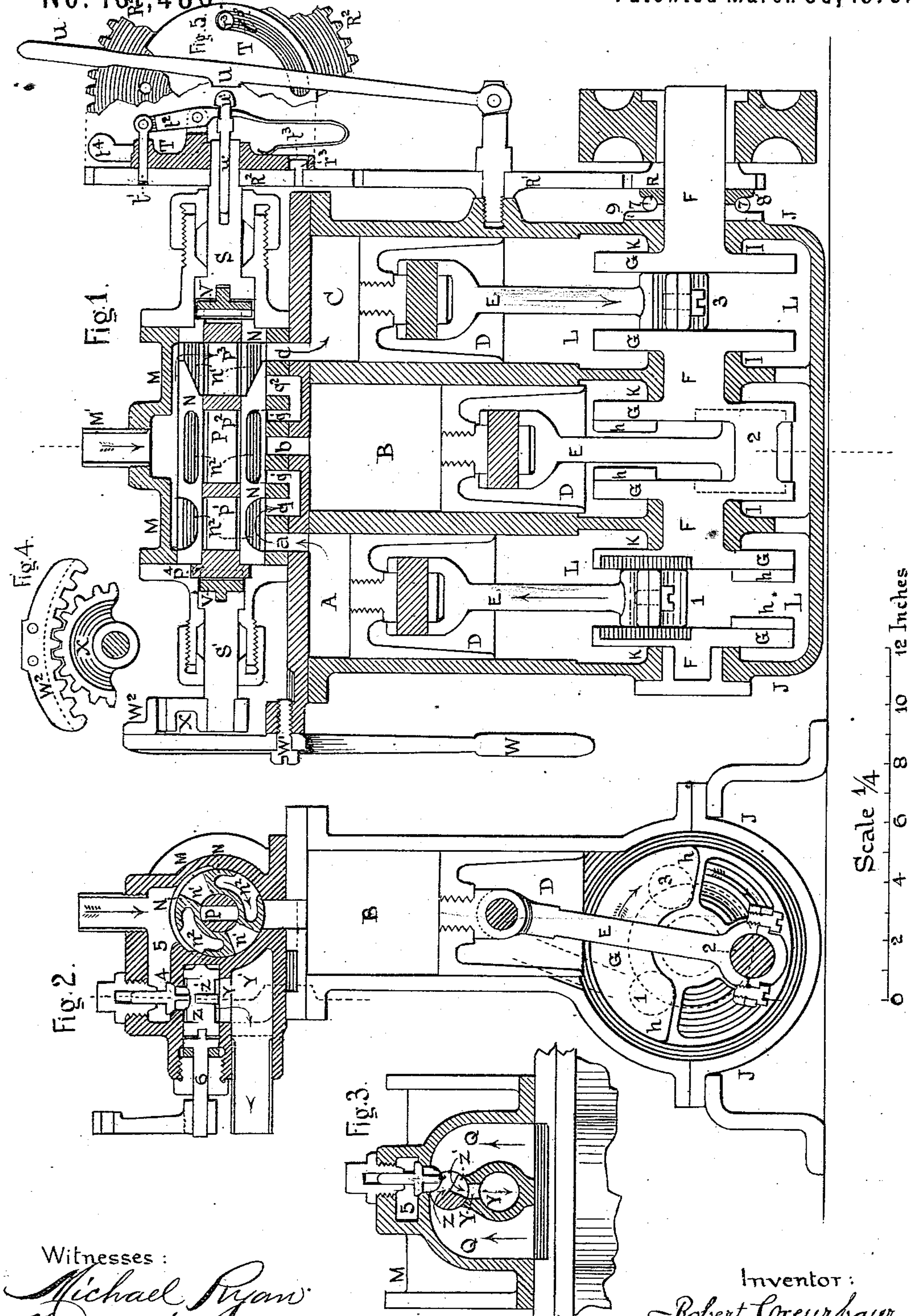
2 Sheets--Sheet 1.

R. CREUZBAUR.

Direct-Acting Reciprocating-Engine.

No. 161,486. Patented March 30, 1875.



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2 Sheets--Sheet 2.

R. CREUZBAUR.

Direct-Acting Reciprocating-Engine.

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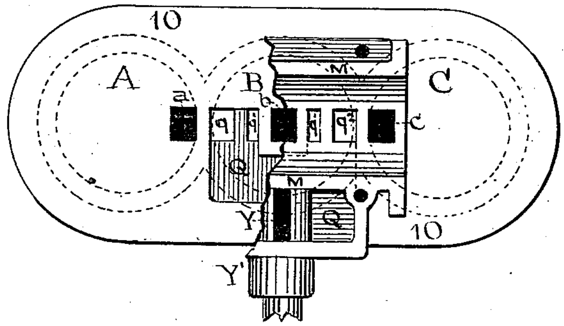
Fig. 6



½ Scale

Fig. 7

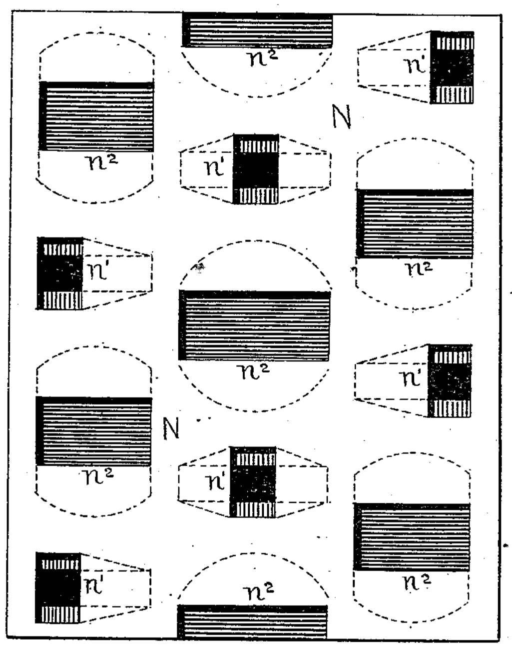


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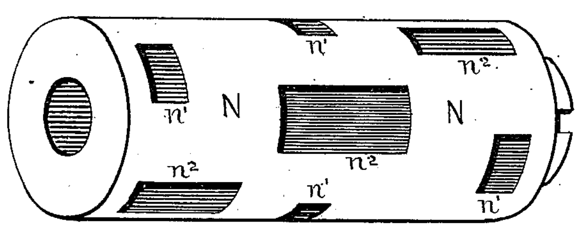
Fig. 8.



Full Size

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UNITED STATES PATENT OFFICE.

ROBERT CREUZBAUR, OF WILLIAMSBURG, (BROOKLYN,) NEW YORK.

IMPROVEMENT IN DIRECT-ACTING RECIPROCATING ENGINES.

Specification forming part of Letters Patent No. **161,486**, dated March 30, 1875; application filed May 26, 1874.

To all whom it may concern:

Be it known that I, ROBERT CREUZBAUR, of Williamsburg, in the city of Brooklyn, county of Kings and State of New York, have invented certain Improvements in Single-Acting Reciprocating Engines, of which the following is a specification:

The first part provides for the pressure and wear on the valve being always in the same direction as that on the pistons, crank-shaft, crank-pins, and their connections, and the preservation of a proper relation between all of the several parts of the engine notwithstanding the wear.

The second part provides for diminishing the obliquity of the connecting-rod on the working side by about one-half.

The third part provides for the steam distribution by one rotating valve serving for two or more steam-cylinders, arranged as described.

The fourth part provides for cutting off the steam at any part of the stroke of one or more such engines by a valve placed centrally into the aforesaid distributing-valve, in the manner named.

The fifth part provides for rotating such distributing-valve and controlling such cut-off valve each by an intervening loose T-head, giving independent lateral motion to each separately, with reference to their respective controlling-shafts, which allows the said valves to remain undisturbed in their normal positions by the parts controlling them.

The sixth part provides a simple combination for reversing the engine while in motion.

The seventh part provides for reducing the stroke of the lever controlling the cut-off valve, so as to prevent an excess of its stroke when used for both forward and backward gear.

The eighth part provides for back pressure on the escape side by obstructing and closing the outlet of the escape steam, and also by admitting boiler-pressure to the escape-passages. This is required, for instance, in the propulsion of street-cars, to stop the car, and to control its speed on a down-grade.

Figure 1 is a vertical longitudinal section of a three-cylinder engine with said improvements. Fig. 2 is a central vertical section of the same at right angles to Fig. 1. Fig. 3 is a section through the valve-head, parallel with Fig. 1, along the dotted line, Fig. 2. Fig. 4 is an end view, at right angles to Fig. 1, of the toothed sectors which control the central cut-off valve. Fig. 5 is an end view at right angles to Fig. 1, illustrating the reversing motion. Fig. 6 represents the lower half of part of valve-casing M and the cylinder-cover 10 10, with their steam and escape ports and passages. Fig. 7 is a surface view of the valve N on a plane with the relative position of the ports therein. Fig. 8 is a perspective view of the valve N.

The three cylinders A B C are arranged side by side. Each cylinder has a deep piston, D, and a connecting-rod, E, the latter taking hold of the respective crank-pins 1 2 3. These crank-pins are affixed around crank-shaft F, so that lines passing centrally through these crank-pins, parallel to the crank-shaft, will be one hundred and twenty degrees distant from each other, the crank-pins 1 2 3 being so represented in Fig. 2.

For common purposes, when the engine is to be used mostly in one direction, the obliquity of the connecting-rods E and the friction caused thereby are reduced to one-half by placing the crank-shaft to one side of the cylinder-centers, away from the working side, a distance equal to about one-fourth of the stroke. This adds the obliquity removed from the working side to the non-working return-stroke side, where it does no harm.

The crank-pins 1 2 3 are connected to the crank-shaft F by disks G. These disks may be cored out around the crank-pins, as shown in Fig. 2, for the purpose of balancing the weight of the crank-pins and of about half of the connecting-rods. If still more such balancing weight is required, special weights *h h* are affixed to the disks opposite to the crank-pins, as represented.

The main bearings I of the crank-shaft F are cast with the cylinder-cap J, as represented. The tops K of the shaft journal-boxes are cast upon the main cylinders A B C, as represented. With proper steam distribution the shaft presses constantly upon the lower bearings I, or upon the upper bearings K when running backward under the modified mode of action here below named.

Usually the steam is admitted upon the outward side of the piston only, bearing it inward toward the crank-shaft. On the outward or non-working stroke, the escape steam, together with proper lead in the steam admission, keeps up an overpressure toward the shaft also. All connections between the pistons and the shaft thus sustain compression only and constantly, and wear upon one side solely. Therefore no adjusting parts to take up the wear are necessary, loose journal-boxes and connections being admissible throughout. The friction usually caused by tight journal and crank-pin boxes, unavoidable in engines otherwise constructed, is thus totally avoided.

The placing of the cylinders side by side, as named, is of particular importance, as being essential to press the shaft continuously in one direction, thus avoiding tight journal-boxes, and preventing knocking in the bearings, particularly at high speeds. So placing the cylinders side by side also balances the moving weights against each other, so far as their lateral distances allow it, these weights being equally distributed around the shaft. On account of these lateral distances a better action is attained by balancing these weights in part, as above named.

The dead-points of the crank-pins are not, as usual, in the plane coinciding with and passing through the axis of the cylinders. The connecting-rods E being of a length equal to twice the stroke, and the shaft being to one side of the plane passing through the cylinder-axis a distance equal to one-fourth of the stroke toward the non-working side in forward gear, the crank-pins are on their dead-points upon a line about nine degrees thirty-five minutes, or a distance of one-sixth of the crank-arm, ahead of a line parallel to the cylinder-axis and passing through the shaft-axis.

The main or distributing valve N is cylindrical, and has a bearing upon more or less than a half-circle of its casting M, as represented. The live steam enters by pipe M′, and, bearing upon the top of the valve N, enters the ports thereof exposed to it. The valve N has as many sets of ports as there are working cylinders. The number of ports corresponding to one cylinder, and forming one set, depends upon the relative number of revolutions of the valve and the crank-shaft. The valve of the engine represented makes one revolution while the crank-shaft makes two. Hence there are two steam-ports, n^1, opposite to each other, and two escape-ports, n^2, also opposite to each other, to each cylinder, forming a set. These three sets of ports are arranged around the valve corresponding to the relative positions of their respective crank-pins, to wit: The set of ports of cylinder A is one hundred and twenty degrees ahead of that of cylinder B, and the set of ports of the latter are one hundred and twenty degrees ahead of the set of ports belonging to cylinder C, and so on. Each cylinder has a corresponding port, marked, respectively, *a*, *b*, and *c*. The two steam-ports n^1 n^1 of each set connect, so that the steam from the upper valve-chamber can pass centrally and alternately through the valve into the said cylinder-ports *a*, *b*, and *c* when the ports n^1 and *a*, *b*, or *c* coincide, unless obstructed by the cut-off valve P, as here below named. The escape-ports n^2 connect the ports *a b c*, respectively, with the passages q q^1 q^2, which open into the chamber Q, Fig. 3, from which, in engines for usual purposes, the steam escapes directly.

The cut-off valve P is stationary, except while it is made to change the grade of expansion, or to cut the steam off totally. It has three slots, p^1 p^2 p^3, parallel to each other, and corresponding in length and position to the inner formations of the three couples of valve steam-ports n^1. On account of the slower advance of the valve N over the cut-off valve P, as compared to its passage over the ports *a b c*, on account of the greater distance of the latter from the center of motion of the valve, the openings P^1 P^2 P^3 through the cut-off valve P must be longer than the ports *a b c* in the reverse ratio to such difference in speed, the inner conformation of the valve-ports n^1 conforming to such greater length.

The area admitting steam during the opening and closing of the ports should be in proportion to the speed of the pistons and in proportion to the admission of steam during their maximum speed. To obtain such proportion the ports *a b c* and the corresponding steam-ports in the valve must have a certain width, determined by the diameter and relative velocity of the valve Such width is obtained in this case by dividing four times the area of the port by the diameter of the valve.

Motion is given to the valve N from the crank-shaft by two or more gear-wheels. The drawing represents three such wheels, R R^1 R^2, arranged to give the valve half the number of revolutions of the shaft. The wheel R^2 sets loosely upon the valve-carrying spindle S. The reversing-wheel T is keyed upon spindle S, and is carried by the said wheel R^2 by bolt t^1, the latter being held in place, as shown, by pivoted lever and spring t^2. The lever U, pivoted upon the stud of the transmission-wheel R^1, serves to disconnect the wheel T and the valve from the gear-wheel R^2 by pressing upon the central pin U′, this pin being loosely connected to the lever-spring t^2. The wheel R^2 has another entrance-hole for the bolt t^1, corresponding to its position when the valve and engine are reversed. The stud r^3, upon the face of wheel R^2 moves during the reversing motion in the circular slot t^3, cut into the wheel T.

The reversing parts operate in this manner: The engine being, for instance, attached to a street-car in motion, the pressure by lever U upon the head of pin U′ raises the connecting-bolt t^1 out of the gear-wheel R^2. The valve, by its friction, then ceases to move.

The wheel R^2 continues to move with the engine and car, the latter impelled by steam already delivered to the cylinder and by momentum. When the stud r^3, moving with the wheel R^2, will have arrived at the other end of the slot t^3 the driving-bolt t^1 will have reached its seat in wheel R^2, and is snapped into it by the lever-spring t^2, the said stud and slot preventing the passage of the bolt t^1 over its seat without entering. The valve is then in full position for the reverse motion. When the parts have not sufficient momentum fully to accomplish the reversing motion, the valve is turned back by hand, taking hold of the hand-knob t^4 upon wheel T for that purpose. The rotations of the spindle S are transmitted to the valve by the universal joint or T-head V, formed of a disk, with a tongue across it on each side, at right angles to each other, which tongues fit into corresponding grooves cut into the ends of spindle S and valve N. The diameter of the T-head and of the valve end are made smaller than their casing, so that the valve may have perfect liberty to accommodate itself freely at all times to its bed or casing M.

The cut-off valve P is connected to its controlling-spindle S′ in like manner, the head p^4 of this valve having also ample play, so as not to impede the main valve. When the cut-off valve is to be used for forward gear only, its spindle S′ is controlled by a simple lever; but when it is to be used both in back and forward gear, the swing of the lever would become excessive. Therefore the lever W, pivoted at W^1, is attached to the toothed sector W^2, having about double the radius of the small sector X, keyed upon the spindle S′. To cut the steam off shorter, the cut-off valve is turned in the reverse direction of the valve's motion.

When it is desired to have the valve balanced for obtaining a higher steam duty, at the cost of simplicity and durability, it is given a slight taper with a bearing all round, and with duplicate ports *a b c* on opposite sides. The steam in such case is admitted at the end to the center of the cut-off valve P, this valve being also tapered and closely fitted.

When such an engine is to be used, for instance, in controlling a street-car, and so that the car can be stopped and checked on a down-grade, by steam, instead of by ordinary brakes, a special combination becomes necessary.

The means for retarding the engine and the car are these: Upon cutting off the steam entirely by the cut-off valve P, or otherwise, more or less of a vacuum must form behind the pistons, retarding the car. If the escape steam is throttled or retained, the car must also be retarded. Neither mode is sufficient for extreme cases, and for rapidly stopping the car. More than sufficient retardation for all cases is obtained by admitting the boiler-pressure into the escape-passages.

The escape steam from the chamber Q, Fig. 3, is made to pass by the valve Z and through port Y into the escape-steam delivery-pipe Y′. The escape steam is throttled or totally retained by covering port Y by the valve Z. This valve is a cylindrical block, cut away in the middle, so as to leave a section of about one-third of the cylinder, which is sufficient to cover the port, and allows the passage of the steam by and over it. Midway, a nose, Z′, is left standing, which, after the port Y is closed, serves to raise the little valve 4, which opens a passage to the live steam in the chamber 5 of valve-casing M. Through the closing of the port Y the confined steam might be so compressed by, for instance, the momentum of a car that a pressure injurious to the engine might be produced. In such case the little valve 4 acts as a safety-valve, preventing an excessive pressure by allowing the surplus to enter the boiler. When the car or engine is to be checked rapidly, the valve Z is turned until the nose Z′ raises the valve 4, and admits the boiler-pressure into the escape-passages. The valve Z is operated by spindle 6. A tongue on its end disk enters a slot in the end of the valve, this slot being so cut that when the valve is covering port Y the slot will point to this port, downward, the valve in that position being entirely unimpeded by its carrying-spindle 6.

To prevent the entrance of dust into the crank-shaft chamber L a rubber ring, 7, is applied to press the washer 8 closely against the gear-wheel R, the ring also excluding dust from between the two washers 8 and 9, or between the washer 8 and the engine-casing. The crank-chamber L is an air-space only. To free it of water formed by steam leaking past the pistons a small trap in a pipe, of any usual construction, is attached to let out the water, while preventing the entrance of dust.

It is evident that when this engine is reversed the obliquity of the connecting-rod on the then working side becomes three times as much as when working forward. Therefore, if the engine is to be much used in reverse-gear, the shaft should be placed centrally to the cylinders. The engine may, however, be used in the reverse direction with less additional friction, the connecting-rod being retained on the same side both in forward and backward gear, and without additional friction, if the engine is not worked expansively, as follows: The reversing parts above named are dispensed with, excepting the disk-wheel T, knob r^3, and slot t^3, the play of this knob in the slot t^3 being equal to twice the lead of the valve.

The escape steam is passed through the crank-shaft chamber L, and from there through a four-way cock or equivalent slide-valve to its destination. The live steam also passes from the boiler through the four-way cock or valve to the distributing-valve chamber. The operation of the engine in forward gear is precisely as described and represented.

To reverse the engine a quarter-turn is given to the four-way cock, so as to connect the escape-passages with the boiler, and the valve-casing M with the escape-steam outlet. The chamber L will then be full of live steam, keeping the connecting-rods continuously on tension, the outer cylinder-chambers A B C filling with steam and discharging alternately. As the steam passing to the cylinder-chambers A B C first fills this chamber L, there is always an overpressure in the latter, keeping the connecting-rods on tension. When live steam is upon both sides of one of the pistons, its non-working inward stroke takes place. When the steam escapes from its outer end, the working and outward stroke takes place. The steam is used expansively during the non-working or inward stroke, during which the connecting-rod has the most obliquity; consequently the pressures upon the opposite ends of each piston during this stroke are not nearly balanced, as they are during the non-working stroke while operating in forward gear, as first above described. In proportion to the difference in these pressures, or in proportion to the degree of the expansion used, the obliquity of the connecting-rod causes friction in the moving parts attached to it; but this difference in the pressures upon the piston, or the difference in the friction produced by it, is evidently not near as much as when running backward without live steam in the chamber L, as first described, as in that case the working side has the greatest obliquity of connecting-rod, while none of the pressure upon the steam side of the piston is balanced by steam upon the other side. When running backward by this mode of reversing with a four-way cock or slide-valve, the advantage of half the usual obliquity of the connecting-rod during the working stroke is preserved, as named.

The modifications required for using this engine upon the compound system are simple and self-evident. They are made the subject of a separate specification.

I claim as my invention—

1. The combination of two or more single-acting cylinders arranged side by side, a crank-shaft arranged at one end of the said cylinders, in connection with the pistons thereof, and a rotary valve, common to all of said cylinders, arranged at the opposite end thereof to the crank-shaft, and driven by gearing from the said shaft, all substantially as herein described.

2. The combination, with the two or more single-acting cylinders A B C, arranged side by side, and their pistons and connecting-rods, of the crank-shaft F, placed to one side of the central plane of the several cylinders, substantially as and for the purpose herein specified.

3. The rotating distributing-valve, with its duplicate steam-ports n^1 n^1 and duplicate escape-cavities n^2 n^2, in combination with the valve-seat having ports a b c q q q^1 q^1, the whole arranged substantially as herein described.

4. The variable cut-off valve, composed of a spindle, with transverse slots p^1 p^2 p^3 extending through it, one for each cylinder, in combination with the surrounding rotary main valve having two steam-ports, n^1 n^1, the whole arranged substantially as herein described.

5. The combination of a rotary valve, its stem, and a connection-piece, provided with tongues on opposite sides to fit into grooves in the adjoining ends of the valve and stem, substantially as set forth.

6. The combination, for reversing the engine, of the loose gear-wheel R^2, the valve-carrying wheel T, driving-bolt t^1, spring-lever t^2, and check-stud r^3, arranged to operate substantially as and for the purpose hereinbefore set forth.

7. The combination, with a cut-off valve, P, and its controlling-spindle S^1, of the sectors X W^2 and lever W, arranged substantially as and for the purpose hereinbefore set forth.

8. The escape-steam stop-valve Z and port Y, in combination with the check-valve 4, operating in relation to each other substantially as described, and for the purposes set forth.

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