Sheet 1, 3 Sheets.

J. Ericsson.

Steam Engine.

No. 6,844. Patented Nov. 6, 1849.

Fig: 1.

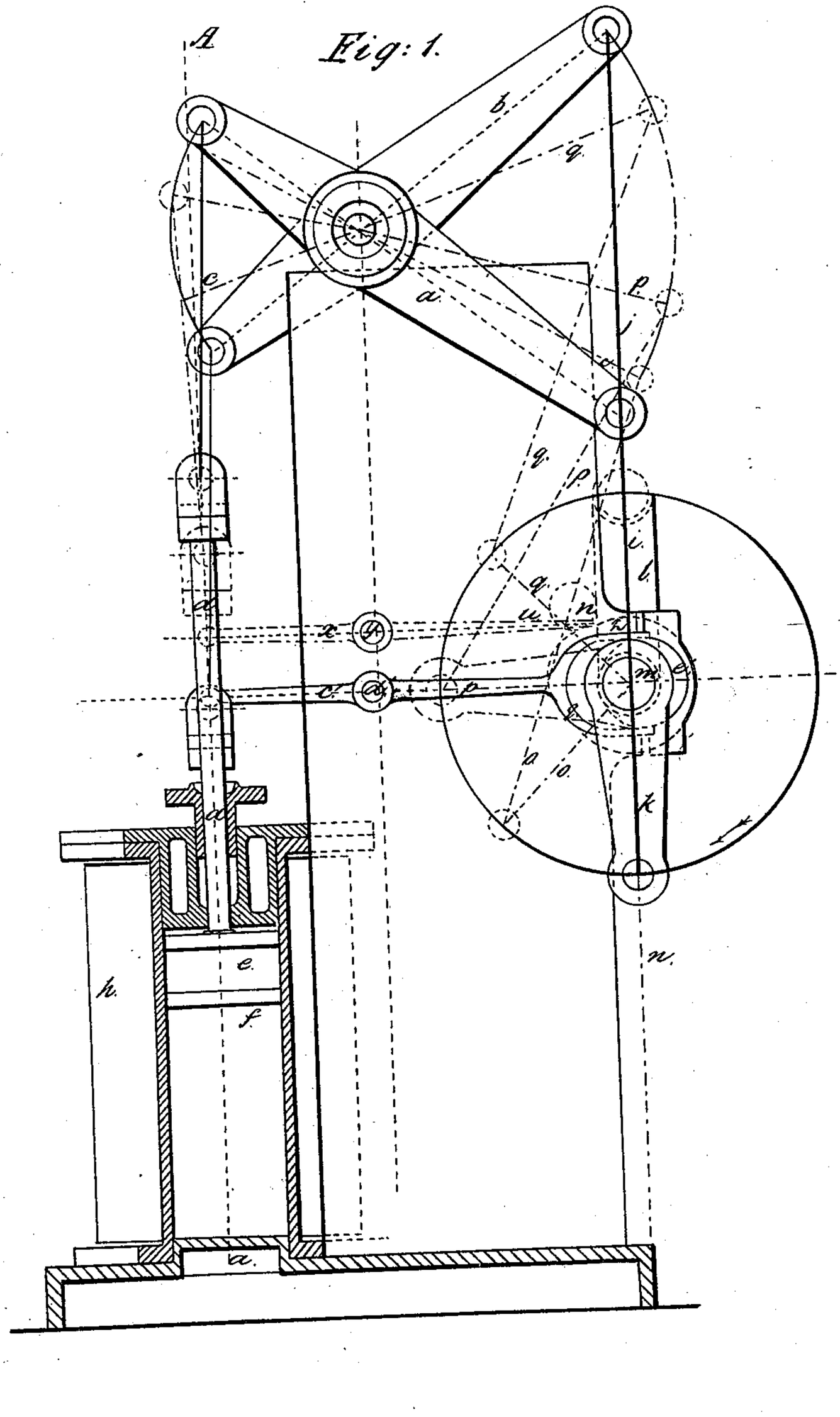

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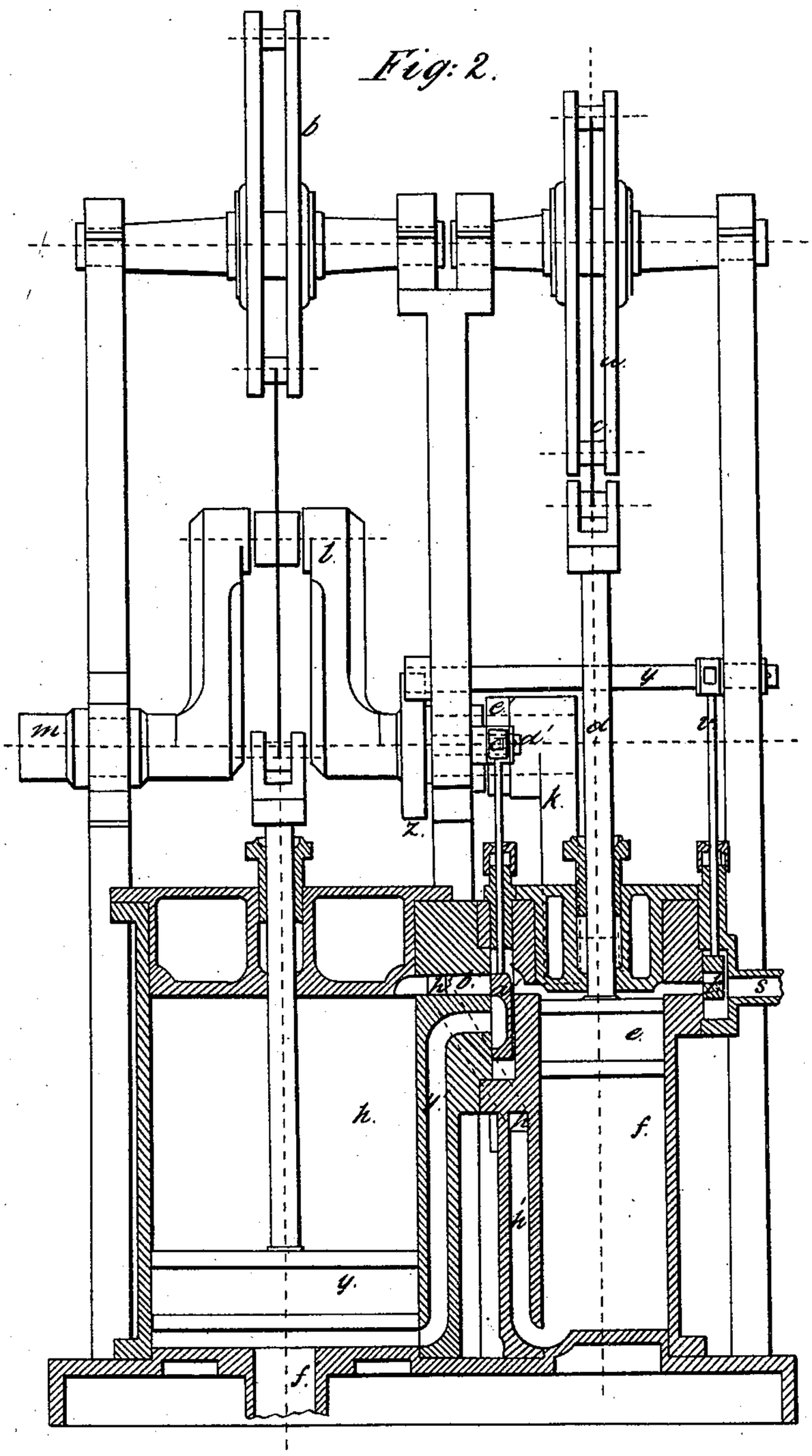
Fig: 2.



Sheet 3, 3 Sheets.

J. Ericsson.

Steam Engine.

No. 6,844. Patented Nov. 6, 1849.

Fig: 3.

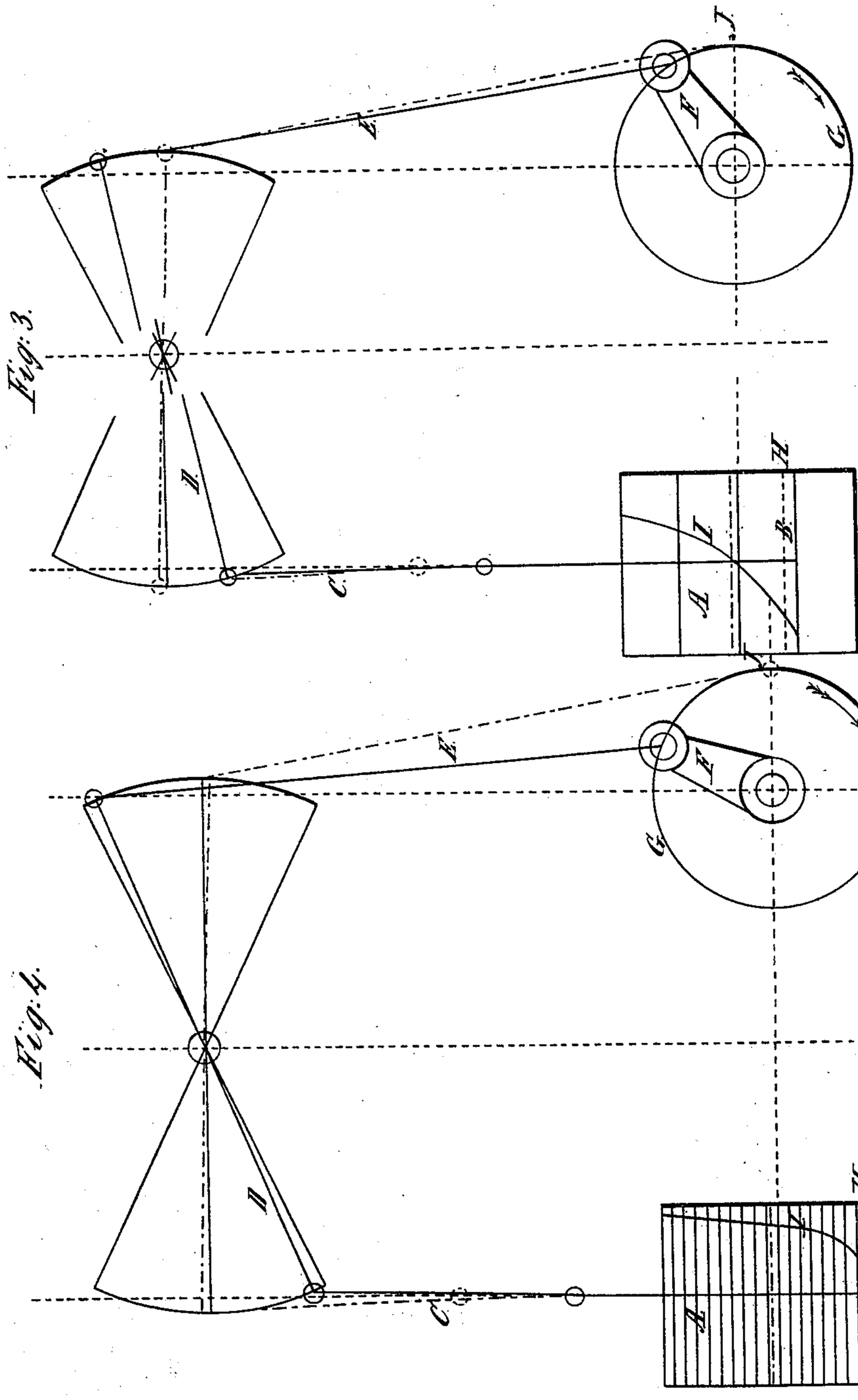


Fig: 4.

UNITED STATES PATENT OFFICE.

JOHN ERICSSON, OF NEW YORK, N. Y.

ARRANGEMENT OF ENGINE FOR USING STEAM EXPANSIVELY.

Specification of Letters Patent No. 6,844, dated November 6, 1849.

To all whom it may concern:

Be it known that I, JOHN ERICSSON, of the city, county, and State of New York, have invented certain new and useful Improvements in Steam-Engines, and that the following is a full, clear, and exact description of the principle or character which distinguishes them from all other things before known and of the manner of making, constricting, and using the same, reference being had to the accompanying drawings, making part of this specification, in which—

Figure 1, is a vertical section of a steam engine on my improved plan, taken in a plane parallel with the beams and passing through one of the cylinders and the crank shaft; and Fig. 2, another vertical section taken at the line (A, *a*,) of Fig. 1; Figs. 3 and 4, are diagrams of the ordinary beam engine to illustrate the irregular mechanical force of the crank of steam engines working expansively.

The same letters indicate like parts in all the figures.

It is a well known fact in the application of steam as a motive power, that the more the principle of expansion is introduced the more economical will be the effect produced, provided some element or elements be not introduced in the mechanism to counteract it. To give the full effect to this expansive principle of steam either it should be applied to a resistance which decreases in the exact ratio of the decreasing pressure of the steam by reason of its expansion or dilatation, or what amounts to the same thing the leverage of the connections with the body impelled by this force should increase in the inverse ratio of the decreasing pressure. The ordinary crank engine in general use presents in nearly every particular the reverse of the requirements of this problem, and it would be difficult to conceive a mechanism theoretically so ill adapted to the application of this principle, but still from its practical advantages in other particulars it continues in use because of the practical objections to all other plans which have been suggested for overcoming its theoretical defects.

The irregular mechanical force of steam applied expansively to the ordinary beam engine is illustrated in diagrams, Figs. 3 and 4, the former being based on the assumption that the steam is cut off at one quarter of the stroke, and the latter at one twentieth. In these diagrams (A) represents the cylinder; (B) the piston; (C) the piston connecting rod; (D) the beam; (E) the crank connecting rod; (F) the crank; (G) the circle described by the center of the crank pin in the rotation of the crank; and (I) the line of pressure of the expanding steam.

When the steam is cut off at one quarter of the stroke one half of the whole mechanical force of the steam is expended in forcing the piston up to the dotted line (H), a little more than one quarter of the entire stroke, the crank making but about one third of its semi rotation from the dead point, and therefore along that part of the rotation in which it presents the shortest leverage. During the next quarter of the stroke the crank passes to the red line (J) which indicates the half of the semi-revolution, and in passing to this point the leverage of the crank increases nearly in the inverse ratio of the decreasing pressure of the steam on the piston; but this is the only part of the stroke in which the motion and leverage of the crank are in such relation to each other as to give an approximation to a regular action of the steam, whereas during the remaining half stroke the leverage of the crank decreases as the pressure decreases. The great defect is to be found in the fact, that, (when the steam is cut off at quarter stroke) one half of the mechanical force of the steam is exerted in moving the crank through only one third of the circuit due to the entire stroke, the other two thirds remaining to be effected by the other half of the mechanical force of the steam, and therefore the power applied during one half of the semi revolution of the crank is much less than during the other half, and that too by a force decreasing as the leverage to which it is applied decreases. But it will be seen by reference to diagram Fig. 4, that this irregularity so wasteful of power, increases as the steam is cut off at a less portion of the stroke, as for instance, in this diagram the steam is supposed to be cut off at one twentieth of the stroke. In this example the line of mean pressure (H) is at one eighth of the stroke and therefore one half of the mechanical force of the steam has been exerted in moving the piston only one eighth

of its stroke, the remaining seven eighths of the stroke having to be effected by the remaining half of the mechanical force. It follows from these illustrations that the more expansively steam is applied to the ordinary crank beam engine the more irregular will be the effect produced. To give a clear idea of this defect I will state it in another form.

In the present crank beam engine the piston passes through $\frac{11}{20}$ths of the stroke while the crank pin performs a quarter of a circle from the dead center farthest from the piston, and if the steam in the cylinder be expanded four times the piston in passing these $\frac{11}{20}$ths of the stroke exerts about three-fourths of the power developed during the entire stroke. The amount of force transmitted to the crank during the first quarter of the semi revolution from the said center will accordingly be three times as great as during the second quarter.

The leading feature of the new engine consists in the proportioning and combining its various parts in such a manner that the amount of force transmitted to the crank during the first and second halves of its semi revolutions shall be alike although the steam be expanded upwards of twenty times and notwithstanding the extreme irregularity of such high degree of expansion. By reference to the drawing it will be seen that the equable distribution of the irregular motive power is effected by a machine as simple as the present crank engine.

Much has been pretended in regard to the application of the expansive principle to crank engines but no important result has heretofore been realized.

To apply the irregular pressure on the piston in such a manner that a continuous power shall be transmitted to the crank corresponding in magnitude to the arcs through which it moves has not hitherto been the problem which engineers have proposed to solve.

The new engine it will be seen is a solution of this problem; not only does it transmit an equal amount of motive power during each half of the semi-revolutions of the crank at ordinary practicable degrees of expansion; say four times the original bulk, but even when the steam is expanded upwards of twenty times with its attendant extreme irregularity of force does the engine produce a more uniform power than the present non-expansion crank engine, at the same time reducing the consumption of fuel to only about one fourth of the latter.

I have taken the common crank beam engine as the example because the union of all my improvements, by which I am enabled to obtain the best results, requires the crank beam engine; but it will be found that the same defects exist in all crank engines heretofore used, and by the use of some of my improvements applied to crank engines without the beam, I am enabled to obtain good results.

My invention therefore consists first, in placing the axis of the crank shaft in a plane nearer than heretofore to the axis of vibration of the beam which transfers the power from the piston to the crank, that is instead of placing the axis of the crank shaft as heretofore in a plane midway between a plane passing through the axis of the connection of the connecting rod with the beam at the two extremities of its vibration and a plane parallel to it and passing through this point of the beam at the middle of its vibration, I place it within this plane, that is in or near a straight line passing through the axis of the connection of the connecting rod and beam at the extremities of the vibrations of the beam, whereby less than the first half of the stroke of the piston shall carry the crank through one half of its semi-revolution, that is, from the dead point to the right angle, and the remaining portion of the stroke more than one half shall give to the crank the remaining half of the semi revolution, that is, carry it from the right angle to the other dead point, and at the same time bring the center line of the connecting rod which should be shorter than heretofore, say a little more than double the throw of the crank nearer to a right angle with the crank during the second half of its semi revolution than during the first half, and thus not only increase the proportional velocity of the piston while impelled by the expanding steam but make it act on a larger lever than by any other known crank engine. Secondly, in combining two expansion single action crank engines, acting on cranks placed on the shaft at an angle of 180 degrees, whereby I am enabled to apply the force of expanding steam more economically, and produce a more regular motion than by any other plan of crank engine before known. And thirdly—in combination with a two throw crank shaft having the two cranks on opposite sides of the center the making of the second of the two engines so connected with the same crank shaft of greater capacity than the first and receiving steam at one end only and from the first, this end being alternately connected with the first engine to receive steam and with the condensor for exhausting, that the piston may be acted upon in one direction by the expansion of steam after it has acted in the first engine, there being a vacuum in both sides of the piston during its return motion, when this is combined with the first engine which receives the steam at one end only, its other end being connected with that end of the second engine which receives the steam, so that during the return stroke of the piston

in the first engine it shall be balanced by the expanding steam while it is acting on the piston of the second engine.

In the accompanying drawings (*a*) and (*b*) represent two beams having the same axis of vibration, and both of the same proportions. The short arm of the one (*a*) is connected by a rod (*c*) with the piston rod (*d*) of a piston (*e*) that works in the cylinder (*f*) of what I denominate the first engine and the corresponding arm of the other beam (*b*) is in like manner connected with a piston (*g*) working in the cylinder (*h*) of the second engine, and which is to be placed as near as practicable to the first. The long arms of the two beams are connected by rods (*i j*) with two cranks (*k*, *l*,) on the crank shaft (*m*) and opposite to each other, that is dividing the circle into two equal parts, that one piston may be up while the other is down, and, vice versa. The connecting rods (*i*, *j*,) should be about two and a half times the length of their cranks. The axis of the crank shaft is in the straight line (*n*) passing through the center of the connections of the connecting rods (*i*, *j*,) with the beams (*a*, *b*,) when at the extremity of the vibration of the beams from which position relatively to the proportions of either one of the beams, length of crank and connecting rod, it results that the long arm of the beam in being moved to the position indicated by the dotted line (*o*), about one third of its entire vibration, by one third of the down stroke of the piston (*e*), will carry the crank (*k*) from the dead point to the right angle, one half of its semi-revolution as indicated by the dotted lines (*p*) and that in passing through the remaining two thirds of its vibration to the position occupied in the drawings by the beam (*b*), by the remaining two thirds of the down stroke of the piston (*e*) the crank (*k*) will be carried the remaining half of its semi revolution to the second dead point. The dotted lines (*q*, *q*, *q*, *o*, *o*, *o*,) and (*p*, *p*, *p*,) illustrate how much nearer to a right angle the pull of the connecting rod is on the crank during the second half of its semi-revolution than during the first half, for this directness of the pull during the second half of the semi-revolution must be greater than during the first half in the proportion of the greater range of motion of the piston during, one than the other, that is in the proportion of two to one, or nearly so. So soon as the first piston has reached the end of its down stroke and its crank has performed the effective half of its revolution, the second piston begins to descend producing the same effect on its crank; and in this way the two pistons and their cranks alternate, no force being applied to either of the pistons during their up motion; and the cranks therefore each passing through the remaining half of their revolutions without any impelling force being applied to them.

Steam is admitted to the upper end of the first cylinder (*f*) from the steam pipe (*s*) by a slide valve (*t*) which is held up in the position represented in the drawing, and with the port closed by an arm (*x*) of a rock shaft (*y*) which has another arm (*u*) with a weight (*w*) to bear it down on the periphery of the cam (*z*) by which the required motions are given to the valve. This cam is represented by dotted lines, and from the point 1, to 2, it is concentric and during this part of the rotation of the crank shaft the valve remains closed by the weight, but from 2 to 1 the cam has an enlargement which acts on the arm of the rock shaft to depress and open the valve for the admission of steam to the cylinder, and therefore the extent of this cam-like projection in the direction of the periphery will determine at what portion of the stroke the steam shall be cut off. After the valve is closed the steam acts on the piston expansively until the end of the down stroke, a sliding valve (*a'*) then opens a port (*b'*) which establishes a communication between the upper end of the two cylinders that the steam may act on the piston (*g*) to force it down solely by its expansive force, the second cylinder (*h*) being of much greater capacity than the first, and so much larger, that the steam acting by expansion therein during the range of the piston shall exert on it a mechanical force about equal to that which it exerted on the first piston. It will be seen that the arm of the second cylinder, as represented in the drawing is five times that of the first cylinder and hence when the steam in the latter is cut off at one quarter stroke, the steam will have been expanded twenty four times by the time that the piston in the second cylinder has reached the termination of the down stroke. It will also be seen that notwithstanding this great expansion the regularity of the force transmitted to the crank shaft will be greater than in common engines expanding the steam only twice the original bulk in the cylinder. The stem of the valve (*a'*) is jointed to a lever (*c'*) that turns on a stud pin at (*d'*) its other end being forked to embrace an eccentric (*e'*) on the crank shaft by which it is operated.

The lower end of the second cylinder is always in communication with the condenser by means of the pipe (*f'*), and the upper end also communicates with the condenser by means of a passage (*g'*) governed by the valve (*a'*), and the motion of this valve is such, that at the end of the down stroke of the piston (*g*) this passage is opened, which exhausts the steam from the cylinder, thus establishing a vacuum above as well as below the piston, that it may move in vacuum during its return motion, and

while the piston is carried down in the first cylinder by the pressure of the steam.

There is a connection or passage (h') between the lower end of the first cylinder and the upper end of the second cylinder, partly represented by dotted lines, so that when the upper end of the second cylinder is exhausted the lower end of the first is also, to establish a vacuum below the piston (e) during its descent, but when the valve (a') is opened to pass the steam from the first to the second cylinder, it also communicates with the lower end of the first cylinder by the passage (h') so that while the second piston is being forced down by the expanding steam the first piston is balanced during its return motion by the pressure of the steam on both sides of it, thus making the full pressure of the steam on the large piston available instead of having it react against the surface of the first piston, as in Wolf's expanding engine.

I do not wish to limit myself to the precise proportions or location of the crank shaft as these may be greatly varied within the principle of my invention without effecting the result except in degree. Nor do I wish to limit myself to the employment of all my improvements in connection as important results can be obtained by either one of them separately. As for instance obtaining an equal or nearly equal mechanical force on the first and second halves of the semi-rotation of the crank when using steam expansively by the principle involved in changing the position of the crank shaft relatively to the axis of vibration of the beam, may be advantageously employed with only one engine for many purposes. The use of two engines with the cranks on the same shaft and on opposite sides of the center may be advantageously applied to obtain a more regular mechanical action on the crank shaft by the use of expansive steam on two ordinary engines with or without the beams, without the use of the first or third branch of my invention.

What I claim as new is—

1. Placing the axis of the crank shaft of single acting beam engines in which the steam is applied expansively nearer to a line parallel to the axis of the cylinder and passing through the axis of vibration of the beam on the principle herein specified, and for the purpose of obtaining a more regular mechanical action on the crank by the application of the expansion principle of steam, as described.

2. I also claim the employment of two single action expansion crank engines with their cranks on one and the same shaft and on opposite sides of the center, that is, at an angle of 180°, substantially as described.

3. And I also claim in expansion engines having two cylinders with pistons moving in opposite directions, and connected with cranks on opposite sides of the center, in one of which the steam acts by expansion alone, having one end of the large or expansion cylinder at all times in connection with the condenser, and the other alternately in connection with the condenser and with the steam end of the smaller cylinder, that the large piston during its return stroke may have a vacuum on each side, as described, when this is combined with the smaller cylinder connected with the boiler and so arranged as to have both ends in connection with one end of the larger or expansion cylinder so that when the piston of the smaller cylinder is acted upon on one side by the steam there shall be a vacuum on the other side, and when the steam is acting by expansion on the larger piston, it shall be in connection with both ends of the small cylinder as described. I do not wish to be understood as claiming the mode of connecting the small and the large expansion cylinders when so arranged that the two pistons are connected and move together and in the same direction, for this was known before in what is known as the Leghwater engine; but I do claim it when arranged as, and in the combination herein specified.

4. And thirdly in combination with a two throw crank shaft having the two cranks on opposite sides of the center, the making of the second of the engines so connected of greater capacity.

J. ERICSSON.

Witnesses:
PETER HOGG,
JAS. B. WARD.