T. Carpenter,

Steam Cut-Off.

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TISDALE CARPENTER, OF PROVIDENCE, RHODE ISLAND.

STEAM-ENGINE.

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To all whom it may concern:

Be it known that I, TISDALE CARPENTER, of Providence, in the county of Providence and State of Rhode Island, have invented certain new and useful Improvements in the Arrangement and Manner of Working the Valves of Steam or other Engines, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, making a part of this specification, in which—

Figure 1, is a side elevation of the cylinder of a horizontal engine, including that portion of the bed piece to which it is attached with the regulator and valve gearing arranged in their natural position when the engine is at rest. Fig. 2, is an end elevation of the same in a similar condition. Fig. 3, is a plan view of the same as it would appear in looking directly downward upon it. Fig. 4, is an end view of the cylinder head, the same as Fig. 2, would appear with the bonnets taken off so as to expose to view the valve seats and the manner in which they are arranged. Fig. 5, is a cross section of the same directly through the center, showing still further the arrangement of the valves upon their seats, together with the steam passages and the direction of the steam in its motion in and out of the cylinder. Fig. 6, is an enlarged plan view of the lower half of the cam C, C′, by the means of which the induction valves are closed, so arranged, as to illustrate the manner in which the time of closing said valves is made variable. Fig. 7, is an enlarged view of the steam valve and its surroundings, and, Fig. 8, is a cross section of the same for the purpose of illustrating the difference in the manner of taking the steam into the cylinder in the present arrangement instead of the one usually employed.

In the arrangement of the figures the same letters refer to the same parts.

The nature of my invention and improvements in steam or other engines consists in operating the induction or supply valves with a positive motion in each direction, and a variable cut off; by means of a compound cam, and variable rocking levers either with or without a regulator and without detaching or releasing the said valves from the devices that move them, also in arranging and operating the eduction or exhaust valves in the cylinder heads parallel with the motion of the piston by a separate or independent valve movement.

That others skilled in the mechanic arts may make and use my invention, I will now proceed to describe the manner in which I have carried it out.

In the drawings A, represents a portion of the frame or bed piece to which the working parts of an engine are attached.

B, is the cylinder represented in the drawings and model as cased up in the usual style to prevent condensation.

C, C′, is the compound cam by which the induction valves are worked.

D, D, represent the rocking levers to which the induction valves are attached by the valve stems *t*, *t*. They also show the sliding rods *z*, *z*, dotted into the figure and carrying on their outer ends the trucks or friction rolls *r*, *r*, placed there to avoid friction and wear on the cam C, C′.

e, *e*, are standards carrying the rocking levers on trunnions *y*, *y*, and also forming the support for the small toothed quadrants *s*, *s*, the teeth of which, working into similar teeth upon the sliding rods *z*, *z*, form with the rods *f*, *f*, an obvious connection with the regulator.

The upright shaft H, is driven by a horizontal shaft and bevel gears directly from the main shaft of the engine. These are not represented in the drawings and model, the only thing necessary being that the gears shall be of equal size so that the shaft H, will make the same number of revolutions as the main shaft does. Said shaft H, carries upon its lower end the cam J, which with the yoke *k*, sliding rod L, and connections *m*, *m*, move the exhaust valves *u*, (see Figs. 4 and 5) so as to open and close the exhaust passage *x*, the object in view, and this arrangement permits, the exhaust valves to be opened very quickly at the proper time to remain at rest with the port wide open as long as possible, and then to close quickly again; both valves being attached to the same rod L, of course work in unison. The advantages obtained by this arrangement over the common way of working with an eccentric, are, first, that the valve is opened and closed quicker, which allows a better egress to the steam; second, that the valve does not have to move so far, only requiring just enough lap to insure against leakage; third, that it takes less power, because the

valve is at rest a part of the time, instead of being constantly in motion under steam pressure; fourth, that the valve is moved at the time when the pressure upon it is least, so that it wears less upon its seat; fifth, and last, as the valve does not have to move so far there is less space around it that has to be filled and exhausted at every stroke of the engine; this point will be more fully explained as we proceed. The shaft H, also carries upon its upper end the spur gear G, which meshes into the corresponding wheel G′, which is placed upon the lower part of the shaft I, this shaft revolves in bearings at its extreme ends, the lower one of which is stepped upon the upper side of the cylinder and the other bearing may be obtained in any manner that may be convenient. This shaft forms the upright spindle of the regulator, and carries immediately above the gear, the cam C, C′. Said cam is formed of two disks of cast iron the corresponding surfaces of which may be chilled or otherwise hardened to make them durable. The upper disk has a projection upon its under surface similar in outline to the dotted mark at C′, Fig. 3, which projection will as the cam rotates in the direction of the arrow (see Fig. 6) alternately depress the rolls *r*, *r*, and as a matter of course raise the valve stems *t*, *t*, and open their corresponding valves. The lower disk or half of the cam is made just the reverse of the upper one; that is where there is a projection on the one there is a depression on the other, the object being to arrange the corresponding parts so that however irregular they may be, there will be just room for the free passage of the friction rolls *r*, *r*, between any part of their surfaces when they are in rotation. This in practice need not necessarily be very exact although a near approach in the outline of one disk to the reverse of the other adds a little to the smoothness of the motion. This arrangement produces a positive closing as well as opening motion to the valves, the object of which is to avoid using a weight or spring for that purpose, in which case the engine has to overcome the resistance arising from said weight or spring every time that it opens the valve, and further, it insures the valve's return to its seat without any slamming or injury in that respect, and never allows it to stick and leave the port open when it ought to be closed, which will often happen with engines using weights or springs to close the induction valves, unless great care is taken in adjusting the stuffing boxes, and other parts connected with the valves; as well as the difficulty arising from the variable pressure of the steam in the boilers; as for instance a weight or spring that will close the valve under fifty or sixty pounds of pressure will not be able to do so, if any accident should increase the pressure to eighty or ninety pounds, which leads to the objectionable practice of choking the steam in the induction pipe of engines that work with such means to close the valves. I wish also to draw the distinction between this plan, and any one by which the valves working with a spring or weight, may finally be closed, with a positive motion at the end of the stroke, if they should fail to do so at the time of cutting off; for in the subject under consideration the valves must necessarily close at said time be it early or late, or the pressure on the valve great or small. The engine also has only the force produced by the pressure of the steam upon the valve to overcome in opening it, while in the other case it has the same force, to which is added the weight or spring that is to produce the returning movement.

I will now describe the combined action of the sliding rods *z*, *z*, with their trucks *r*, *r*, and the cam C, C′, that produced the variation in the time of cutting off the steam and closing the valves.

In the drawings the regulator is represented in its lowest position corresponding to a state of rest, or when the engine is just starting and before it has arrived at its average speed. It would be seen by reference to the figures that the roll *r*, upon the opening valve is at the outside of the circumference of disk C, its point of contact resting upon the line marked 1, (Fig. 6,) consequently the valve will remain open until the disk has rotated so as to bring the point marked 1′, in line with the roll, which corresponds in the drawings to about three quarters of the stroke. This point may be varied at will in constructing the cam so as to make the steam follow a greater or less part of the stroke when the engine is at its lowest speed, and as the speed increases and the regulator rises the latter will slide the rod *z*, *z*, out until the roll *r*, coming nearer and nearer the center of the disk will continue closing the valve earlier and earlier as the points 2′, 3′, 4′, 5′, 6′, 7′, 8′, are reached until the inequalities on the surface of the cams cease, when they will revolve without moving the valves at all and will consequently entirely cut off the supply of steam. As the rods slide toward the center of the cam the point of contact of the roll *r* is carried farther from the trunnion *y*, (which is the fulcrum of the rocking levers D, D,) at every increase of the speed, so that the valve not only closes earlier in regard to the stroke, as the engine requires less steam, but when it begins to cut off short it opens the valve a less distance, which has the effect of making the engine regulate itself with the throttle wide open, no matter how light the load, or how high the pressure of the steam.

I have described the working length of the rocking levers as being varied by making one part to traverse in the other; but I do not limit myself to this mode of construction as they may be made differently and produce the same result; or the rollers may be arranged to traverse on the levers.

The valves are in the cylinder heads instead of being upon the side of the cylinder. It is obvious that the nearer the piston approaches the end of the cylinder, at either extreme of the stroke, the more completely it expels the exhaust steam, and that less fresh steam will be required to fill the area between the piston and cylinder head; which space be it great or small must be filled and exhausted at every stroke of the engine before any effective pressure is obtained upon the piston. It is also obvious that the closer the valve seats are to the interior of the cylinder, the less area of steam passage to or from the ports will have to be filled and exhausted in the same way; and that this applies to the exhaust as well as the induction valves. Now by reference to Fig. 8, it will be seen that the valve *v*, is separated from the interior of the cylinder only by the thickness of the metal forming the head. Consequently the only steam lost at said valve is the amount required to fill that space. The exhaust valves are arranged in a similar manner the valve *u*, Fig. 5, being made as small as possible for this purpose while the mode in which it works allows a full and free passage to the exhaust steam.

In regard to the common manner of taking the steam through the side of the cylinder, with the ports as shown dotted in at 4, Fig. 8, it is evident that, if the piston (a section of which is shown at 1, 2, and 3, in the same figure) comes near the end of the cylinder, the first admission of steam is directly upon the side of the piston which of course produces a deleterious effect upon the working of the engine, to avoid which, it is customary to stop the piston at from one half to three quarters of an inch (or even more in some modes of construction) from the end of the cylinder, and also to bevel off the corner of the piston opposite the port, this produces a large space or area that must be filled and exhausted at every stroke of the engine amounting in a machine of a hundred horse power to not less than two hundred cubic inches.

In the arrangement as now presented the loss of steam in the ports is reduced to the smallest possible amount while the piston may be carried as near the end of the cylinder as may be desired and still receive the steam directly upon its surface in the direction of its motion. In this manner the area of the waste spaces is reduced to the smallest possible extent and the steam admitted and delivered to or from the cylinder in the most direct way. These results are not confined to horizontal engines alone but with slight modification may be adapted to upright ones; and the positive opening and closing motion derived from the compound cam C, C′, may be applied to valves arranged in the usual manner. This motion can also be used as an adjustable cut off on engines that have no regulator to make them automatic, by simply using a binding screw, or its equivalent to hold the rods *z*, *z*, at any place in the rocking levers D, D, that the engineer may choose to set them.

I believe I have now described and represented the improvements which I have made so that any person skilled in the mechanic arts may make and use them.

I will now state what I claim and desire to secure by Letters Patent:

1. In combination with the governor of a steam or other engine the compound cam C, C′, and the rocking levers D, D, when constructed and arranged substantially as described whereby a variable opening and closing of the induction valves is automatically produced by a positive motion as specified.

2. The above combination of the cam C, C′, and the rocking levers D, D, with the induction valves of engines when arranged and operated substantially as described, as an adjustable cut off without a regulator to make it automatic.

3. Operating the eduction or exhaust valves in openings in the cylinder heads said openings being on a line parallel with the motion of the piston constructed as described, and said valves being worked by a movement separate from the induction valves of the engine.

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