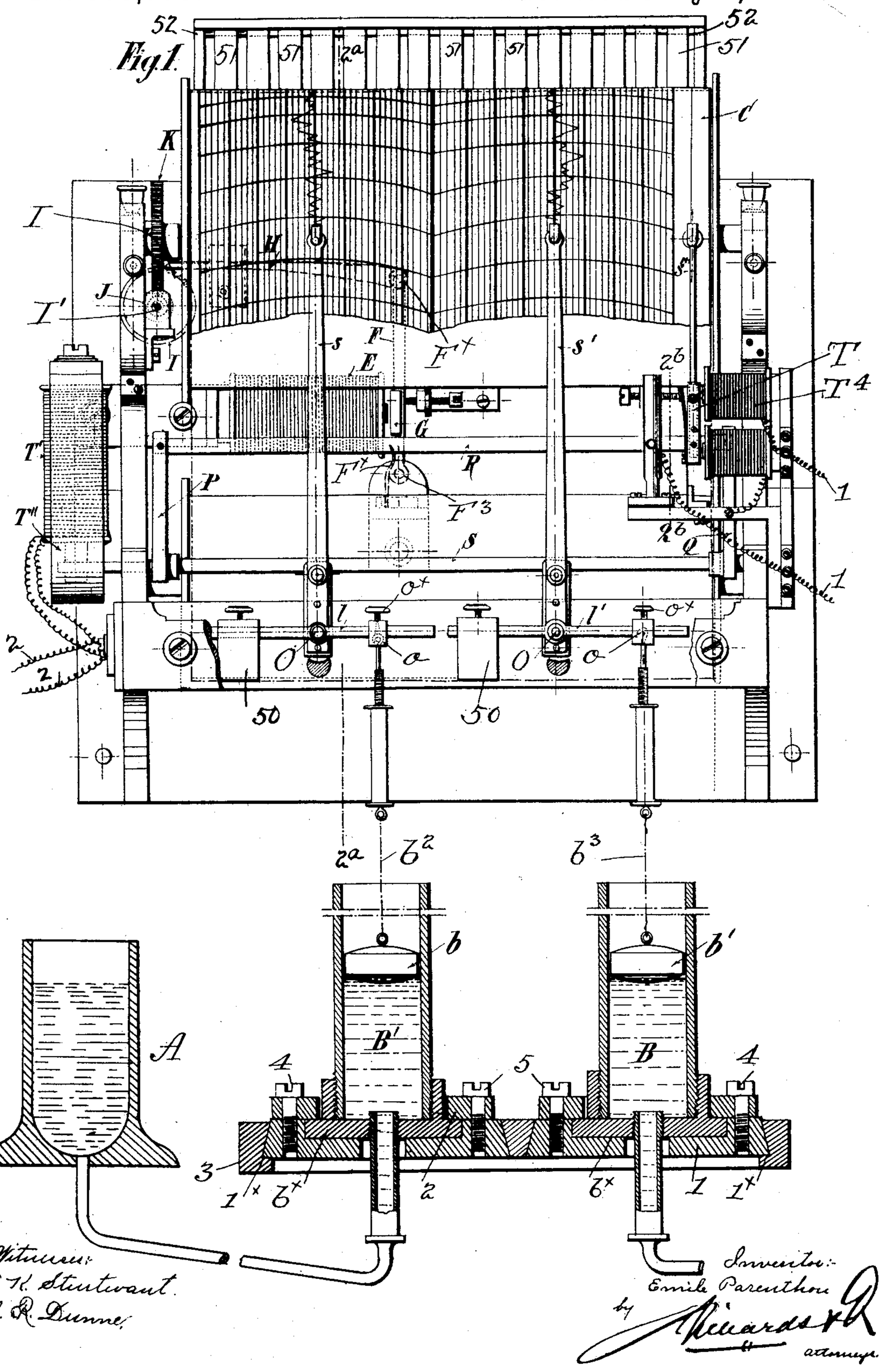
(No Model.) 4 Sheets—Sheet 1.

E. PARENTHOU.

APPARATUS FOR RECORDING THE FLEXURE OF BRIDGES.

No. 500,775. Patented July 4, 1893.

Fig. 1.



Witnesses:
E. K. Stuntevant.
A. R. Dunne.

Inventor:
Emile Parenthou
by Richards & Co
attorneys.

(No Model.) 4 Sheets—Sheet 2.

E. PARENTHOU.

APPARATUS FOR RECORDING THE FLEXURE OF BRIDGES.

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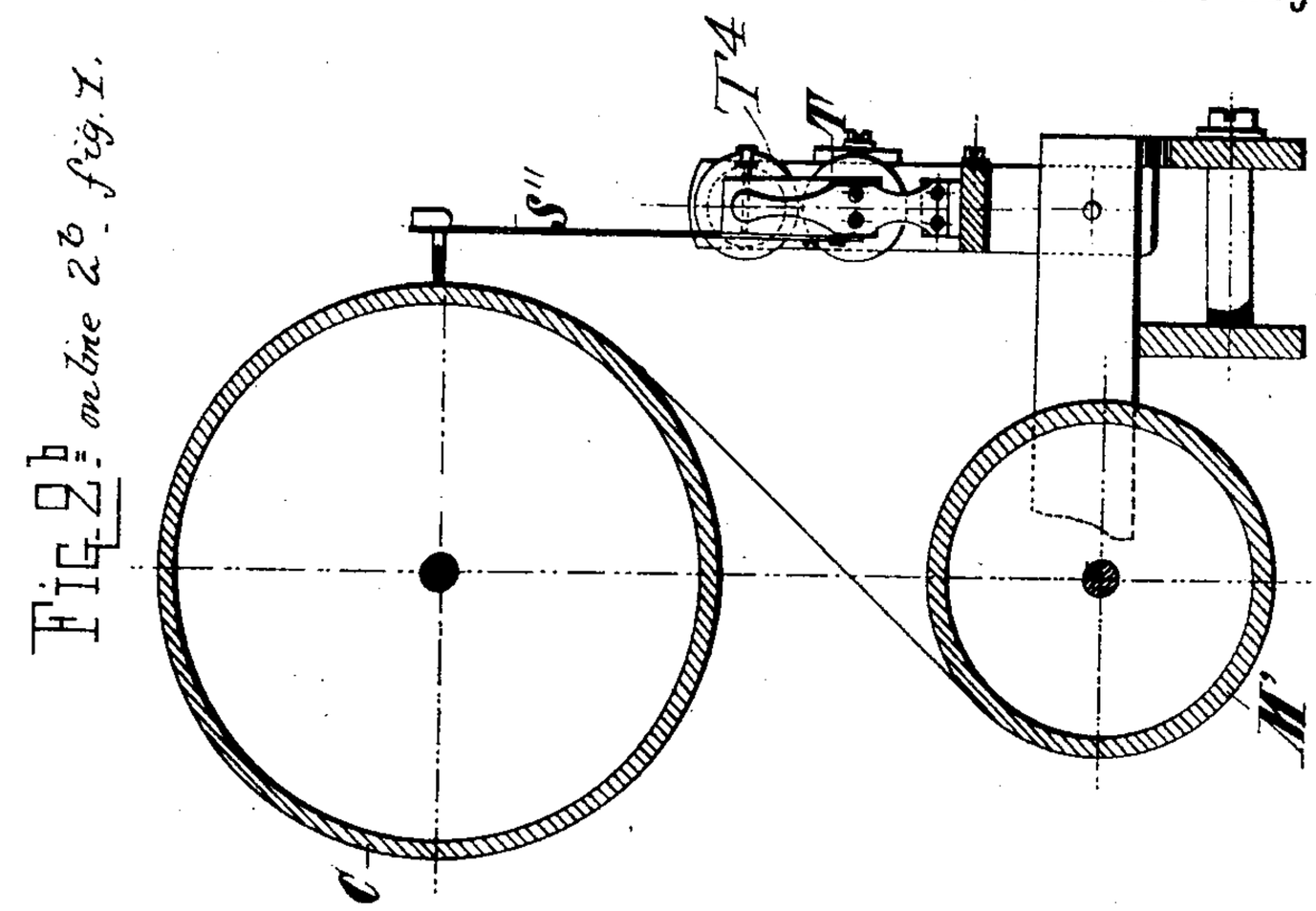
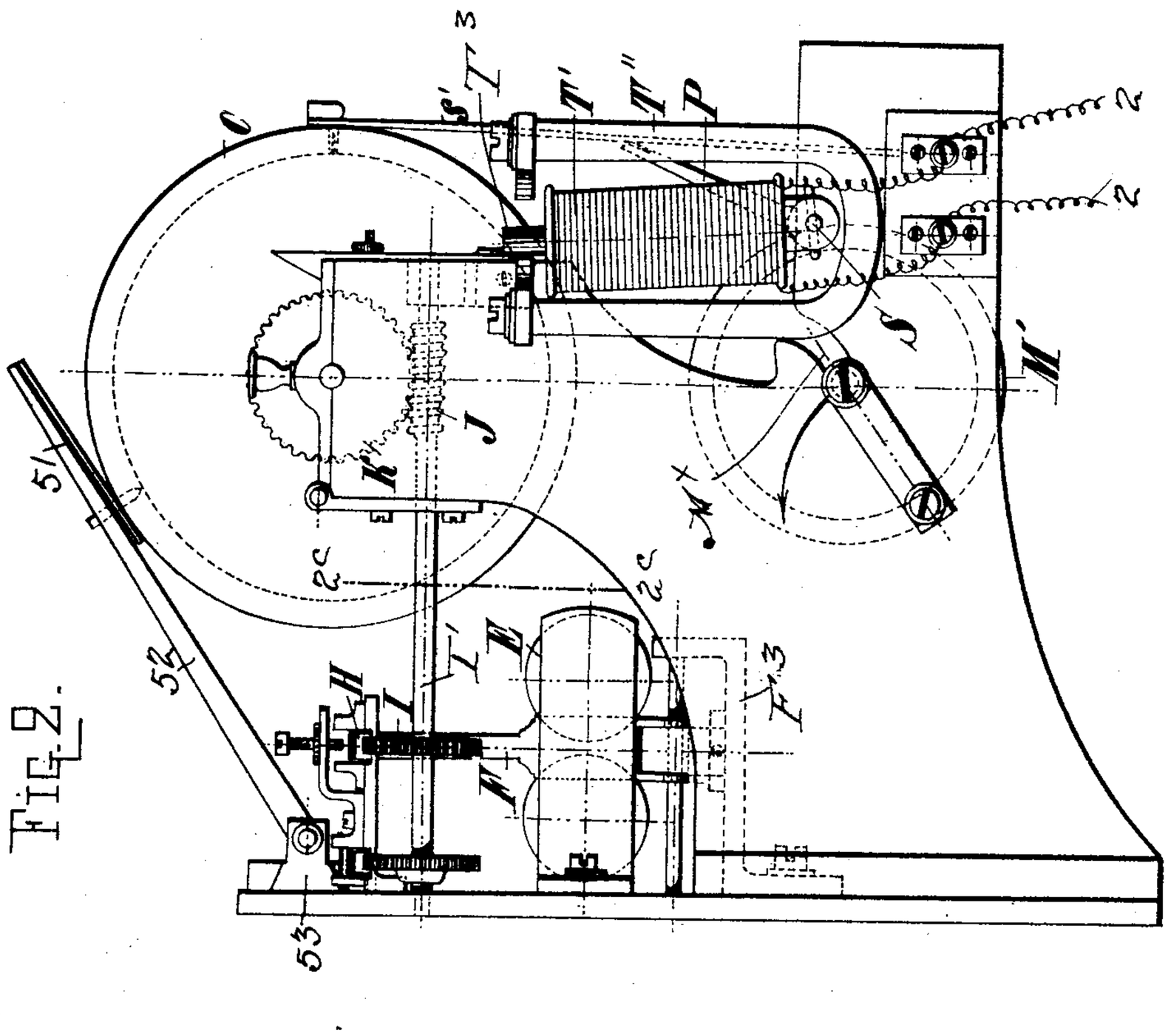
Fig. 2. Fig. 2b on line 2c-2c.





Witnesses:-
E. K. Stoutenburgh
A. R. Dunne

Inventor:-
Emile Parenthou,
by Howard & Howard
Attorneys.

(No Model.) 4 Sheets—Sheet 3.

E. PARENTHOU.

APPARATUS FOR RECORDING THE FLEXURE OF BRIDGES.

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Fig. 2c on line 2c fig 2

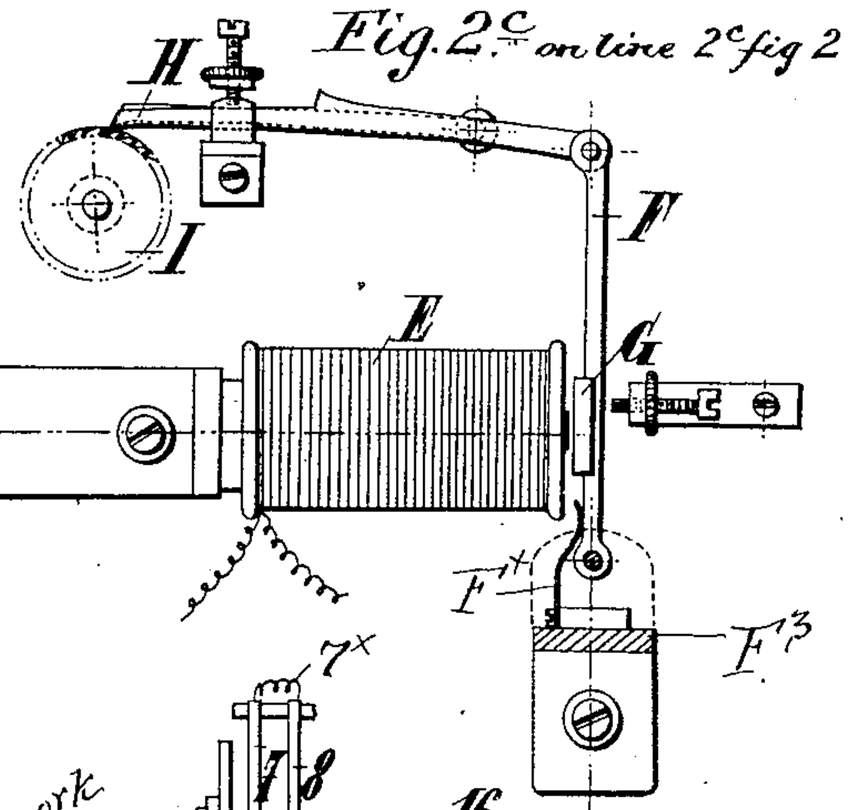
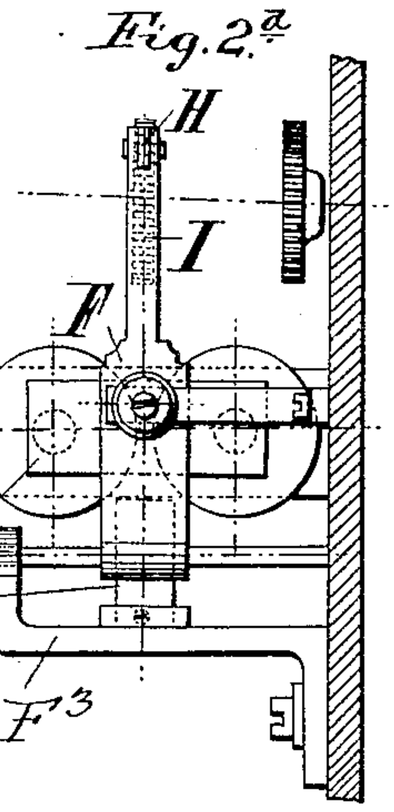


Fig. 2a



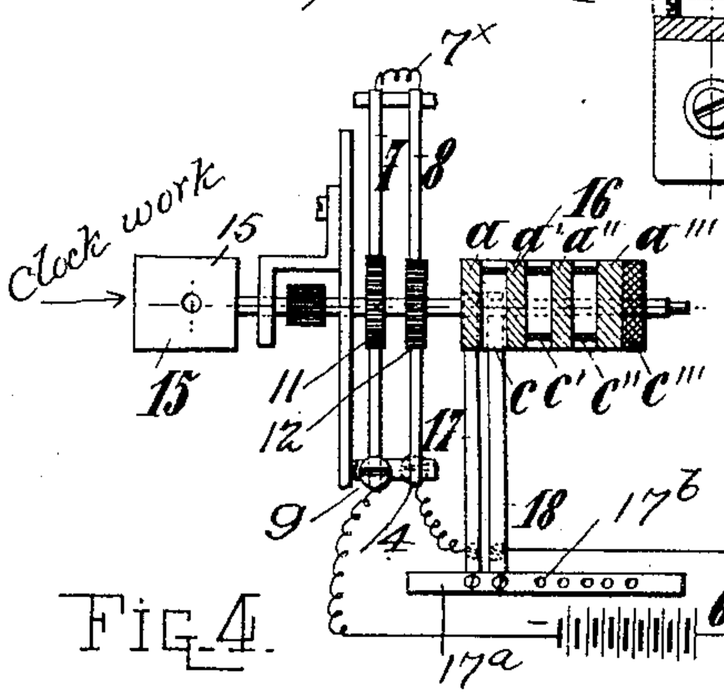


Fig. 4.

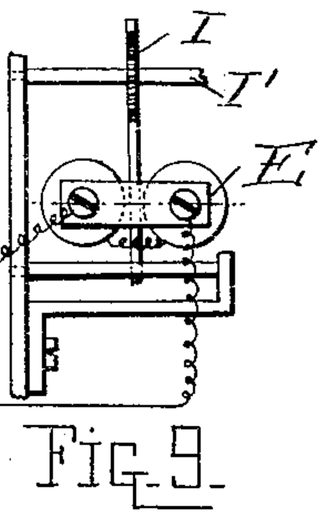


Fig. 11.

Fig. 9.

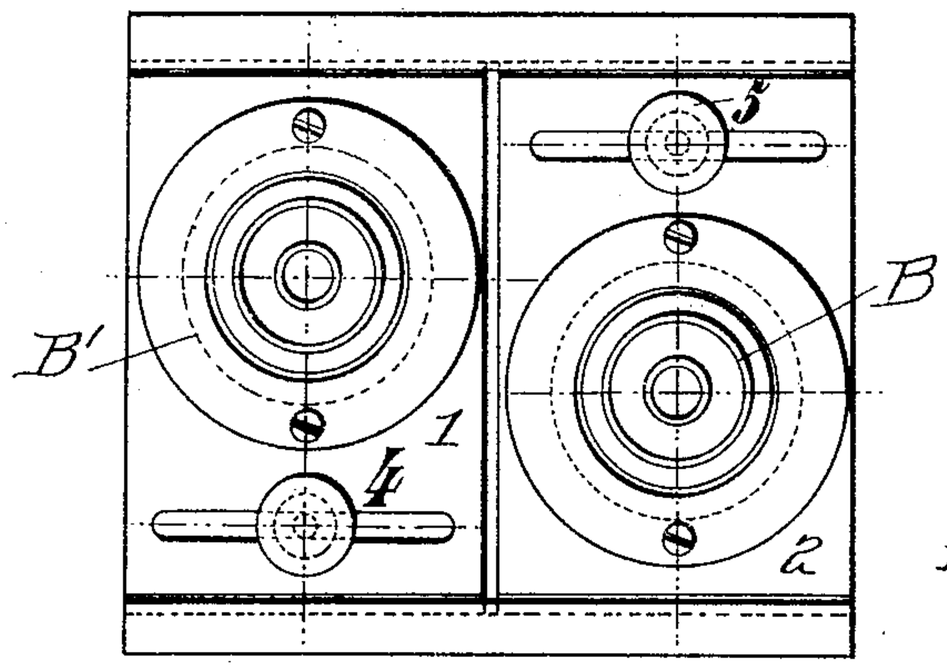
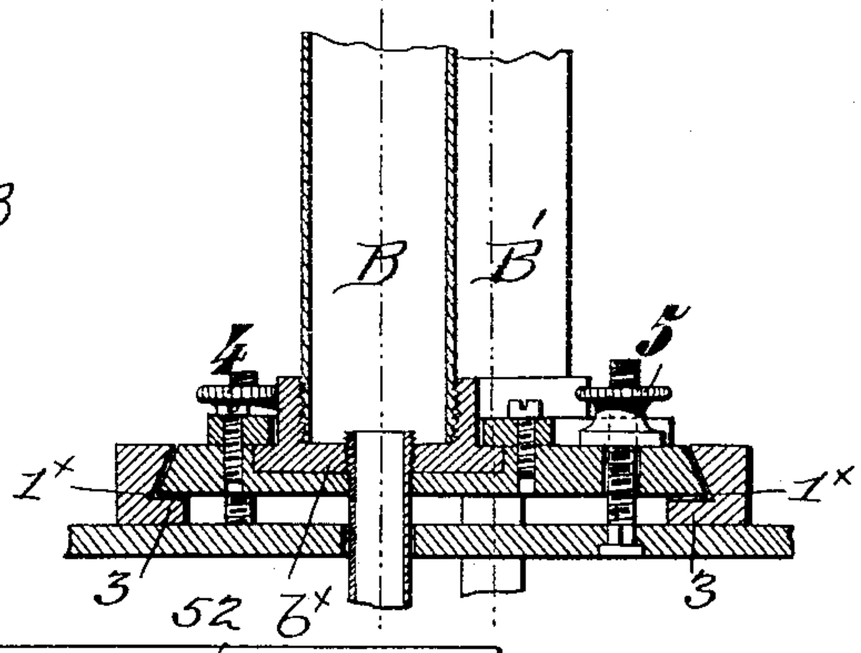
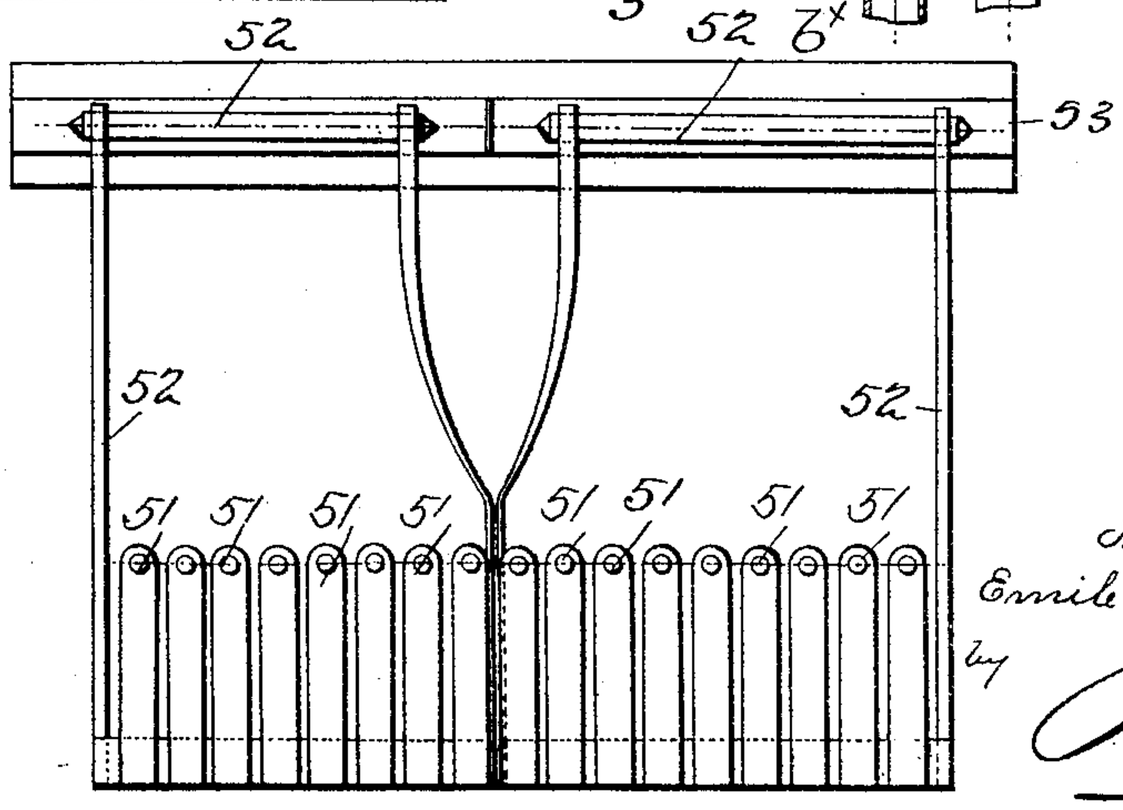


Fig. 3.





Witnesses:
E. K. Stuetevant
A. R. Dunne

Inventor:-
Emile Parenthou
by Richards & R
attorneys.

(No Model.) 4 Sheets—Sheet 4.

E. PARENTHOU.

APPARATUS FOR RECORDING THE FLEXURE OF BRIDGES.

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Fig. 10.

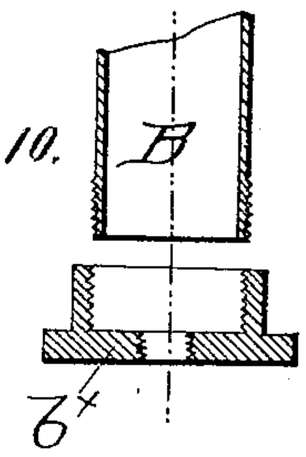
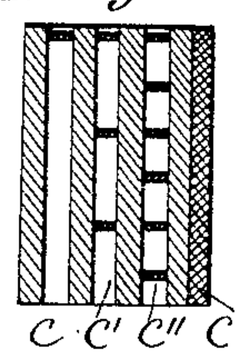


Fig. 7.



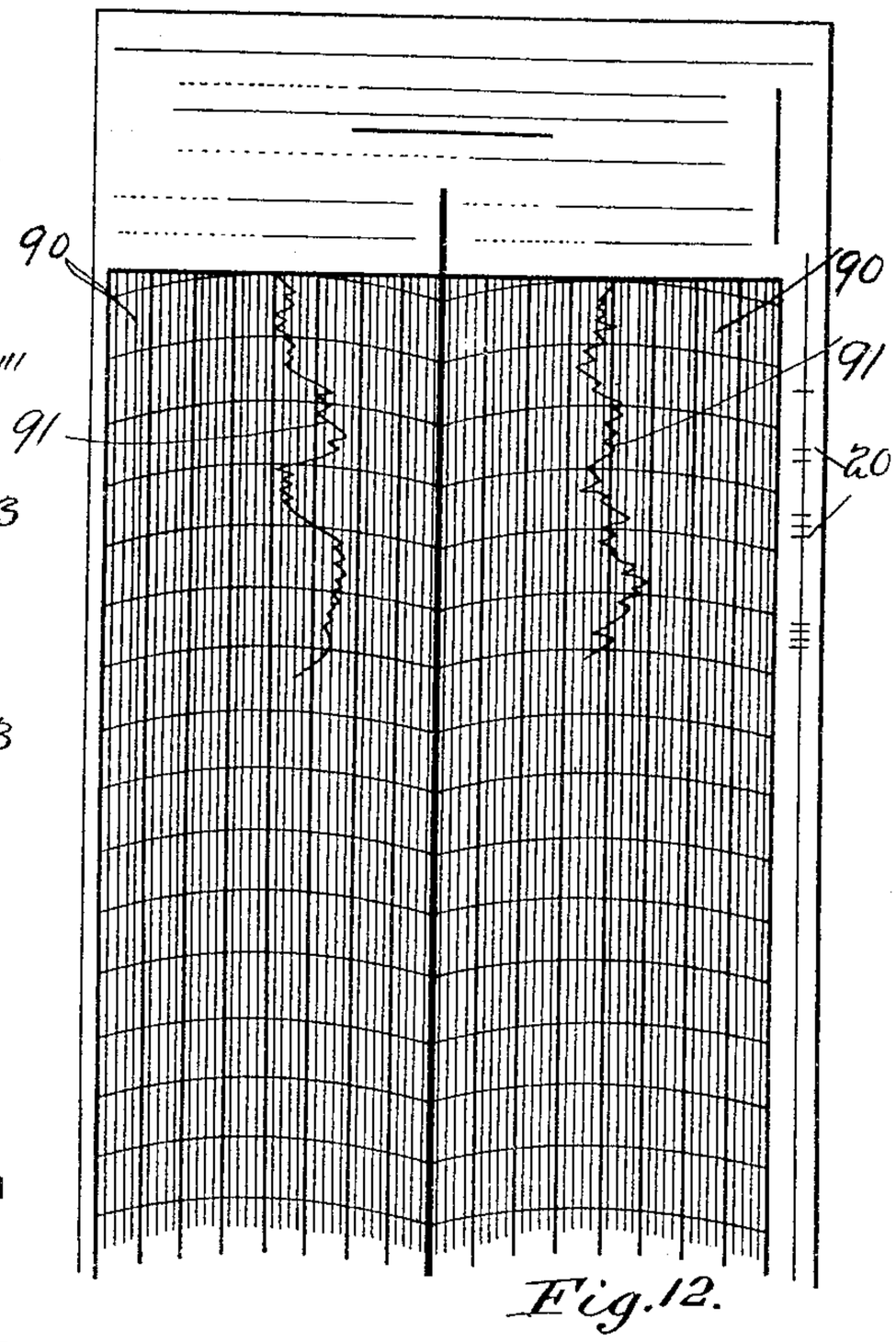


Fig. 12.

Fig. 8.

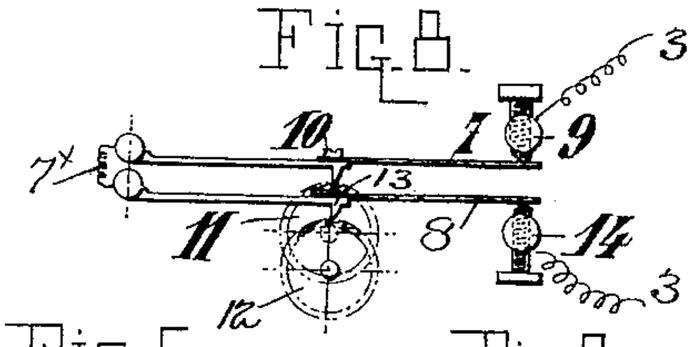


Fig. 5.

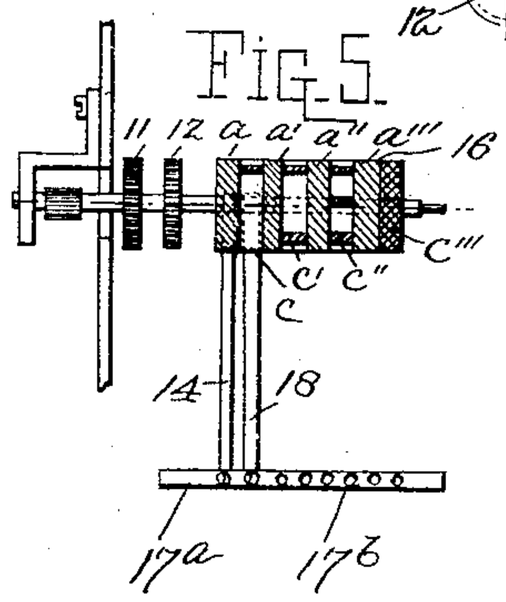


Fig. 6.

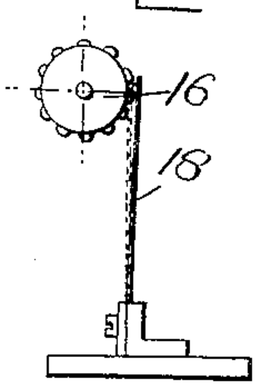
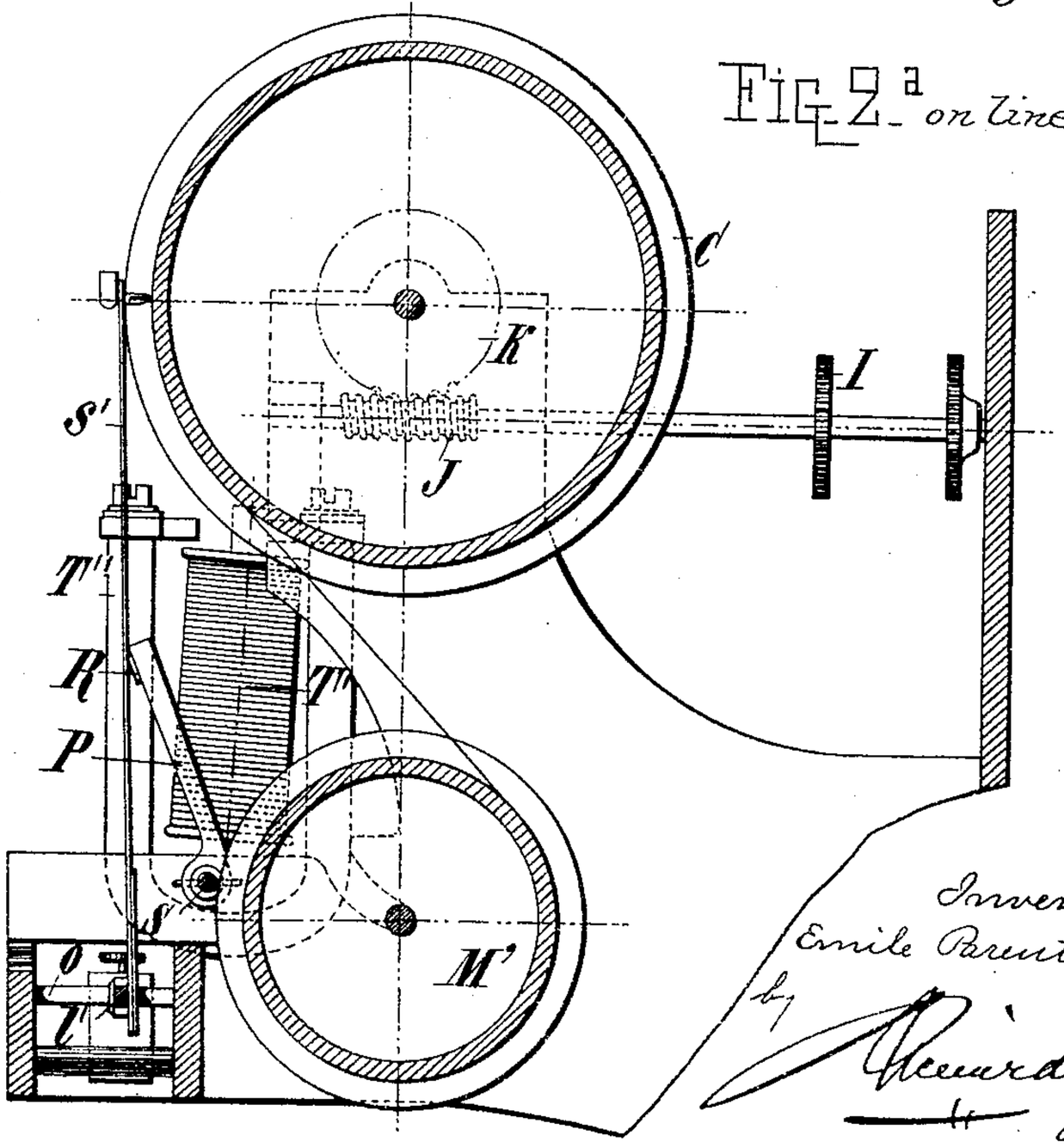


Fig. 2. a on line 2a fig. 1.



Witnesses:-
E. K. Stinterant
H. R. Dumm,

Inventor:-
Emile Parenthou,
by Howard & R
attorneys.

UNITED STATES PATENT OFFICE.

EMILE PARENTHOU, OF PARIS, FRANCE.

APPARATUS FOR RECORDING THE FLEXURE OF BRIDGES.

SPECIFICATION forming part of Letters Patent No. 500,775, dated July 4, 1893.

Application filed July 8, 1892. Serial No. 439,439. (No model.) Patented in France September 15, 1891, No. 2,161.

To all whom it may concern:

Be it known that I, EMILE PARENTHOU, a citizen of the Republic of France, residing at Paris, France, have invented an Apparatus for Recording the Flexures of Bridges, &c., of which the following is a specification.

The invention has been patented in France under the date of September 15, 1891, No. 2,161.

My invention refers to an indicating and recording apparatus, which permits of recording the variations in flections of metallic structures, and particularly that of the beams of bridges.

My apparatus can also be used where continuous beams are made use of, which have several resting points, and the same will indicate and record flections with stationary loads or rolling loads.

My apparatus is based on the following principle:—Suppose a receptacle A, is set up at any point of a bridge beam, which contains water or any other liquid such as mercury, oil, kerosene, &c., to a certain height. This receptacle communicates by a tube with another receptacle B set up stationarily beyond the bridge. In virtue of the principle which exists in two communicating vessels, no matter what the flection be of the beam at the points where the receptacle A is placed, the same level will be established at A and at B, so that any lowering of the receptacle A will determine in the stationary receptacle, a corresponding lowering of the level of the liquid and vice versa, if the receptacle A were raised, the level of the water or liquid in the receptacle B will be raised in the quantity inversely proportionate to the surfaces of the liquid in the two vessels.

In the accompanying drawings, Figure 1 is a view of my apparatus in its entirety arranged for experiments on metallic structures with two beams, only one of the reservoirs A placed on the beams being shown. Fig. 2 is an end view of the same apparatus. Fig 2^a is a section on line 2^a—2^a of Fig. 1. Fig. 2^b, is a section on line 2^b—2^b of Fig. 1; Fig. 2^c a section on line 2^c—2^c of Fig. 2, and Fig. 2^d is a view from the right of Fig. 2^c. Fig. 3 is a plan view of the upper frame. Fig. 4 shows in plan view the stationary reservoirs situated beyond the bridge. Fig. 5 is a circuit breaker used in my apparatus. Fig. 6 is an end view of the same. Fig. 7 shows the developed cylinder of the circuit breaker. Fig. 8 shows in detail the automatic mechanism actuating the circuit breaker. Fig. 9 is a section of the support of the two stationary cylinders of which Fig. 10 gives the detailed view. Fig. 11 shows the connection of the electro magnet actuating the cylinder with the circuit breaker, actuated by a clock-work. Fig. 12, is a view of one of the sheets used to receive the impression or marks from styluses.

The apparatus as shown in the drawings comprises two stationary vessels as B, B′, Fig. 1 and two vessels, A, only one of the latter however being shown, but the apparatus can be constructed having a larger number of vessels if experiments are to be made on metallic structures, composed of a larger number of beams. The vessels A are placed one on each beam or other part of the bridge to partake of the movement thereof. Two floats, b and b' placed in the vessels B and B′ follow the variations of the level of the liquid and communicate their movement to two flexible blades s and s' each bearing a stylus, by means of two of the levers l l'. These levers are pivoted to the frame work at the points O. At one end of each of these levers the cords b^2 b^3 respectively are attached. The counterbalance weights 50 are carried on the other ends of said levers. These levers and weights are shown in Fig. 1. The stationary vessels and the movable ones have not the same cross sectional area in order to augment in the vessel B, the variations of the level of the liquid produced by the variations of the level in vessel A, which result is obtained by having the cross sectional area of the vessel B less than that of the vessel A, or else to diminish the variations which result is obtained by giving B a larger cross sectional area than in A. Each float is connected to one end of the corresponding levers l or l', of which the other end bears the counter weight 50, which establishes the equilibrium to the weight of the float. Each movement of one of the floats will produce on the corresponding stylus an oscillation around the point O. The scope of the oscillation will depend upon the length of the movement of the float. A recording cylinder C, Figs. 1, 2 and 2^a which has a regular

rotary movement, is placed opposite the stylus carrying blades *s* and *s'*, the styluses of which mark on the surface of this cylinder or the paper carried thereby, the oscillations produced by the movement of the floats.

The rotary movement of the cylinder is obtained by means of the electro magnet E, Figs. 1, 2, and 11 which magnet is energized at intervals from the circuit shown in Fig. 11, which circuit is controlled by a circuit breaking mechanism shown on the left of said Fig. 11 and in Fig. 5 and hereinafter described. This magnet attracting the plate G, fixed on the lever F, pivoted in the bracket F^3, Figs. 1 and 2 moves the rod H, toward the left, Fig. 1, and this latter, which is pivoted to the lever F at $F^\times$ Fig. 1 engages and actuates the tooth wheel I to the amount equal to the breadth of a tooth. By the endless screw J on the shaft I' of the toothed wheel I and the gearing K, on the shaft of the cylinder C, Figs. 1 and 2 the rotary movement of the wheel is transmitted to the recording cylinder. The lever F is returned to normal position by the spring $F^\times$.

To obtain a regular movement and different speeds according to the experiments to be made, it suffices to control the electro magnet by an automatic circuit breaker, giving a constant number of interruptions per unity of time during the whole duration of the operation.

I will describe farther on the circuit breaker mechanism which I have adopted to obtain this result. The paper upon which the different inscriptions of the stylus are to be made, comes from a storage roller M', journaled in the frame of the apparatus at the slotted part $M^\times$ Fig. 2, and rolls onto the cylinder C after having been subjected to the action, first of the stylus on the blade *s* and that on the blade *s'* actuated by the floats *b b'*, so that said blades have movement longitudinally of the recording cylinder, second of the stylus blade *s''* which can at the will of the operator, be given a back and forward movement through a suitable circuit hereinafter referred to by means of the armature T and magnet T^4 shown in Figs. 1 and 2^b and which by producing on the paper a number of small signs, or better, small cuts 20 Fig. 12, which can be varied at the desire of the operator, permits of recording the oscillations produced by the stylus during the different experiments, and third,—by a series of equally distant styluses 51 placed above the cylinder and which are destined to trace on the paper a number of parallel equally distant lines.

The several styluses 51 are mounted on the frame 52 Fig. 3, divided into two parts each of which is dovetailed into the main supporting frame at 53, to be adjusted so as to bring at the beginning of the operation the recording stylus in contact with the zero line. This dovetailed construction is shown in Fig. 2.

It may be useful to separate the cylinder for a certain time from the recording stylus so as not to inscribe the oscillations produced by outside causes and which are not to be recorded, such as for instance when experimenting with a bridge, and it is desired to temporarily stop the recording during the passage of a train, &c. To cause this separation, the two flexible blades *s*, *s'* bearing the styluses, are placed opposite the frame P, Q, R, mounted on the axle S in such a manner that the rotation of the latter carries with it the frame and consequently the cross bar R, which then bearing on the stylus blades, separates them from the cylinder.

The rotary movement of the axle S is obtained by means of the electro magnet T', Fig. 2 which is arranged in the following manner:—The permanent magnet T'', is horse-shoe shaped and extends around the electro-magnet T', at the interior of which there is a soft iron core, whose end T^3 lies between the two poles of the permanent magnet T''. As long as there is no current traversing the electro-magnet T' the soft iron core will remain without motion in position where the current placed it during the preceding experiment. As soon as the current goes through the electro-magnet T', a pole will be formed on the extremity T^3 of the soft iron in regard to its position to the permanent magnet T'' and this end of the soft iron will be attracted by the pole of a contrary quality. By this attraction, it will turn the rock shaft or axle S as said electromagnet is carried thereby at the lower end, as shown at the left of Fig. 1, and consequently the frame P, Q, R, will be turned which will move the styluses to or from the cylinder. To separate the soft iron core from the pole of the magnet T'' which attracted it, the direction of the current is changed, which, in all cases, lasts but an instant.

The scope of the oscillations of each recording stylus, although dependent upon the pitch of the beam and difference of the cross areas of the stationary and the movable vessels, depends also from the point to which the corresponding float is attached on the lever *l*. The fastening point of the float on the lever, can be charged and fixed by the set screws $o^\times$ Fig. 1 and to permit the cord connecting the float to the lever, to remain in a vertical position, the receptacle B and B' must also be movable. To this purpose, the plates 1—2, on which the receptacles are placed, can be adjusted in the guides $1^\times$ to the apparatus in a groove made in the lower guide 3 Figs. 1, 4 and 9. The two plates are fixed in the desired position by means of screws 4 and 5. By mounting the stationary vessels B B' on lower plates, or caps $b^\times$ Figs. 1 and 9 they can be turned around on their axis so as to conveniently place the tubes which form the connection with the movable vessels A A and the apparatus can also be placed in different posi-

tions in respect to the movable vessels, according to the arrangements of the metallic structure upon which experiments are to be made.

The apparatus, such as described, or its parts working by electricity, can be placed at a distant point from the spot where the operator is, who can also work several apparatus at a time, provided the different electrical circuits be united at the center of operations. Each apparatus has three circuits: first, circuit No. 1, Fig. 1 provided with a magnet and armature which actuates the stylus *s''* or numbering stylus; second, circuit No. 2, Figs. 1 and 2 which serves to separate the cylinder when desired, from the recording stylus the said circuit being controlled by the operator; third, circuit No. 3, Fig. 11 which actuates the recording cylinder and which is arranged in the following manner: The batteries 6 Fig. 11, are united by one of the circuit wires to the conducting plate 7 Figs. 8 and 11 and the current can pass through the plate only when it is in contact with the contact No. 9. This takes place only at the precise moment when one of the teeth of the wheel 11 bears with its apex on the bearing No. 10 on the plate 7. At this instant, a current goes to contact 14 and passes only if the contact is established. It is thus seen that the current can traverse the apparatus shown at Fig. 8 only when the two plates 7 and 8 are in contact with the contacts 9 and 14, which will last only an instant, in consequence of the ratchets of the wheels 11 and 12 which move the plates 7 and 8 respectively. These wheels are rotated by a clockwork placed at 15, which also actuates the circuit breaking drum 16. The plates 7 and 8 are connected electrically at their pivoted ends by the wire $7^{\times}$. This drum 16 is formed of four conducting rings *a*, *a'*, *a''*, *a'''* and four non-conducting rings *c*, *c'*, *c''*, *c'''* provided with conducting parts, adapted to form an electrical connection between the blade 18 which bears thereon and the blade 17 bearing on the conducting ring the said conducting ring being in electrical connection with the conducting portions of the adjacent non conducting rings *c*, *c'*, *c''*, *c'''*. The number of conducting parts on the ring *c'* is greater than on the ring *c*, and likewise the ring *c''* has more than the ring *c'*, and the ring *c'''* more than the ring *c''*, so that the number of electrical connections established between the blades 17 and 18 in one revolution of the drum 16 may be changed by adjusting the arms 17, 18 as desired. The electrical current coming from the contact 8 passes into the blade 17, Fig. 11 and is sent to the electro magnet E whenever the blade 18 comes into contact with one of the conducting parts of the rings *c*, *c'*, *c''*, *c'''*. It is seen that according to the adjusted position held by the blades 17 and 18 in respect to the drum 16, the current traverses the electro magnet a greater or less number of times in a given period of time. The cylinder C will therefore have a speed which varies according to the position of the blades 17 and 18 in relation to the circuit making and breaking rings above mentioned.

The adjustment of the blades 17 and 18 may be effected in any suitable manner but for convenience I have indicated in Figs. 5 and 11 that the blades may be set at different points along the base board or plate 17^{a} which is provided with a series of holes 17^{b} to receive the holding screws of the blades.

In the operation of the devices the rotary movement of the cylinder will cause the styluses 51 to make a series of parallel lines on the paper as at 90 Fig. 12. The styluses carried on the blades *s s'* will move transversely of these lines under the rise and fall of the liquid in the vessels B B' due to the variations in the height of the liquid in the vessels A A, and the amount of flexure will be seen by the number of these parallel spaces or lines which are traced or crossed laterally by the marks or lines 91 made by the styluses *s s'*. One of said styluses may move more than the other according to the flexure at the point where the vessel A corresponding thereto is placed and it can thus be seen at a glance which part of the structure has the most flexure. The electric circuits 1, 2 controlling the action of styluses *s s'* and *s''* respectively are opened and closed at the will of the operator by means of any ordinary push button or circuit closers. The series of styluses 51, operate by pressing upon the paper on the cylinder.

I claim—

1. In combination the movable-liquid containing vessel, the stationary vessel, the pipe connections between them, the float in the stationary vessel, a recording device, and a connection from the said float extending outside the vessel to the recording device, substantially as described.

2. In an apparatus for recording the flexure of a flexible structure the combination of the recording cylinder with means for moving it, a recording stylus, a pivoted lever carrying the same, a float connected with said lever, a vessel containing a liquid and said float, and a second liquid-containing vessel carried by the flexible structure and connected with the vessel first mentioned, substantially as described.

3. In combination in a recorder, the stylus with operating means therefor, the cylinder, the electro magnet, the armature, the ratchet and ratchet shaft operated by the armature, the cylinder shaft having a worm wheel and the worm on the ratchet shaft, substantially as described.

4. In combination the cylinder with means for moving it, the stylus in normal engagement with the cylinder, the pivoted support for said stylus, the means for operating the same to make the record, consisting of the stationary vessel having a float connected to the pivoted support and the movable vessel having a pipe connection with the stationary

vessel, the shaft and frame for moving the said stylus toward and from the cylinder, the electro magnet and armature in connection with the said shaft and frame for controlling it and the electric circuit including the said magnet whereby the operation of the stylus may be controlled from a distant point, substantially as described.

5. In combination the recording cylinder, the stylus, the lever carrying the stylus, the vessel B carrying a float, a liquid supply, a pipe connection between the said vessel and the liquid supply, the adjustable connection between the float and the stylus lever the said vessel being adjustable also, and the means for adjustably holding the said vessel substantially as described.

6. In combination, the recording cylinder, a series of styluses arranged to bear on said cylinder and extending from end to end thereof to make parallel lines longitudinally of the strip and a recording stylus supported to have movement longitudinally of the cylinder and laterally of the paper strip thereon to cross the parallel lines made by the series of styluses, and means for operating the recording stylus longitudinally of the cylinder whereby the record marks and the parallel lines crossing the same are placed simultaneously on the paper strip, substantially as described.

7. In combination the recording cylinder with means for moving it, a pair of styluses, one near each end of the said cylinder, the movable supports for said styluses, the two vessels B, B, arranged side by side containing liquids, the floats therein, the connections from the floats to the movable stylus supports, and the independent means for operating the floats adapted to be placed at different sides or portions of the flexible structure, said means consisting of the movable vessels and the flexible connections therefrom to the vessels B B, substantially as described.

8. In an apparatus for recording the flexure of bridges and like structures, the recording cylinder arranged to be placed at a distance from the structure on a stationary support, the recording stylus, the vessel B having a float connected with the said stylus the liquid vessel A adapted to be placed on the structure the conduit between the vessels A and B the said stylus being movable toward and from the cylinder and the means for moving the stylus to or from the cylinder and controlling said movement from a distant point consisting of the electro magnet and armature and the electric circuit extending therefrom to the said distant point, substantially as described.

9. In combination the cylinder, the recording stylus, the means for operating it over the surface of the cylinder, consisting of the liquid containing vessel B, the float therein connected to the stylus and the second liquid containing vessel connected to the vessel B, the numbering stylus s'' and the means for operating the same at the will of the attendant consisting of the electro magnet and armature and the electric circuit whereby the number of the records may be made upon the paper by the attendant from a distant point, substantially as described.

10. In combination, the cylinder the recording stylus with vibrating operating means therefor adapted to transmit the vibrations of the structure to be tested, the means for rotating the cylinder consisting of the electro magnet and armature, the operating connections between the said armature and the cylinder shaft, the electric circuit extending from the electro magnet to a distant point and the adjustable circuit breaker at said distant point whereby the rotation of the cylinder may be varied to correspond to the rapidity of the vibrations of the flexible structure, substantially as described.

11. In combination the cylinder, the electro magnet and armature with connections to the said cylinder, the electric circuit with an adjustable circuit breaker, the recording stylus with vibrating means for operating the same to make the record of vibrations of the structure to be tested, the electro magnet and armature having connections with the said stylus to regulate its position relatively to the cylinder, and the electric circuit extending to a distant point for controlling the said magnet and armature, substantially as described.

12. In combination, the cylinder, the electro magnet and armature with connections to the said cylinder, the electric circuit with an adjustable circuit breaker and the recording stylus with means for operating the same the said adjustable circuit breaker comprising the cylinder 16, with a series of conducting and non-conducting rings, the adjustable blades 17, 18, to contact with said rings and the means for operating the cylinder, substantially as described.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

EMILE PARENTHOU.

Witnesses:
ROBT. M. HOOPER,
JOSEPH TOURNIER.