(No Model.)

J. RAE.

STEAM ENGINE INDICATOR.

No. 366,252. Patented July 12, 1887.

Fig. 1.

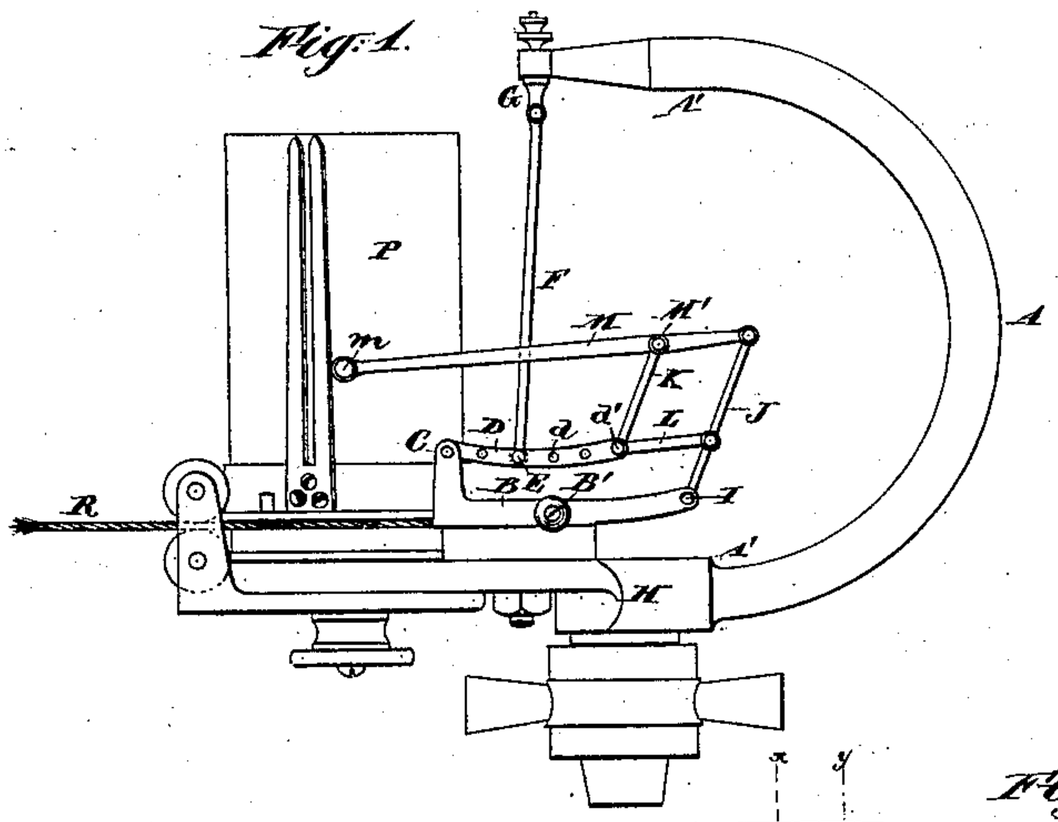

Fig. 2.

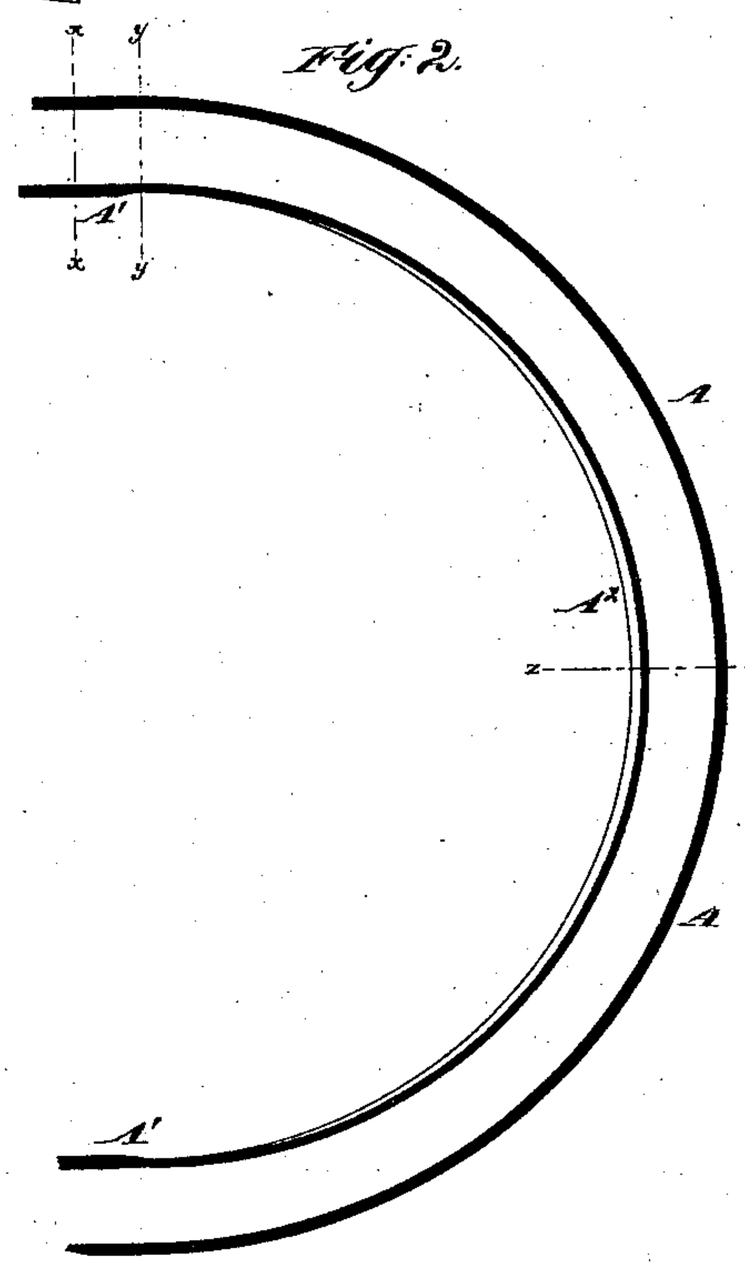

Fig. 6.

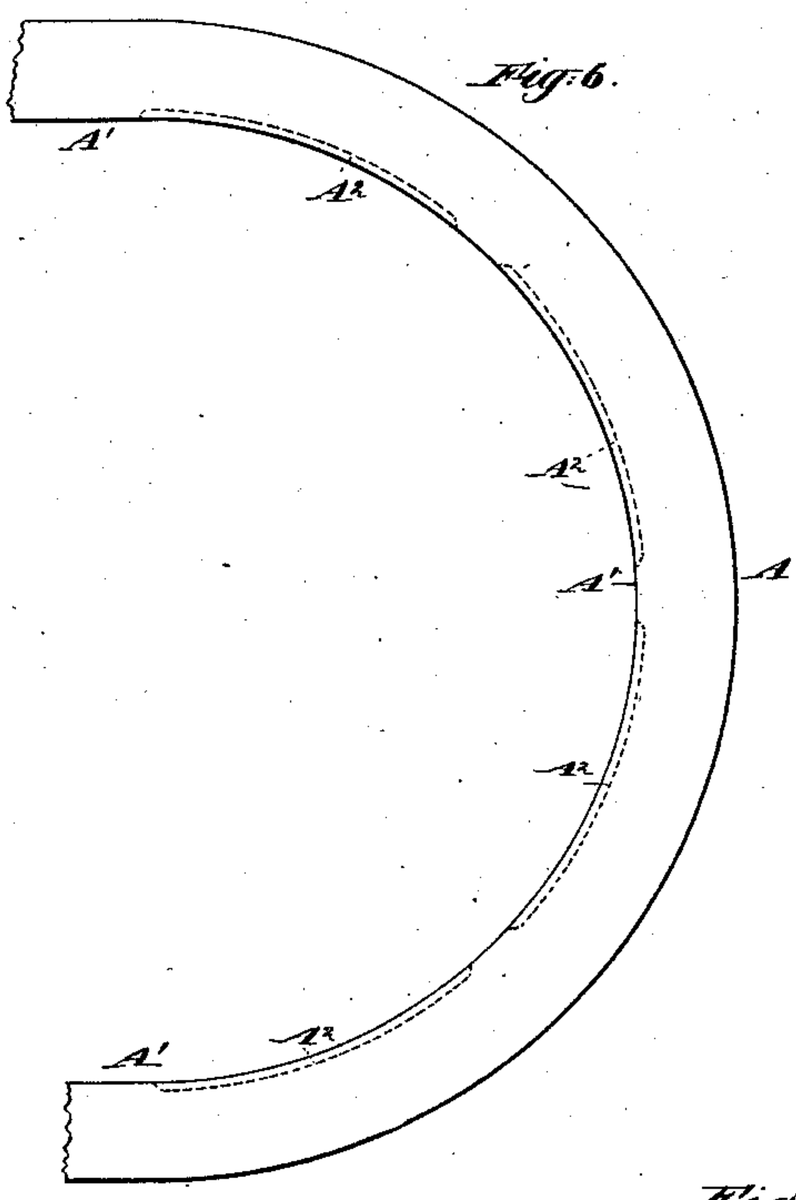

Fig. 3.

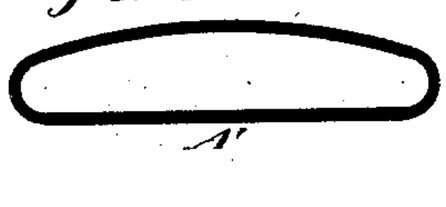

Fig. 4.

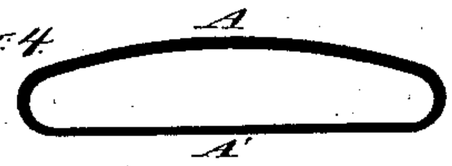

Fig. 5.

Witnesses:
Charles R. Searle,
Florence A. Richmond

Inventor:
John Rae
by his attorney
Thomas Drew Stetson

UNITED STATES PATENT OFFICE.

JOHN RAE, OF NEW YORK, N. Y.

STEAM-ENGINE INDICATOR.

SPECIFICATION forming part of Letters Patent No. 366,252, dated July 12, 1887.

Application filed August 30, 1886. Serial No. 212,176. (No model.)

To all whom it may concern:

Be it known that I, JOHN RAE, of the city and county of New York, in the State of New York, have invented a certain new and useful Improvement in Steam-Engine Indicators, of which the following is a specification.

My improved indicator is of the general class set forth in the patent to me dated May 21, 1878, No. 204,086. I have devised an important improvement, whereby the action is very free and the indications more decided and reliable.

The improvement relates to the hollow spring. In all indicators of this class the pressure of the steam, or of fluid subject to the pressure of the steam, is received in a hollow curved spring, which, as the steam is received, expanded, and exhausted, induces a slight movement of the spring, which is by suitable multiplying devices transmitted to the pencil and caused to produce the proper record on the paper, which is by other mechanism moved in contact therewith. The same general arrangement of hollow curved spring receiving the pressure of steam in its interior has been employed as a gage to simply indicate the pressure in the boiler. The spring is usually a flattened tube of hard spring-brass. The pressure of the steam in its interior tends to swell or bulge the flat faces of such spring and induces a partial straightening. So soon as the pressure is relaxed in whole or in part the elasticity of the flattened tube restores it partially or entirely to its original form. In some cases the tube has been simply flattened. In others it has been hollowed on the inner face. A spring thus hollowed in its inner face is set forth in the patent to E. Bourdon, August 3, 1852, No. 9,163. I have endeavored to apply such a spring in combination with indicator mechanism to indicate the greatly-varying pressures which obtain in a steam-engine cylinder in different periods of the stroke. In other words, I have endeavored to apply the Bourdon hollow-face spring to my indicator of 1878. In doing this I have made an important discovery. A hollow extending uniformly from one end to the other on the inner face of the spring and of the same thickness required for the other parts does not operate successfully; but by making the hollow concave thinner and making it concave in both directions relatively to the spring—that is to say, making the inner face hollowed in cross-section and also hollowed in longitudinal section—I get better results. It will be understood that the curve of the spring induces a hollow; but I make the hollow reckoned longitudinally on the inner face a quicker curve than that of the axis or central line of the spring. In other words, the inner face of my spring is concaved longitudinally to a greater degree than the curve of the spring. The tube may be the ordinary flat tube at each end, or the ends may be slightly hollowed on the inner face, or they may be bulged, or swelled on the inner face. If hollowed, they are less hollowed at the end than in the intermediate portion. The effect of this construction, making the inner face thinner and hollow both in cross-section and in longitudinal section relatively to the general contour of the spring, causes the inner face to act archwise to straighten the spring when the pressure is admitted.

The accompanying drawings form a part of this specification, and represent what I consider the best means of carrying out the invention.

Figure 1 is a side elevation of an indicator having my invention. The remaining figures are on a larger scale. Fig. 2 is a vertical longitudinal central section of the spring. Fig. 3 is a transverse section on the line *x x* in Fig. 2. Fig. 4 is a corresponding section on the line *y y*. Fig. 5 is a section on the line *z z*. Fig. 6 shows a modification. It is a side elevation.

Similar letters of reference indicate corresponding parts in all the figures where they occur.

It may not be necessary to minutely describe the parts which are shown in my patent of 1878 referred to.

A is the curved hollow spring, certain portions being designated when necessary by additional marks, as A′ A^2, &c. When relieved from pressure, the outer face corresponds

to that of the ordinary flattened tube bent to the curvature required. The edges may be of the ordinary form.

The novel construction relates to the concaved inner face. The inner face at each end is marked A′, and is similar to the corresponding parts of an ordinary flattened bent tube. The intermediate portion of the inner face is marked A^2. This portion A^2 is hollowed transversely, as indicated in cross-section in Fig. 5. It is also hollowed longitudinally to a greater extent than the curvature of the tube, as indicated in longitudinal section in Fig. 2. The entire inner face, A′ A^2, is made thin. The means which I have employed for inducing the thinner condition of the parts A′ A^2, with the gradual increase in the thinness from the edge toward the middle, has been attained by temporarily distending the metal A′ and reducing the thickness with a file applied and worked in the obvious position transversely to the curvature of the spring; but I propose to employ machinery for this purpose when operating in a large way. For making a small number of gages it is sufficient to distend the tube on its inner face, which I can effect by introducing a compound filling-horn made of several pieces of thin steel. When such in proper number and form have been forced in, the inner face, A′, of the curved tube A is distended. In this condition the metal is easily removed by a file. When a sufficient area near the center of the inner face has been thinned in this manner and the surfaces are again nicely finished to resist corrosion and other destroying influences, the spring is ready to be joined rigidly to the support H, and on proper connection being made to the cylinder and to the pencil-operating mechanism the device is ready to serve. The paper is stretched on an upright cylinder, P, and is held by the ordinary clamps. The cylinder is partially rotated in one direction and in the other by a string, R. All these parts are of the ordinary construction and operate in the ordinary manner, and need not be particularly described.

B is a support for the pencil-carrying devices, capable, as usual, of swiveling to a slight extent on the main base H. This swiveling motion is imparted at will by the aid of handles B′.

D D are levers connected to the turning-piece B at C. E is a pin adjustable in carefully-located holes *d*. It connects by links F with a swiveling piece, G, attached to the free end of the spring A. These parts are constructed and arranged substantially as in my patent of 1878. Shifting the pin E into different holes *d* gives a greater or less range of motion to the pencil with a given change in the pressure of the steam and consequently in the elongation or contraction of the spring A.

I is a pivot or axis on the turning-piece B. A lever, J, turns thereon, and is controlled in its position by a link, L, pivoted to J and connecting it to a pin, *d′*, in the free end of the levers D. M is a lever pivoted to the upper end of J and carrying a pencil, *m*. It is moved horizontally by levers J. It is moved vertically by links K, which extend from a pivot, M′, on the lever M to the pivot *d′* on the levers D. The effect is to give the increased vertical motion desired to the pencil, corresponding to the partial expansion and contraction of my spring A A′ A^2.

I ascribe the superior effect of my peculiar construction of spring, in part, at least, to an arching effect due to the longitudinal concavity. The portion A^2 is ready to be distended toward the center of the curvature by any sufficient pressure in the interior of the tube. The concavity longitudinally causes the metal to act archwise. When it is distended inwardly toward the center of the curve, it partially straightens an arch previously existing between the unconcaved portions A′ A^2. The effect is to straighten the entire spring more freely and with a more marked result than any construction of hollow spring before known to me.

I have proved by experiment that my spring thus hollowed both longitudinally and transversely and made thinner, as described, gives a marked increase to the movement of the spring. It also lessens the tendency, as compared with the ordinary hollow spring, to contract by a series of steps or to tremble in contracting. I have succeeded with my improved indicator constructed as described in getting a smooth line, apparently an exact indication of the pressure at each point through the whole of those portions of the diagram usually termed "the expansion-line" and "the exhaust-line."

Modifications may be made in the forms and proportions without departing from the principle or sacrificing the advantages of the invention.

Instead of only two portions, A′, I can have three, or even more—that is to say, instead of making the transverse and longitudinal cavity A^2 extend continuously from the portion A′ at one end to the portion A′ at the other end of the spring, I can have a corresponding portion unconcaved at or near the middle of the spring; or I can have three or more such concaves separated by portions which are not concaved. Fig. 6 indicates such a modification, four concaves being shown in dotted lines.

Instead of the special arrangement of levers and links shown, I can use the entire set, as shown in my patent of 1878, or I can use various other devices for properly multiplying the motion of the spring.

I attach importance to the concaving longitudinally and transversely of the inner face, A′ A^2, of the hollow curved spring A even without making that portion thinner. I believe I can make a successful gage by giving those curves without taking any measures to insure that this portion shall be made specially thin. I prefer to make it thin, as described.

I claim as my invention—

1. The curved hollow spring A A′ A², the inner face being concaved both in transverse section and in longitudinal section, adapted to serve as herein specified.

2. The combination, with paper-actuating mechanism, as P R, and pencil-actuating mechanism D E F, of the curved hollow spring A, having its inner face concaved, and also thinner than the main portions of the spring, all arranged for joint operation, substantially as herein specified.

In testimony whereof I have hereunto set my hand at New York city.

JOHN RAE.

Witnesses:
JACOB SCHAUS,
BENJAMIN T. WARD.