moves with it, the push button 39 and the piston 41 in order to be able to withdraw the pin and replace it immediately by another. The cap 35 is then screwed on

again and the perforating system is again ready to operate.

In a general manner the point by point recording semi-automatic device, a constructional example of which is illustrated in Figures 2, 3, 4 and 5 in the accompanying drawing, presents the following advantages.

a). The possibility of adjusting instantaneously the origin of the times by a slight displacement of the recording band forward or backwards, by means of the releasing means 11 which liberate the driving roller 2 and by means of two milled heads 21 and 22 rigid respectively with the driving roller 2 and the braked roller 5. The operation consists in bringing at the commencement of the recording period the ordinate of the recording band corresponding to the moment considered opposite the reference mark 23 which defines the axis of the groove 17, that is to say the fixed perforation ordinate. It is sufficient to close immediately afterwards the starting switch 24 for the band to move automatically at the desired speed.

b). The possibility of regulating the speed of the band either electrically as in the form of construction envisaged, by means of adjustable resistances controlled by milled heads 25 or mechanically, or by any other known means. By extension, the device provides the possibility of obtaining sounding lines which are not distorted by the variations in speed of the ship, and consequently true profiles across the length of the bed by abstracting the speed correction which can be imputed to marine currents. In such diagrams a given unwinding of the band always corresponds to the same distance travelled by the ship, whatever be the fluctuations of speed of the latter. This result may be obtained by suitably associating the member regulating the speed of the band with the apparatus measuring the speed of the ship so as to make the speed of the band vary in a direct ratio with that of the ship.

Thus considering always relative speeds, it is possible for a basic speed of 20 knots, to regulate the speed of the band initially, in such a way that it advances 10 mms. per minute, thus defining the scale of distances travelled for the diagram, that is to say $\frac{1}{3}$ of a nautical mile for an advance of 10 mms.

When the speed of the ship varies more or less with respect to the basic speed of 20 knots, the speed of the band varies in direct ratio with that of the ship, as indicated above, so that the 10 mms. displacement of the band always represents $\frac{1}{3}$ of a mile whatever be the speed of the ship.

c). The possibility of taking into account the correction for the water draught as indicated above, by displacing the rod 15 with respect to the rod 12 by an amount equal to the draught, the effect of which is to change the origin of depths.

d). The possibility of rapidly replacing the empty braked roller 5 by an identical roller carrying the new band by means of the device shown in Figures 2, 3 and 5 in the accompanying drawing. This device comprises

a wall 26 (Figures 2 and 3) which can be lowered about a hinge 27;

an oblique groove 28 formed in one of the side walls of the frame and serving as a guide for one end of the shaft of the roller during its removal or insertion;

a conical adjustable stop 29 (Figure 5) in which engages the other end of the shaft of the roller 5;

an abutment spring 30 with regulating screw 31 fixed upon the side wall of the frame by the side of the inclined groove 28 and pressing the shaft of the roller against the conical stop 29 in its correct position.

Finally the brakes 7, which are fixed on the hinged wall 26, hold the shaft of the roller 5 in position in normal use and on the contrary release the said roller when the wall is lowered for changing the roller.

e). The possibility, on account of the slowness of movement of the band, of inscribing thereon, during the operation of the apparatus itself, all useful indications regarding the position and the speed of the ship and all the points of note set down and all observations which may subsequently be of interest in navigation or fishing.

f). The possibility of avoiding the use of recording bands previously graduated in time, for which the setting to the hour sometimes necessitates unwinding suitable lengths of bands causing a waste of paper and a loss of time at the moment when it is desired to employ the apparatus.

It is preferable to employ for example simple commercial paper divided into millimetres, which generally comprises the most pronounced lines every 50 millimetres, so that by choosing as scale of time 10 mms. per minute, the minutes in multiples of five and the hours may be characterised by these pronounced lines without primary graduation.

It is thus possible to effect the time setting instantly and employ the apparatus immediately when it is necessary. In order to fix a reference mark for the time,

it is sufficient simply to note on the band the time corresponding to the nearest pronounced line to the moment of starting, which line is represented by the ordinate brought opposite the reference mark defining the line of perforation. The whole graduation in "time" is immediately deduced from this indication of origin.

g). The possibility of having always in front of the eyes during the sounding operation itself a great length of recorded band, which is perfectly readable and corresponds to a considerable duration of travel of the ship which may be of use from the point of view of navigation and fishing.

h). The possibility, even though the apparatus is not completely automatic, of having a control of the accuracy of the curve traced on account of the use of marking by perforation which in addition permits the direct photographic reproduction of the sounding lines, the perforations appearing clearly on the photographic proof.

The simple and compact apparatus described above may be employed advantageously in all cases when an entirely automatic apparatus will be considered too costly or too delicate. Thus, in the case of submarine soundings the apparatus is particularly convenient for trawlers for which economy is strictly necessary and on which an experienced staff is not employed, and the high purchase price and the special conditions of maintenance of completely automatic apparatus are obstacles which make it impossible to record the soundings.

The semi-automatic device described above may be employed by the captain of the trawler without it being necessary for the latter to have assistance. He can himself record the elements of sounding lines which appear to him to be of interest and note all the additional indications which he considers necessary. He can thus easily provide himself with documentary information the subsequent use of which may be of great service to him in the rational pursuit of fishing operations.

The constructional example described relates more particularly to sounding operations, but it may find its application in any other directions on condition that in each case the recording band and the rod are suitably graduated as indicated above.

The case may be envisaged when it is necessary to record at close intervals the varying deliveries of a fluid and in particular water, passing through a duct. A known method of measuring deliveries consists in employing the Venturi device composed of a duct element interposed between two points A and B of the duct, through which flows the fluid, the variations in delivery in which it is desired to measure, this duct element comprising a throttling and a manometric tube, as shown in Figure 6 in the accompanying drawing.

Now the Venturi device does not measure the deliveries directly but simply gives the differences in pressure h existing at any moment between two points of different section of the interposed tube element. As in addition the speed of the fluid and consequently the delivery are not proportional to this difference in pressure it is necessary to transform the indications h read on the manometric tube each time.

In Figure 6, S and S^1 represent respectively any section of the interposed tube element and the section of the throttling. The speeds of the fluid in these two sections are respectively V and V^1 and both correspond to the same delivery $V.S. = V^1.S^1$. The difference in pressure h measured by the manometric tube as a height of mercury is expressed by

$$h = \frac{V^{12} - V^2}{2g} \times \frac{1}{\delta},$$

g being the acceleration of gravity and δ the density of the mercury.

It follows from the constant delivery into both sections, that

$$h = \frac{V^2 \left[\left(\frac{S}{S^1} \right)^2 - 1 \right]}{2g.\delta}$$

In other words h is proportional to V^2 as $h = KV^2$ or, differently expressed, assuming $K^1 = \frac{1}{\sqrt{K}}$ $V = K^1\sqrt{h}$.

This relationship defines the mode of graduation of the rod and of the recording band, so that the diagram obtained represents directly the variations in speed of V in the section S, which speed characterises the delivery per unit of section or, better still, the variations in the product V.S., that is to say in the total delivery.

Figures 7 and 8 in the accompanying drawing illustrate the mode of graduation envisaged. The graduation of the rod in values of h is not linear. It follows in fact a parabolic law of proportionality to $\sqrt{h}$ and is obtained graphically by the curve traced in Figure 7 which expresses the law $V = K^1\sqrt{h}$. The graduations of the recording band are on the other hand both linear, the abscissæ x representing the times t and the ordinate y representing the deliveries $K^1\sqrt{h}.S.$, as shown in Figure 8.

The constructional example described thus permits variations in delivery to be obtained directly on the diagram, as a function of time, although the Venturi device only furnishes differences in pressure which are not proportional to the deliveries to be recorded. The new device automatically effects the required transformation without any additional work on the part of the operator, whose function is limited to preserving the position of the cursor on the rod, so that it will always be in agreement with the indications h read on the manometric tube.

Figures 7 and 8 correspond to the following numerical example:

$S=120$ cm^2 $S^1=60$ cm^2
$g=981$ $\delta=13.6$

From which $K^1=94.5$.

The parabolic graduation of the rod is obtained by the curve traced in Figure 7, which expresses the relationship: $V=94.5\sqrt{h}$.

The linear graduation of the ordinates of the recording band is obtained as indicated in Figure 8 by determining a point of graduation corresponding for example to the reading $h=10$ cm.

From this we find that $V=94.5\sqrt{10}=298$ cm. per second and the delivery $y=298\times120=35,760$ ccms, per second.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Means permitting the semi-automatic and indirect transformation of the visual indications of a measuring apparatus on a graph in rectangular coordinates, set out point by point from readings made at intervals of time which are sometimes very close, these means being characterised by the combination of a recording band the automatic displacement at which at constant or variable speed on a rigid support permits the first coordinate "time" to be recorded automatically with a graduated rod arranged at right angles to the movement of the band, and on which a cursor carrying a tracing or perforating member which is not rigidly connected to the indicating member, can be moved by hand, so as to keep it in agreement with the indications read on the measuring apparatus, the graduation on the rod being, according to the case, either proportional to the indications read or proportional to a function of these indications.

2. Means according to claim 1, characterised by the use of a tracing or perforating device (18) comprising a support (33) rigid with a cursor (13) sliding on a graduated rod (12), the said support carrying a guiding socket (34) for the tracing member proper (19), which is carried by a piston made of two parts (37, 41), moving in the socket (34) and subjected to the action of a spring (38) which tends to keep the member (19) in its withdrawn position while a push button (39) permits the piston and the member carried by the latter to be lowered.

3. Means as claimed in claim 1 or 2, characterised by a rigid support over which passes the recording band (1) and which, in the case when use is made of a perforating member, comprises a groove (17) transverse to the direction of displacement of the band and disposed along the line of piercing of the perforating member (19) this support being if desired a table (16) of certain size permitting a considerable length of band to appear continually before the eyes and indications of all kinds to be inscribed during the operation of the apparatus.

4. Means according to claim 1, 2 or 3, characterised by a device permitting a rapid replacement by a full roller of a band carrying roller (5) after it has been unwound the said device comprising on the one hand a wall (26) adapted to be lowered, carrying brakes (7) having a constant action, which press upon the bosses (8) of the roller (5) in normal use, and on the other hand an inclined groove (28) permitting one end of the shaft of the roller (5) to be inserted and removed, the correct position of which roller in its longitudinal direction is ensured by the pressure of an adjustable abutment spring (30) which presses the other end of the shaft of the roller (5) against a conical stop (29).

Dated this 31st day of March, 1930.

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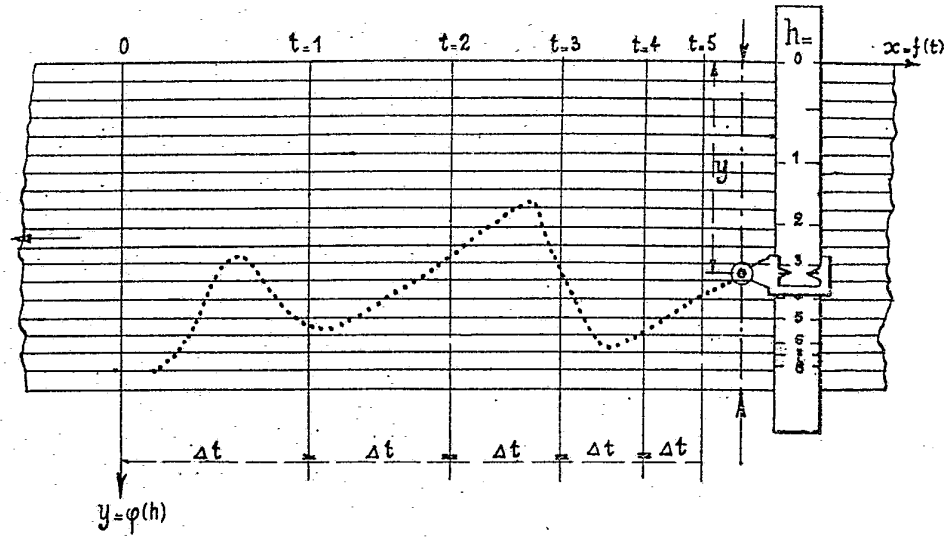
Fig. 1.



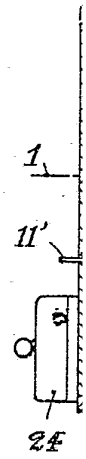
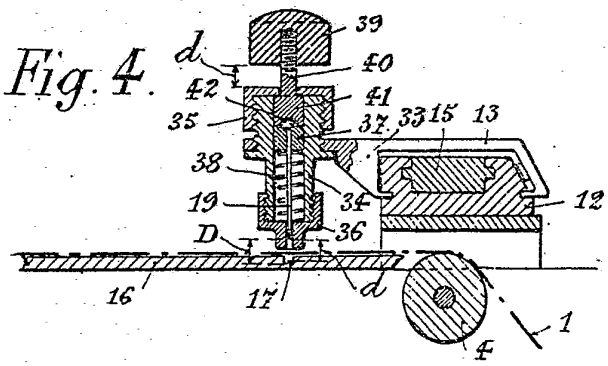


Fig. 4.



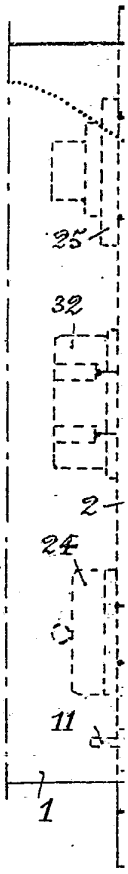


Fig. 5

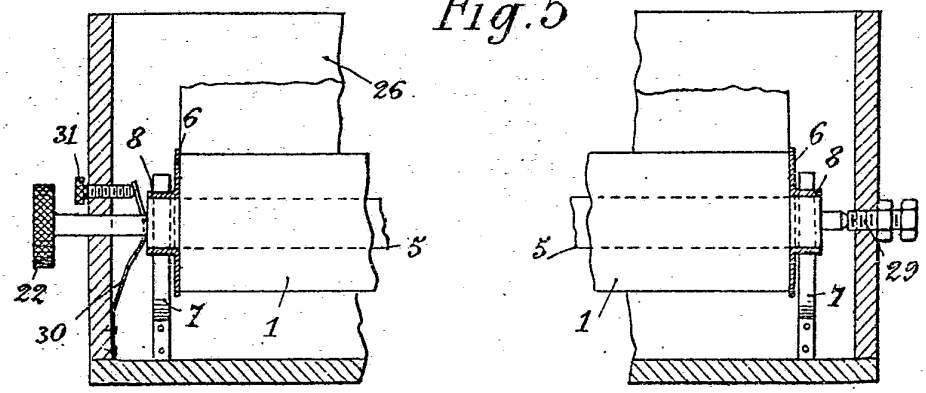


Fig. 2.

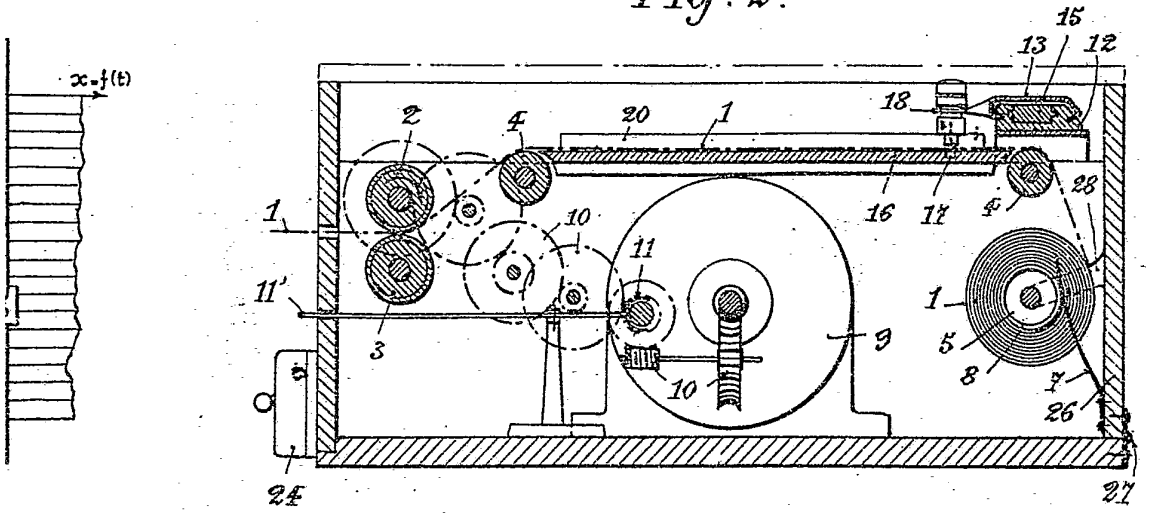
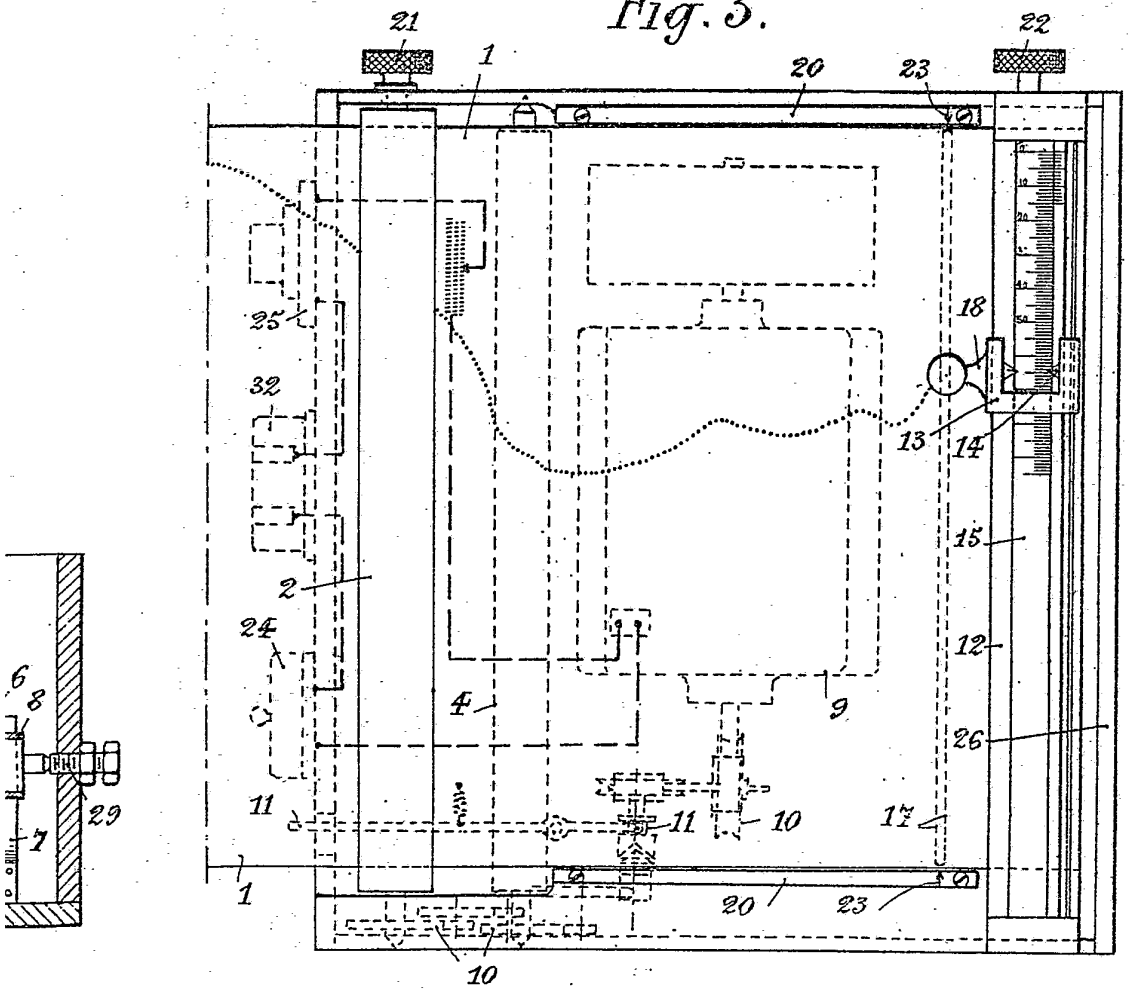


Fig. 3.



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[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1.

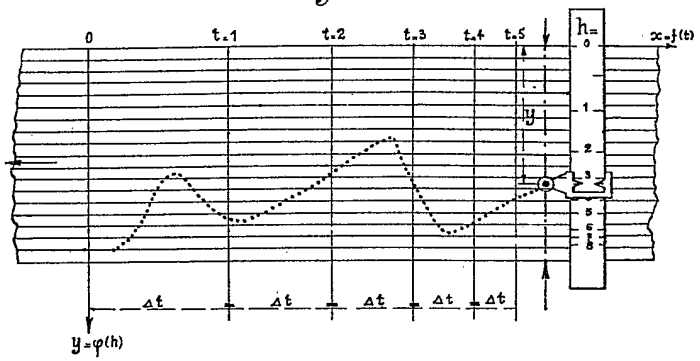

Fig. 2.

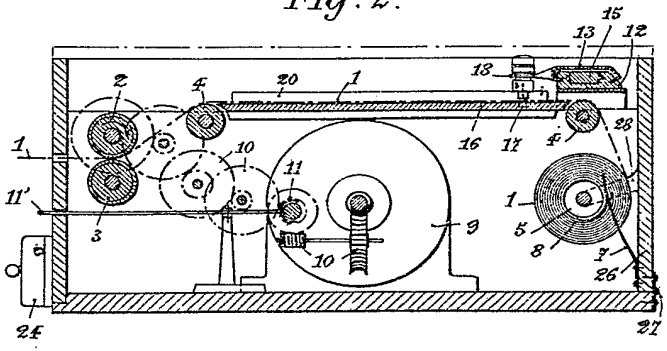

Fig. 4.

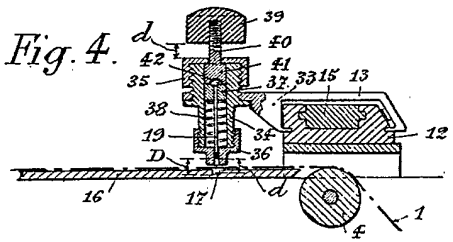

Fig. 5

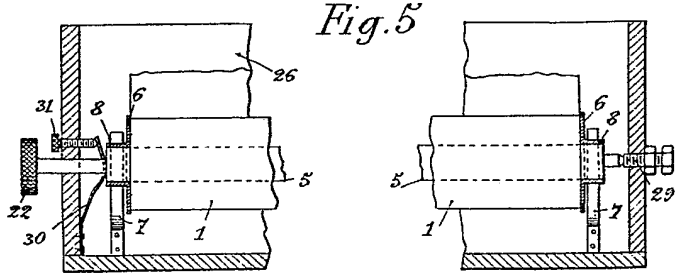

Fig. 3.

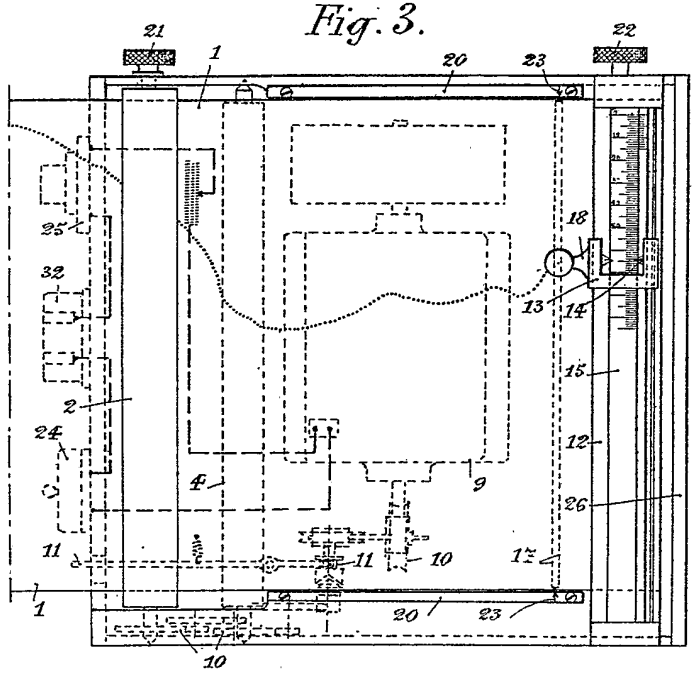

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Fig. 6.

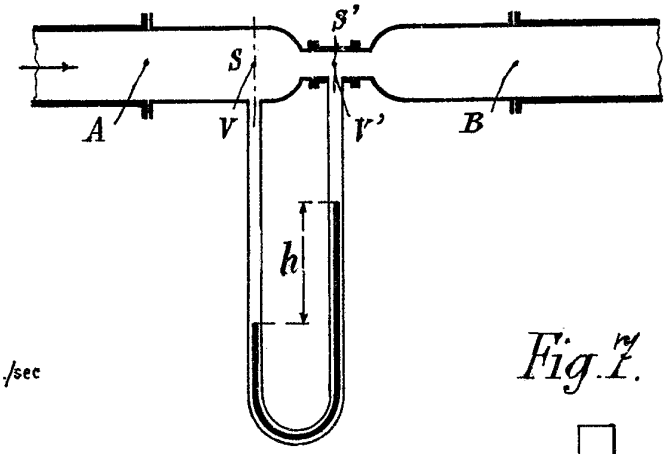


Fig. 7.

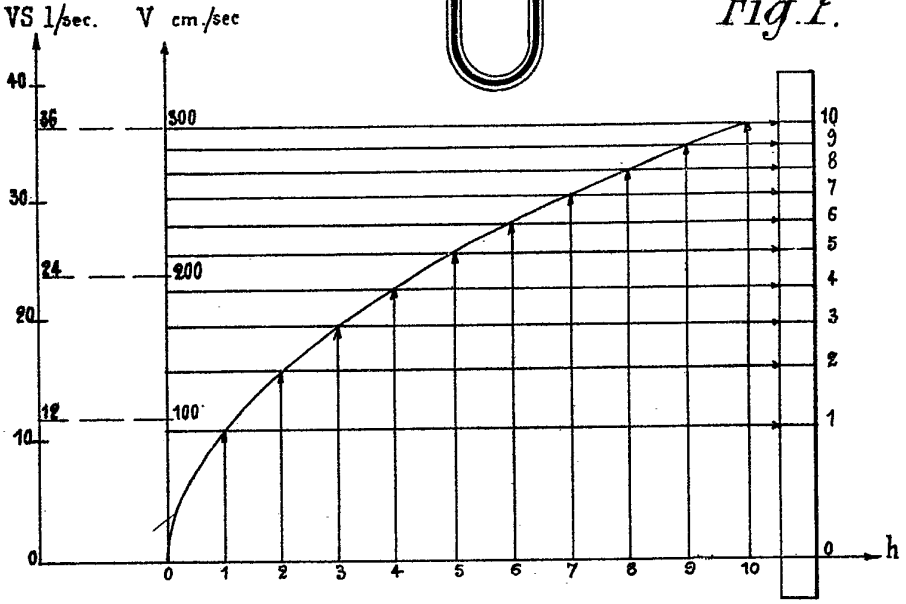
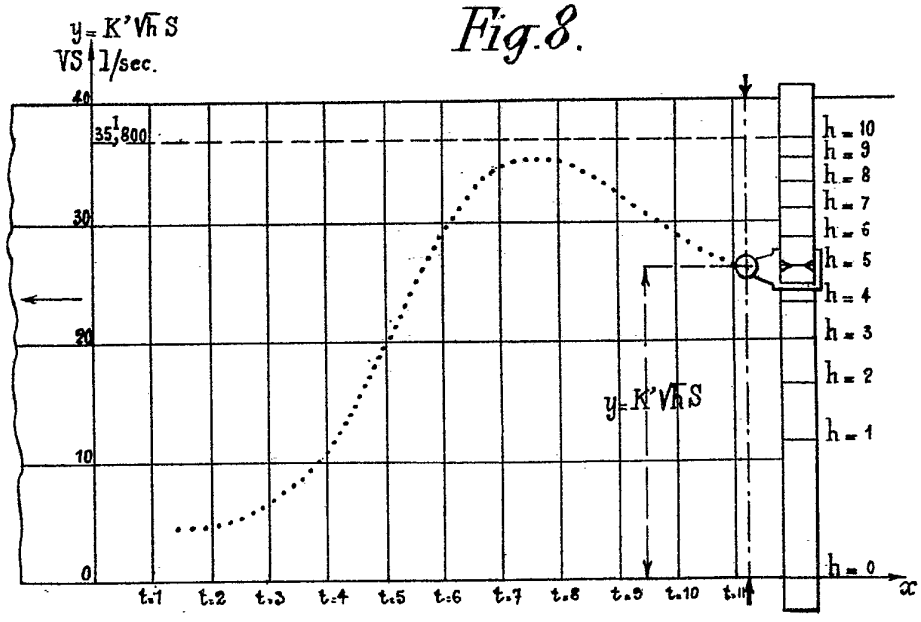


Fig. 8.



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